LEAD COMMISSIONER REPORT

RENEWABLE POWER IN CALIFORNIA: STATUS AND ISSUES

DECEMBER 2011

CEC-150-2011-002-LCF

CALIFORNIA ENERGY COMMISSION

2011 INTEGRATED ENERGY POLICY REPORT LEAD COMMISSIONER
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ABSTRACT

Developing renewable energy in California will create thousands of jobs, build the businesses of the 21st century, increase energy independence, and protect public health. California's Renewables Portfolio Standard requires utilities to increase the amount of renewable generation sold to customers to an average of 20 percent per year from January 1, 2011, to December 31, 2013; 25 percent by December 31, 2016; and 33 percent by December 31, 2020. In addition, Governor Jerry Brown's Clean Energy Jobs Plan identifies a goal of installing 20,000 megawatts of renewable generating capacity, including 12,000 megawatts of localized electricity generation and 8,000 megawatts of utility-scale generation, by 2020. This report outlines progress toward each of these goals and discusses the issues the state must address to develop clean, renewable electricity generation and the transmission infrastructure needed to bring that electricity to customers as the first step toward creating a strategic plan to increase renewable generation and transmission infrastructure development in California.

Keywords: American Recovery and Reinvestment Act, biomass, California Independent System Operator, California Public Utilities Commission, cogeneration, competitive renewable energy zones, Desert Renewable Energy Conservation Plan, digester gas, distributed generation, energy storage, environmental impacts, environmental justice, feed-in tariff, financing, geothermal, greenhouse gas emissions, renewable integration, interconnection, land use planning, landfill gas, levelized cost, local government, natural gas, permitting, Public Interest Energy Research Program, Public Utilities Regulatory Policies Act, Renewable Energy Action Team, Renewable Energy Transmission Initiative, renewable net short, Renewables Portfolio Standard, small hydroelectric, smart grid, solar photovoltaic, solar thermal, transmission, wind, workforce development

Please use the following citation for this report:

2011. *Renewable Power in California: Status and Issues*. California Energy Commission, December 2011, Publication No. CEC-150-2011-002LCF.

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EXECUTIVE SUMMARY

Governor Jerry Brown's Clean Energy Jobs Plan emphasized the importance of investing in renewable energy as a central element of rebuilding California's economy. Investments in renewable energy create local jobs both in clean tech industries and support industries like construction. Renewable generation facilities also provide economic benefits in the form of increased property and sales taxes. In addition to its contribution to the state's economy, renewable energy also improves California's energy independence by using local energy sources and fuels rather than imported natural gas, which is susceptible to supply shortages and price spikes. Increasing the amount of renewable resources in California's electricity portfolio also benefits the environment by reducing fossil-fuel generation that has negative impacts on air and water quality. Renewable resources are also essential to achieving the state's greenhouse gas emission reduction goals and reducing climate change impacts.

Remarkable progress and development of renewable projects began during Governor Brown's first administration with construction and operation of more than 11,000 megawatts (MW) of power plants using efficient cogeneration (combined heat and power) and innovative small power production technologies. That progress is continuing with direction from Governor Brown for the California Energy Commission to prepare a plan to "expedite permitting of the highest priority (renewable) generation and transmission projects" to support investments in renewable energy that will create new jobs and businesses, increase energy independence, and protect public health. As the first step in developing a strategic plan for renewable development in California, Energy Commission staff developed this *Renewable Power in California: Status and Issues* report. The report describes the status of renewable development in the state and identifies challenges that will affect the state's ability to meet its renewable goals. The intent of this document was to develop consensus among stakeholders on the major challenges facing renewable development in California as the basis for development of a more comprehensive strategic plan that establishes a vision, goals, and suggested strategies. Toward that end, the Executive Summary recommends several high-level strategies based on the analysis in the report and on oral and written comments provided by stakeholders in public workshops. These strategies will be used as the starting point in developing a renewable strategic plan during the *2012 Integrated Energy Policy Report Update* proceeding.

Status of Renewable Development in California

For more than a century, California has used renewable energy – energy from natural resources like sunlight, wind, rain, and the earth's heat – to help meet its electricity needs. Renewable energy represented a relatively small portion of California's electricity mix until the late 1970s when, under Governor Brown's first administration, the California Public Utilities Commission ordered utilities to establish standard offers for buying electricity from alternative suppliers ("qualifying facilities") at cost-based rates, with the price equal to the buyer's full avoided cost. At the federal level, Congress enacted the Public Utility Regulatory Policies Act (PURPA) and the Federal Energy Regulatory Commission adopted regulations to implement PURPA. A key element of national and state PURPA policy was diversifying and strengthening domestic

electricity production by encouraging the development of cogeneration and renewable energy facilities. As part of Governor Brown's first administration, California established policies that resulted in thousands of MW of new cogeneration and renewable generating capacity by the early 1990s. However, continuing suspension of standard offers for new facilities beginning in 1985 through today and declining fossil fuel prices in the 1990s led to a drop in renewable development as PURPA contracts expired and renewable projects were not able to compete with new natural gas turbines.

The late 1990s saw electricity market restructuring with increased emphasis on competition to reach equitable and efficient outcomes. The electricity crisis of 2000 and 2001, combined with the continuing absence of a standard offer for new qualifying facilities, created uncertainty about how new facilities would be built in California. Concerns over global warming and increasing oil prices revived interest in the use of renewable fuels. The California Legislature passed many new laws in response to the energy crisis, lack of new qualifying facility options, and global warming concerns. In 2002, as part of that effort, the Legislature established the Renewables Portfolio Standard (RPS) to diversify the electricity system and reduce growing dependence on natural gas by increasing the amount of renewable electricity in the state's power mix to 20 percent by 2017. In 2006, this target date was accelerated to 2010, and in 2011 the RPS was revised to require that renewable electricity should equal an average of 20 percent of the total electricity sold to retail customers in California during the compliance period ending December 31, 2013, 25 percent by December 31, 2016, and 33 percent by December 31, 2020. To support the RPS targets, Governor Brown's Clean Energy Jobs Plan calls for adding 20,000 MW of new renewable capacity by 2020, including 8,000 MW of large-scale wind, solar, and geothermal as well as 12,000 MW of localized generation close to consumer loads and transmission and distribution lines.

California appears to be on track to achieve the 20 percent by 2013 RPS target, with nearly 16 percent of statewide retail sales coming from renewable generation facilities in 2010.[1] The California Public Utilities Commission contracts data shows that 2,600 MW of new renewable capacity has begun commercial operation since the RPS was established in 2002. Publicly owned utilities have added another 2,000 MW of renewable capacity since the RPS program began. As of 2010, California had about 10,000 MW of renewable generating capacity, with more than 4,300 MW from utility-scale renewables, 1,700 MW from wholesale distributed generation facilities, and nearly 1,000 MW from customer-side distributed generation systems.[2]

California has also made progress toward achieving the Governor's 12,000 MW renewable distributed generation goal, with 2,469 MW of distributed generation capacity installed as of June 2011.

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1 Depending on the source of data, total renewable generation figures vary between 15 and 16.5 percent of statewide retail sales from renewable generation in 2010. Renewable procurement and generation sources include: The Power Source Disclosure Program, CPUC RPS Compliance Filings, Energy Commission RPS Tracking, and the Energy Commission's total system power.

2 Accurate data regarding the breakdown of wind capacity into utility-scale and wholesale DG was not available at the time of publication of this report.

Table ES-1: In-State Renewable Capacity and Generation (2010)

Renewable Resource	Utility-Scale Capacity (MW)	Wholesale Distributed Generation Capacity (MW)	Distributed Generation Capacity (MW)	Total Capacity (MW)	Total Generation (GWh)
Biomass	1,070	458	25	1,553	5,745
Geothermal	2,521	127	0	2,648	12,740
Small Hydro	315	989	0	1,304	4,441
Solar	408	82	780	1,270	908
Wind	No data	No data	8	3,027[A]	6,172
Total	**4,314**	**1,656**	**813**	**9,802**	**30,005**

A Includes 3019 MW of utility scale and wholesale distributed generation wind capacity. Based on California ISO data on wind projects located in the California ISO and the California Energy Commission's "CEC-1304 QFER Database California Power Plant Database." http://energyalmanac.ca.gov/electricity/web_qfer/ for wind projects located outside the California ISO.

Source: California Energy Commission

If existing state programs to support distributed generation are fully successful, the state could add 5,400 MW of additional capacity in the next five to eight years, leaving a gap of roughly 3,500 MW that may require additional programs or incentives. However, given declining trends in solar photovoltaic costs, it may make sense to focus on developing the low-hanging fruit and reforming permitting and interconnection processes in the early years to take advantage of cost reductions and improved regulatory structures in later years.

Energy Commission staff has developed regional targets to break down the 12,000 MW distributed generation goal into its component parts as a starting point to help meet the goal and measure progress over time (Table ES-2). These regional targets are "soft targets" that serve as a starting point for discussions on a local level and may be reevaluated annually by the Energy Commission.

The Governor's Clean Energy Jobs Plan also sets a target for developing 8,000 MW of utility-scale renewable generating capacity by 2020. In 2010, more than 9,000 MW of new renewable capacity was permitted. Of that amount, about 8,000 MW were associated with new California Independent System Operator transmission lines and upgrades (Table ES-3). If these new lines and upgrades are permitted, built, and operating before 2020, they could allow more than 16,000 MW of additional generation to flow to load centers at any point in time. Only half of the capacity to fill these lines was permitted last year, meaning another 8,000 MW of capacity could be sited in the Competitive Renewable Energy Zones associated with these lines in the future. This is consistent with Governor Brown's goal of 8,000 MW of new capacity sited and built by 2020. Some of these zones are located in California's Mojave and Colorado Desert regions. The Energy Commission continues to support a fully integrated transmission and generation planning process, which includes the land use assumptions and natural resource planning information being developed in the state/federal Desert Renewable Energy Conservation Plan process.

Table ES-2: Proposed Regional DG Targets by 2020

Region	Behind the Meter (all technologies)	Wholesale	Undefined (mix of behind the meter and wholesale)	Total
Central Coast	280	90	0	370
Central Valley	830	1590	0	2,420
East Bay	420	30	0	450
Imperial	50	90	0	140
Inland Empire	480	430	0	910
Los Angeles, *city and county	970	860	2170	4,000
North Bay	220	0	0	220
North Valley	120	50	0	170
Sacramento Region	410	170	220	800
San Diego	500	50	630	1,180
SF Peninsula	480	10	310	800
Sierras	30	40	0	70
Orange	420	10	40	470
Total	**5,210**	**3,420**	**3,370**	**12,000**

Source: California Energy Commission

Table ES-3: Preliminary Regional Targets for 8,000 Megawatts of New Renewable Capacity by 2020

Identified Transmission Line (s)	Total Additional Capacity With New/Upgraded Lines (MW)[A]	Capacity Permitted in 2010 Associated With New/Upgrades (MW)[B]	Additional Project Capacity for 8,000 MW of New Large-Scale Renewables (MW)
Sunrise Powerlink	1,700	760	940
Tehachapi and Barren Ridge Renewable Transmission Projects	5,500	2,810	2,690
Colorado River, West of Devers, and Path 42 Upgrade	4,700	1,825	2,875
Eldorado-Ivanpah, Pisgah-Lugo, and Coolwater-Jasper-Lugo	2,450[C]	1,470	980
Borden-Gregg	800	145	655
South of Contra Costa	535	155	380
Carrizo-Midway	900	800	100
TOTAL			8,620

[A] California Energy Commission data.
[B] Renewable Energy Action Team database. Only projects associated with the transmission projects specified were included.
[C] The total deliverability potential with these lines could be as high as 3800 MW. However, the Eldorado-Ivanpah and the Pisgah-Lugo lines upgrade the same corridor and the capacity associated with the new lines may not be additive. The 2,450 MW includes the deliverability linked to the Pisgah-Lugo and the Coolwater-Jasper-Lugo lines.

Source: California Energy Commission

Looking forward, California has significant potential for additional renewable development to meet the 33 percent RPS target, with an estimated 18 million MW of renewable technical potential (the amount of generating capacity theoretically possible given resource availability, geographical restrictions, and technical limitations like energy conversion efficiencies). Achieving even a fraction of this potential, however, will depend on the ability of project developers to secure financing, permits, transmission, interconnection and power purchase contracts.

Table ES-4: California's Renewable Energy Potential

Technology	Technical Potential (MW)
Biomass	3,820
Geothermal	4,825
Small Hydro	2,158
Solar	
Concentrating Solar Power	1,061,362
PV	17,000,000
Wave and Tidal	32,763
Wind	
On-shore	34,000
Off-shore	75,400
TOTAL TECHNICAL POTENTIAL	**18,214,328**

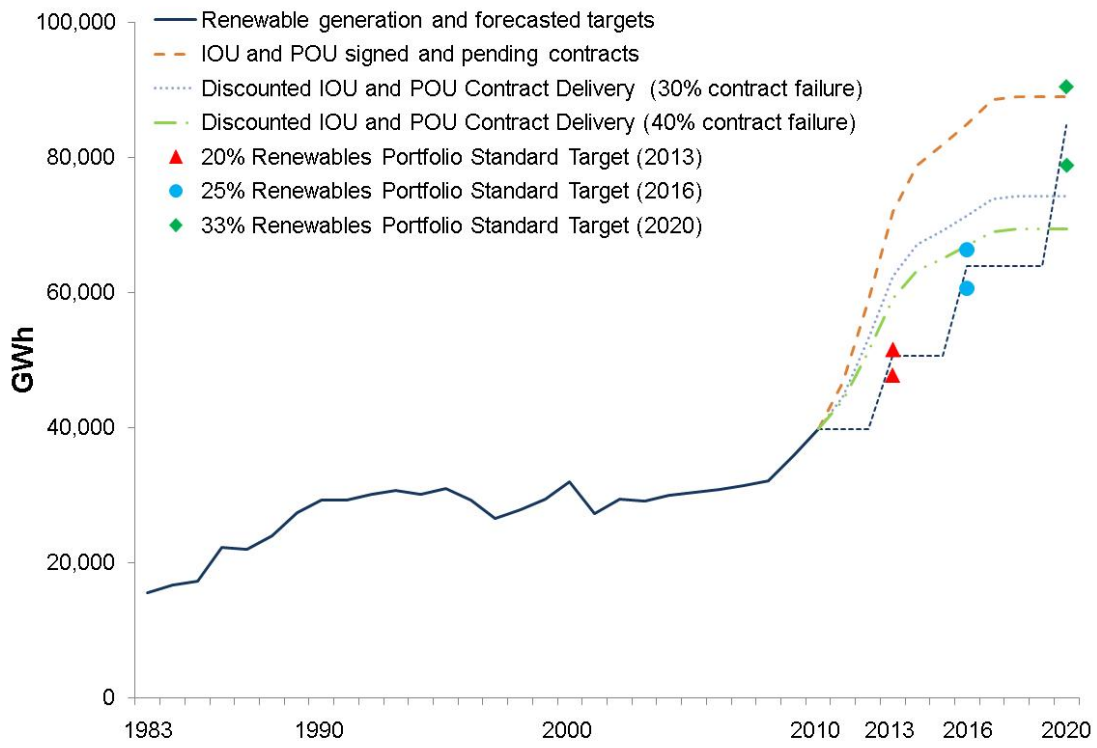
Source: California Energy Commission.

Although an estimate of renewable market potential is beyond the scope of this report, recent trends indicate an increasing market interest in renewable development. The 2009 RPS solicitation by the California Public Utilities Commission drew bids from developers offering to supply enough renewable generation to meet half of the investor-owned utilities' total electrical load in 2020, and investor-owned utilities have signed contracts for about 14,000 MW of new renewable capacity. In 2010, state and local entities issued permits for 9,435 MW of renewable capacity, and renewable projects totaling nearly 26,000 MW of capacity are being tracked in various permitting processes. As mentioned above, the California Independent System Operator's Interconnection Queue includes about 57,000 MW of renewable capacity, and there are 450 active interconnection requests for distributed generation systems in the Wholesale Distribution Access Tariff queue totaling about 5,200 MW.

The ability of developers to navigate successfully through each of these processes will affect the amount of renewable generation that is ultimately built. Estimates of the amount of renewable energy needed to meet the 33 percent by 2020 RPS target beyond what is expected to be provided by existing facilities in 2020 range from 35,300 gigawatt hours to 47,000 gigawatt hours. As of May 2011, enough renewable generation was either on-line or under contract to

achieve this range, assuming all existing renewable facilities remain on-line in 2020 and all to most of the contracted renewables are built (Figure ES-1).

Figure ES-1: Renewable Generation for California and Renewables Portfolio Standard Goals



Source: California Energy Commission

However, this estimate includes a number of short-term contracts that may not be renewed, as well as existing facilities that may retire due to age or contract expiration, which could reduce the contribution from existing facilities. There is also risk of contract failure; data from the Energy Commission's investor-owned utility contract database indicates that since the start of the RPS program, about 30 percent of long-term RPS contracts (10 years or more) approved by the California Public Utilities Commission have been cancelled. The contract failure rate increases to about 40 percent if contracts that are delayed are considered. The 40 percent contract failure rate is also consistent with public comments by utilities on the draft of this report.[3] This suggests utilities should be contracting for a renewable generation in the range of 55,000 gigawatt hours to 85,000 gigawatt hours.

Post 2020, additional investments in renewable generation may be needed to replace generation expected to decline over the course of the next decade, such as generation from expiring coal

3 Transcript of the September 14, 2011, Integrated Energy Policy Report workshop on the Draft *Renewable Power in California: Status and Issues* report, comments by Valerie Wynn, Pacific Gas and Electric Company, (page 72) and Gary Stern, Southern California Edison (page 73), http://www.energy.ca.gov/2011_energypolicy/documents/2011-09-14_workshop/2011-09-14_transcript.pdf.

contracts. Generation from a number of these contracts, which represents about 10 percent of total generation serving California, is expected to decline by 61 percent between 2010 and 2020 due to constraints imposed by the Emission Performance Standard (Senate Bill 1368, Perata, Chapter 598, Statutes of 2006). Remaining coal contracts are expected to expire between 2027 and 2030, which will require replacement with a mix of renewable and thermal generation with storage to satisfy electricity needs while still meeting greenhouse gas emission reduction goals.

When signing the 2011 RPS legislation, Governor Brown indicated that the 33 percent by 2020 RPS target should be considered a floor rather than a ceiling. This is consistent with the need for additional renewable generation and other zero-carbon electricity resources to meet the state's long-term (2050) carbon reduction goals. Rough estimates indicate that if new generation needed to serve expected electricity demand in 2050 is served only by new renewables, this supply would represent 67 percent of total electricity sales in 2050. This assumes that energy efficiency programs in the long term are developed at rates targeted for 2010-2020, distributed generation targets established in the Governor's Clean Energy Jobs Plan are met, more than 5 million full electric and hybrid vehicles along with high-speed rail are developed by 2050, existing in-state renewable facilities operate through 2050, and existing nuclear plants are relicensed through 2050. If the nuclear plants are not relicensed, the estimate of renewable energy needed to provide total zero-emission generation needed in 2050 rises to 79 percent.

Issues Affecting Future Renewable Development in California

This draft *Renewable Power in California: Status and Issues* identifies many of the challenges that must be addressed to achieve California's renewable energy targets and goals. Planning, permitting, and environmental issues can delay or jeopardize project development and increase development costs. Because many renewable resources are located in remote areas, the state will need to upgrade existing or develop new transmission infrastructure to bring electricity from these areas to the state's load centers. This is made more complex by the current disconnect between generation and transmission planning and permitting processes wherein the length of time needed for transmission development requires transmission projects to proceed while there is still uncertainty about where generators will ultimately be located.

Once generation and transmission infrastructure is in place, there are further issues with integrating large amounts of intermittent renewable electricity, such as solar and wind, into the state's electric grid. Because generation from these resources may vary over time in periods as short as seconds, it can cause difficulties for grid operators who must maintain a constant balance between generation supply and real-time customer demand while also meeting established standards for controlling fluctuations in frequency and voltage. Connecting distributed generation projects to the distribution system also involves challenges due to aging infrastructure that also was not designed to accommodate the two-way flows of electricity that can result from high levels of distributed generation on the system.

On the financial side, there are financing gaps at certain stages of renewable development as well as costs associated with environmental review and permitting, construction, and interconnection of renewable facilities. Significant investment is needed to bring down the costs of existing renewable technologies and develop the new technologies that will be crucial to

integrating renewable technologies into the grid, but investment in energy-related research and development is about $1 billion less than a decade ago. Without private and corporate funding for energy-related research and development, government funding for research – such as that provided by the Energy Commission's Public Interest Energy Research Program – becomes even more critical to maintaining the state's leadership role in developing a clean energy economy. However, the Public Interest Energy Research Program is currently funded by a public goods charge that is set to expire January 1, 2012 and reauthorization by the California Legislature or an alternative funding source is needed for the program to continue.

These and other issues discussed in this draft report and current efforts that are helping to address these challenges are summarized below.

Planning, Permitting, and Environmental Issues

- **Site selection:** One of the main lessons learned during the Energy Commission's permitting of more than 4,000 MW of large solar thermal power plants in the California desert in 2010 is that location matters. Locating renewable facilities on undisturbed and/or sensitive lands in the desert raises a host of environmental concerns, including impacts on sensitive animal and plant species, water supplies and waterways, and cultural resources such as areas of historical or ethnographic importance. There are also land use concerns since the majority of desert lands in California are owned by the federal government and managed for multiple uses, including recreation, wildlife habitat, livestock grazing, and open space.

  To help developers design projects that minimize environmental impacts for renewable projects in the desert, the state's Renewable Energy Action Team in December 2010 published the multidisciplinary *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects*. The Desert Renewable Energy Conservation Plan being developed by the Renewable Energy Action Team is also identifying areas in the Mojave and Colorado Desert regions suitable for renewable energy project development and areas that will contribute to the conservation of sensitive species and natural communities. To contribute toward reducing environmental impacts of renewable energy facilities, the Energy Commission's Public Interest Energy Research Program is identifying strategies to reduce the effects of desert solar and wind projects on sensitive species as well as low-risk sites for wind turbine installations to reduce avian impacts.

- **Fragmented or overlapping licensing authority:** A variety of federal, state, and local agencies have licensing authority for different types of utility-scale renewable projects. This can result in inconsistent environmental reviews and standards along with inaccurate and incomplete information on biological and cultural resource impacts. Although state and federal protocols for analyzing these impacts are essentially the same, there is wide variation in the extent of the evaluation, interpretation of results, and mitigation requirements. When involved agencies cannot agree on a set of mitigation or licensing conditions, developers have to satisfy more than one set of conditions, submit duplicate information, or face delays while agencies attempt to come to agreement.

The Renewable Energy Action Team is working to streamline and expedite permitting processes for renewable energy projects, including efforts through the Desert Renewable Energy Conservation Plan process, and state and federal agencies increasing cross-agency cooperation and coordination of renewable permitting processes through a variety of multiagency agreements. In addition, the Energy Commission's Order Instituting Information Proceeding is identifying "lessons learned" during the licensing of large-scale renewable energy facilities in 2010 with the goal of identifying new approaches to planning and permitting in the future.

- **Unclear, duplicative, and uncoordinated requirements for renewable distributed generation projects:** Distributed generation projects are permitted at the local level, but many cities and counties do not have energy elements in their general plans or zoning ordinances to guide renewable development. In addition, the wide variation in standards, codes, and fees among local governments make it difficult for developers to meet permit requirements. Land-use requirements for identical systems can vary significantly from jurisdiction to jurisdiction. Fees also vary widely among municipalities and even within municipalities for the same system size, and are often based on project cost rather than staff time needed for permit review, with many municipalities exceeding estimated cost recovery fees. Developers must also get permit approvals from local fire departments, building and electric code officials, and local air districts, leading to duplication and inefficiency in the permit application process. Finally, while distributed generation projects are subject to an environmental review under the California Environmental Quality Act and in some cases the National Environmental Protection Act, many local permitting agencies only have thorough environmental screening and review processes in place for traditional development and are ill-prepared to assess environmental impacts associated with renewable distributed generation.

  There are efforts at the national, state, and local levels to identify and provide solutions to barriers to permitting renewable distributed generation facilities. The U.S. Department of Energy's Solar America Cities Program provided funding for cities that promote solar power and streamline interaction between local government and residents. In addition, the U.S. Department of Energy's SunShot Initiative provides funding to encourage cities and counties to streamline and digitize permitting processes and to develop innovative information technology systems, local zoning and building codes, and regulations. At the state level, the California State Assembly has introduced Assembly Bill X1 13 (V. Manuel Pérez, Bradford, and Skinner), which would require the Energy Commission to provide $7 million in grants to qualified counties in California to develop or revise rules and policies, including general plan elements, zoning ordinances, and a natural community conservation plan, to promote the development of eligible renewable energy resources. At the local level, many jurisdictions are supporting renewable distributed generation through strategies like identifying permitting barriers and developing expedited permitting processes, offering on-line permits for solar photovoltaic systems, and offering permit fee waivers for solar and wind projects. The California County Planning Directors Association is also coordinating a

multistakeholder effort to draft a model ordinance for solar electric facilities for cities and counties across the state.

Transmission Issues

- **Ensure interconnection of renewable generation projects receiving federal stimulus funding:** There are 13 major transmission projects critical to the interconnection and deliverability of renewable generation in California needed to meet the 33 percent by 2020 renewable mandate (Table ES-5).

Table ES-5: Major Transmission Projects for Interconnection and Deliverability of Renewable Generation in California

Balancing Authority	Transmission	Served CREZ	Cumulative Renewable Deliverability Potential (MW) With Upgrade	Expected Commercial On-line Date
California ISO	Sunrise Powerlink (new 500 kV and 230 kV lines)	Imperial North and South, San Diego South	1,700	2012
California ISO	Tehachapi Renewable Transmission Project	Tehachapi, Fairmont	4,500	2015
California ISO	***Colorado River –Valley Transmission Project and new Colorado River and Red Bluff 500 kV substations.***	***Riverside East, Palm Springs***	***4,700 combined with West of Devers project***	***2013***
California ISO	***Eldorado - Ivanpah 115 to 230 kV conversion***	***Mountain Pass***	***1,400***	***2013***
California ISO	Borden - Gregg (230 kV line reconductoring)	Westlands	800	2015
California ISO	South of Contra Costa (reconductoring)	Solano	535	2015
California ISO	***Pisgah - Lugo 230 kV to 500 kV conversion***	***Pisgah, Mountain Pass***	***1,750***	***2017***
California ISO	***West of Devers 230 kV reconductoring***	***Riverside East, Palm Springs***	***4,700 combined with Colorado River- Valley Project***	***2017***
California ISO	Carrizo - Midway sections of Morro Bay - Midway (230 kV lines reconductoring)	Carrizo South, Santa Barbara	900	2012
California ISO	***Coolwater – Jasper – Lugo (new 230 kV line and other upgrades)***	***Kramer***	***700***	***2018***
California ISO/Imperial Irrigation District (IID)	Path 42 Upgrades	Imperial Valley	1,400	2015
IID	Internal IID Upgrades	Imperial Valley	See above	2011+
Los Angeles Dept. of Water and Power	***Barren Ridge-Renewable Transmission Project***	***Tehachapi, Barren Ridge***	***1,000***	***2016***

Source: California Energy Commission

Many of the projects in Table ES-5 are needed to interconnect renewable generation projects receiving funding through the American Recovery and Reinvestment Act that will be essential to achieving the state's renewable goals (indicated in the table by bold italics). While a number of the 13 projects have been licensed or are under construction, several key projects do not yet have active licensing applications.

- **Lack of coordinated land use and transmission system planning:** Transmission planning processes need to be streamlined and coordinated to ensure siting, permitting, and construction of the most appropriate transmission projects to connect renewable resources while ensuring proper consideration of land use and environmental factors. Currently, the project development process, which identifies routing issues and constraints, does not begin until after the "wires" planning process is complete. This lengthens the transmission development process and increases the risk of approved transmission projects not being developed due to environmental issues. In addition, assumptions and processes used by transmission planning organizations are not always transparent or consistent, and the large number of planning forums makes it difficult for stakeholders to participate effectively.

  The Renewable Energy Transmission Initiative was a statewide land use planning process to help identify transmission projects needed to meet the state's renewable energy goals. This effort identified about 30 "Competitive Renewable Energy Zones" (CREZs) throughout the state that were most likely for cost-effective and environmentally benign generation development with corresponding transmission interconnections and lines. This established the precedent for incorporating land-use planning into the statewide transmission planning process, and led directly to the collaborative land use planning activity occurring in the Desert Renewable Energy Conservation Plan process. Energy agencies are working together to develop a "virtual" process to ensure integration of land use planning from the Desert Renewable Energy Conservation Plan into the California Independent System Operator's annual transmission planning process.

  In addition, the California Transmission Planning Group, whose members include publicly owned utilities, investor-owned utilities, the Southern California Public Power Authority, and the Transmission Agency of Northern California, was formed in 2009. The role of the group is to address California's transmission needs in a coordinated manner by developing a conceptual statewide transmission plan that identifies the necessary transmission infrastructure to meet the state's 33 percent by 2020 RPS goal. The California Independent System Operator has also revised its transmission planning process to include transmission upgrades needed to meet California's policy mandates, with the 2010-2011 Transmission Plan focusing on the RPS mandate in identifying policy-driven transmission projects. The California Independent System Operator also requested and received a one-time waiver from the Federal Energy Regulatory Commission to exempt upgrades associated with renewable projects receiving federal stimulus funding from further study in the 2010-2011 transmission planning process to allow generators to meet the construction start date of December 31, 2010.

- **Better use of the existing grid:** Currently, proposed projects are based on existing need demonstrated by individual interconnection requests. Allowing "upsizing" of projects, for example, by constructing a double circuit line in an existing right-of-way, can provide unused capacity available for future use and maximize the value of land associated with already necessary transmission investment and avoid future costlier upgrades needed to accommodate additional renewable development.

  One of the goals of the Desert Renewable Energy Conservation Plan is to support consolidation of renewable development, including transmission infrastructure, rather than scattered "leapfrog" development. In addition, the Energy Commission's Public Interest Energy Research Program has funded a wide variety of projects related to improving the performance of the existing transmission system, including technologies to increase the carrying capacity of existing lines, reduce instabilities that are causing some transmission connections to be operated thousands of megawatts below maximum capacity, and develop transmission cables that can be operated at higher temperatures and allow more power to be transferred over existing transmission rights-of-way.

Integration Issues

- **Grid-level integration:** Maintaining reliable operation of the electric system with high levels of intermittent resources will require regulation to follow real-time ups and downs in generation output, voltage, or frequency caused by changes in generation or load; ramping generation from other units up or down to follow swings in wind or solar generation; spinning reserves provided by generating resources standing by and ready to connect to the grid if needed; and replacement power for outages. In addition, system operators need strategies to address potential overgeneration issues that occur when there is more generation than there is load to use it. California currently relies on large hydropower and natural gas generators to provide many of the services needed to integrate intermittent renewable resources, but as more renewable generating facilities are added to the system, it will become increasingly challenging to maintain system reliability and stability.

  Successful integration will require improvements in forecasting of wind and solar technologies so that transmission and generation dispatchers know how much variability to plan for. In addition, complementary technologies like natural gas-fired power plants, energy storage, and demand response can be used to provide integration services. Natural gas units can provide quick startup, rapid ramping, regulation, spinning reserves, and energy when intermittent resources are not available. Energy storage can provide flexible and controllable ancillary services at the transmission level through voltage support and frequency response, and can store excess energy when on-line generation exceeds load. Demand response – having electricity customers reduce their consumption at critical times or in response to market prices – can help with integration by combining smaller loads to provide regulation or ramping through automatic controls that turn individual loads up or down as needed.

  There are a number of efforts underway to address integration issues. The California Independent System Operator is working to improve its forecasting techniques to reduce

uncertainty and the amount of standby capacity that will be needed to compensate for variations between generation and load. Formal planning for adding cost-effective energy storage to the electric system began with the passage of Assembly Bill 2514 (Skinner, Chapter 469, Statutes of 2010), which directed the California Public Utilities Commission and publicly owned utilities to evaluate the need for and benefits of cost-effective and viable energy storage systems, and determine appropriate targets by October 2013. Demand response is being used throughout the United States for ancillary services, and the California Independent System Operator offers two demand response products that are laying the foundation for the role of demand response in renewable integration efforts. In addition, the California Independent System Operator is scheduled to implement a regulation energy market in spring 2012 that will allow demand response and energy storage to submit bids to provide ancillary services. The California Public Utilities Commission is also evaluating integration costs as part of its Long-Term Procurement Plan proceeding for various scenarios. Finally, the Energy Commission's Public Interest Energy Research Program is funding a wide array of projects intended to develop better forecasting tools for wind and solar generation, develop and demonstrate energy storage technologies, identify ways that demand response can support renewable integration, and develop the smart grid of the future.[4]

- **Distribution-level integration:** There are also significant challenges to integrating large amounts of renewable distributed generation into the distribution system, which brings power from substations to consumers. These resources include small projects on the customer side of the meter that produce energy to satisfy a customer's own electric load; medium-sized projects that provide energy for a customer's load, for export to the grid, or some combination of the two; and larger systems that export all of their power to a utility or some other entity. Today's distribution system still uses designs, technologies, and strategies that were developed to meet the needs of mid-20th century customers. While these large and complex systems have historically provided reliable electric power to tens of millions of customers throughout the state, aging infrastructure coupled with modern demands is beginning to erode this capability. One major challenge is that the system is designed to move electricity in one direction, from central-station generator to substation to customer. However, as more distributed generation is added to the system, power generated by these resources may exceed demand and flow backward into circuits or substations, requiring new protection and control strategies to avoid damaging the electric system. Another challenge is the increasing number of requests for interconnection and the need to reduce the complexity, expense, and length of time associated with that process.

  California utilities are already modernizing their distribution systems by replacing equipment at the end of its useful life with new equipment that often has more advanced communication and functional capabilities. This modernization is likely to increase as a

4 A "smart grid" incorporates information and communications technology into electricity generation, delivery, and consumption to minimize environmental impacts, enhance markets, improve reliability and service, reduce costs, and improve efficiency.

result of Senate Bill 17 (Padilla, Chapter 327, Statutes of 2009), which requires utilities to develop smart grid deployment plans. To address interconnection challenges, the California Public Utilities Commission has established the Renewable Distributed Energy Collaborative working group. There are also fast-track processes available within each of the state's interconnection processes to streamline interconnection of smaller projects, and utilities are providing information on their websites to allow developers to identify locations on the distribution grid where projects can be interconnected more quickly and at lower cost. The Energy Commission and the California Independent System Operator are also funding a study on renewable distributed generation integration in Germany and Spain to identify strategies that can be applied to California's system. Other research funded through the Public Interest Energy Research Program is focused on predicting the impacts of distributed generation on distribution circuits, and developing smart grid and battery storage technologies that can support integration at the distribution level.

Investment and Financing Issues

- **Ensuring adequate financing at critical stages of renewable project development:** Like all emerging industries, there are key financing challenges that face renewable energy development including acquiring significant capital that is injected at the right time, incentives that drive down costs, and solutions that help to reduce or mitigate risk. Lack of funding during early stages of project development can affect the ultimate success of a renewable project. There is little financial incentive for private companies to invest in the types of research and development that are most beneficial to society because there is no certainty of return on their investment. During the later stage of early commercial development, significant capital is needed to finance projects and demonstrate the viability of a project at scale. Technologies currently at or anticipated to be at this stage over the next three years include concentrating solar power towers, advanced solar manufacturing, and energy storage. Because these funding gaps are not addressed by the private sector, government has an important role in addressing financing challenges by promoting research and early technology innovations, reducing credit risks, and developing and maintaining stable and predictable regulatory policies to provide information for medium- and long-term investment decisions.

  National government laboratories are helping to address these funding gaps by performing cutting-edge research on a variety of clean energy technologies. In addition, the federal Advanced Research Projects Agency – Energy funds high-risk, high-reward technologies to bridge the gap between basic energy research and industrial application. Other federal government support mechanisms include tax incentives such as the business energy investment tax credit and the renewable production tax credit as well as accelerated depreciation of renewable energy assets and loan and bond financing programs. There are a number of state incentives as well, including programs to support renewable distributed generation, although some of these programs are threatened by the expiration of public goods charge funding, and sales and use tax exclusions under California's Advanced Transportation and Alternative Sources Manufacturing Sales and Use Tax Exclusion Program. On the research side, the Public Interest Energy Research Program provided about

$179 million for renewable energy research between 1997 and 2010, including seed funding for technology incubators that accelerate the growth and development of clean technologies. Other efforts include the state's Innovation Hub initiative, which leverages research parks, technology incubators, universities, and federal laboratories to provide an innovation platform for startup companies, economic development organizations, business groups, and venture capitalists. Finally, tools like feed-in tariffs (one of the most widely implemented renewable policies in place in 61 countries and 26 states/provinces) are providing greater certainty of project revenues, reducing transaction costs, and helping projects to secure financing.

Cost Issues

- **Renewable technology costs:** Renewable technologies have a wide range of costs depending on the technology. More mature technologies, like geothermal and biomass, have a narrower range of levelized cost than emerging technologies, although biomass costs too can vary depending on feedstock availability. Historically, technologies like solar thermal electric and solar photovoltaics were thought to have levelized costs greater than those of conventional generation. However, recent contract bids show that this is changing. According to the Energy Commission's investor-owned utility contract database, the majority of solar thermal power tower technology contracts that have been signed and are pending are below the 2009 Market Price Referent, a proxy for the levelized cost of a new 500-megawatt natural gas combined cycle facility.

  In addition, in the past distributed generation projects were considered more costly due to higher transaction costs and lack of economies of scale. However, standardization of contract terms and the way photovoltaics are manufactured and sold have affected bids for distributed generation systems. Pacific Gas and Electric and Southern California Edison have filed advice letters with the California Public Utilities Commission stating that all contracts signed under their solar photovoltaic programs, which are for projects 20 MW and smaller, are also below the Market Price Referent.

  As retail rates increase and solar photovoltaic costs drop, distributed generation projects on the customer side of the meter are also likely to become more cost-competitive even without state rebate programs. For example, even though Pacific Gas and Electric is offering a Performance Based Incentive of only 5 cents per kilowatt hour (down from 39 cents per kilowatt hour less than five years ago), systems are continuing to be installed. It is likely that there will be significant changes in the market in the next five to ten years as distributed generation systems become more cost-competitive.

  For utility-scale renewable projects, the Energy Commission continues to work with the California Independent System Operator and the California Public Utilities Commission to determine the costs of transmission and renewable integration. While costs of both appear significant, they are certainly not insurmountable. Distribution system upgrades and modernization could be significant depending on the location of distributed generation projects and the pace at which they are deployed. However, there are a variety of efforts to

identify optimal locations for such projects and to develop the smart grid technologies needed to ease integration into the distribution system.

Finally, in any discussion of the costs of renewable technologies, it is important to recognize that renewables provide important benefits that have not been adequately quantified, such as the value of having a diverse portfolio of generating resources that reduces costs and risk to ratepayers, business and economic development benefits, reduced dependence on natural gas and vulnerability to natural gas supply shortages or price spikes, and reduced greenhouse gas emissions and climate change impacts.

Research and Development Issues

- **Maintaining state funding for energy-related research and development**: Continued public sector investment in energy-related research and development is essential to address the various challenges to achieving California's renewable energy goals. The Public Interest Energy Research Program has funded a wide variety of research activities to identify ways to address the environmental impacts of renewable energy facilities; develop technologies to improve the performance of the state's transmission and distribution systems; promote integration of renewable generating technologies at both the transmission and distribution level through the development of smart grid, energy storage, and demand response technologies; and reduce renewable technology costs while improving efficiency. With increasing levels of renewable resources in California's electricity mix, continued research will be required in each of these areas to provide the technological advancements needed to support the state's clean energy policy goals.

Environmental Justice Issues

- **Addressing environmental justice concerns:** Environmental justice is defined in California law as "the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies." Environmental justice organizations have repeatedly voiced concerns about the types of power plants that will be built to meet increased electricity demand and replace aging power plants and plants that may retire as a result of the State Water Resources Control Board's policy on the use of once-through cooling in power plants, particularly in the southern part of the state, which has some of the worst air quality in the nation. There are also concerns about the types of fossil generation that may be built to support renewable integration, including flexible natural gas turbines ("peakers") that are less efficient that baseload resources and have increased emissions that may impact the communities in which they will be located.

  The Energy Commission has considered environmental justice issues in its power plant licensing process since 1995, including conducting outreach to community members, identifying areas potentially affected by emissions or other environmental impacts, determining where there are significant populations of minority or low-income residents in an area potentially affected by proposed projects, and determining whether there may be a disproportionate effect on minority or low-income populations. However, given figures in the 2010 census that indicate California has the highest minority population in the nation at

57 percent, it is likely that new power plants, including those that use renewable resources, will be located in areas that could affect minority communities.

Local Government Coordination Issues

- **Coordination between state and local governments on energy decisions**: Renewable development at the local level will be an essential component of the state's efforts to meet its renewable energy goals. Local governments are closely involved in land use decisions, environmental review, and permitting for a wide range of renewable projects. Many local governments face constraints due to scaled-back staffing as a result of the economic downturn, limited expertise about renewable technologies, and lack of energy elements in their general plans and ordinances that could delay the processing of permits for renewable facilities. However, a number of local jurisdictions are showing strong leadership and innovation in promoting renewable energy development, including Kern County, Imperial County, Inyo County, Los Angeles County, San Diego County, San Luis Obispo County, Solano County, Fresno County, Tulare County, Marin County, and the cities of Fremont, Santa Rosa, San Jose, Sacramento, Lancaster, Santa Monica, and Berkeley.

Workforce Development Issues

- **Ensuring a well-trained workforce to support California's renewable policy goals**: A recent Brookings Institution report concludes that nationwide, the clean economy employs more workers than the fossil fuel industry, with California having the highest number of clean energy jobs (see Chapter 1, page 26). While the clean energy economy grew more slowly than the national economy between 2003 and 2010, newer clean tech segments like wind, solar photovoltaics, and smart grid produced explosive job gains. While much of this growth is creating demand for workers in existing occupations, it is also driving the need for workers who need to enhance their skills and for those who need training for emerging occupations. As investment in the clean economy continues to expand, there is a need for a coordinated approach to workforce training that is closely aligned with labor demand. Although there are a number of workforce training programs in place, the fragile economy has made employers hesitant about taking on more employees, which has resulted in low placement rates for some of these programs. In addition, expiration of federal stimulus funding for workforce development may make it difficult for community colleges, trade associations, and other training providers to continue their clean energy training curricula in the future.

  California is at the forefront of workforce training efforts for the green economy with its Clean Energy Workforce Training Program, the largest state-sponsored green jobs training program in the nation. In addition, the Energy Commission's Clean Energy Business Financing Program has awarded funding to six companies focused on production of solar photovoltaic panels that are creating 640 jobs throughout the state.

Public Leadership Issues

- **Demonstrating public leadership**: California has the potential to develop renewable energy systems on state-owned buildings, properties, and rights-of-way to help meet the state's renewable energy goals, create green jobs, and reduce greenhouse gas emissions and other

harmful air pollutants. These investments will also reduce energy costs in state buildings and create new revenue for state government through the lease of vacant or unused land. State leadership will also demonstrate the benefits of renewable distributed generation and help encourage larger-scale deployment throughout the state and across the country.

In December 2010, the Energy Commission adopted a memorandum of understanding with the Departments of General Services, Corrections and Rehabilitation, Transportation (Caltrans), Water Resources, and Fish and Game to promote the development of renewable energy projects on state buildings, properties, and rights-of-way. The California State Lands Commission and the University of California have since signed on to this effort, and there is an option for additional agencies to join in the future. Based on its inventory of state properties to identify opportunities for deployment of renewable distributed generation systems, Energy Commission staff recommended a target of 2,500 MW of new renewable generating capacity on state properties. There are already a number of efforts underway by various state agencies that will contribute toward meeting these targets.

Recommended Strategies

Building upon this thorough study, numerous public workshops, and the input of stakeholders from various communities and industries throughout California, the Energy Commission proposes five overarching strategies to guide the state as it works toward achieving the 33 percent Renewables Portfolio Standard mandate, the 12,000 megawatt distributed generation goal, and promoting economic recovery and job creation through investments in the clean energy sector:

1. Identify and prioritize geographic areas in the state for both renewable utility-scale and distributed generation development. Priority areas should have high levels of renewable resources, be located where development will have the least environmental impact, and be close to planned, existing, or approved transmission or distribution infrastructure. Prioritization should also include increasing efforts between state and local agencies to coordinate local land-use planning and zoning decisions that promote the siting and permitting of renewable energy-related infrastructure.

2. Evaluate the cost of renewable energy projects beyond technology costs – including costs associated with integration, permitting, and interconnection – and their impact on retail electricity rates. This evaluation shall be coupled with a value assessment that could potentially lead to monetizing the various system and nonenergy benefits attributable to renewable resources and technologies, particularly those benefits that enhance grid stability and reduce environmental and public health costs.

3. Develop a strategy that minimizes interconnection costs and time, and also minimizes integration costs and requirements at the distribution level (such as use of remote telemetry and other smart grid technologies) and the transmission level (such as improved forecasting, the development of an energy imbalance market, and procurement of dispatchable renewable generation), and that strives for cost reductions and improvements

to integration technologies, including storage, demand response, and the best use of the state's existing natural gas-fired power plant fleet.

4. Promote incentives for renewable technologies and development projects that create in-state jobs and support in-state industries, including manufacturing and construction. In implementing this strategy, the state should evaluate how current renewable energy policies and programs are affecting in-state job growth and economic activity and identify which renewable technologies rely on supply chains that provide the best opportunities for California businesses.

5. Promote and coordinate existing state and federal financing and incentive programs for critical stages including research, development, and demonstration; precommercialization; and deployment. In particular, the state should maximize the use of federal cash grants and loan guarantee programs by prioritizing the permitting and interconnection of California-based renewable energy projects (and their associated transmission or distribution infrastructure) vying for federal stimulus funds.

Conclusion

Achieving California's aggressive renewable energy goals will require a concerted effort by state agencies, utilities, environmental groups, and other stakeholders to develop a renewable strategic plan that includes a clear vision, quantifiable and measurable goals, a set of strategies for achieving those goals, and milestones against which to measure progress. The *Renewable Power in California: Status and Issues* report is the first step in developing that plan. Detailed implementation strategies and action items will be developed in the upcoming *2012 Integrated Energy Policy Report Update* proceeding to provide further guidance on specific activities in which various state and local entities can engage to successfully carry out these high-level strategies and reduce barriers to renewable generation in the near, medium, and long term.

CHAPTER 1: Introduction

California's Renewable Legacy

Governments, businesses, and environmental groups worldwide now increasingly promote the use of renewable energy to address myriad goals including resource diversification and security, reliability and safety, economic growth and competitiveness, and climate change mitigation. In California, renewable energy and energy efficiency are the cornerstones of the state's energy policy.

The concept of renewable energy – energy from resources that replenish naturally like sunlight, wind, rain, tides, and the earth's heat – is hardly new. Before the discovery of fossil fuels in the mid-18th century, renewable resources were the only available sources of energy; since the late 19th century, renewable resource applications have become part of Californians' lives. For example, in 1887, the High Grove Hydroelectric Station in San Bernardino – the first hydroelectric power plant in the West – began operating and providing electricity to customers in California.[5] In addition, one-third of households in Pasadena relied on solar thermal water heating, and more than 1,600 solar water heating systems were installed throughout Southern California by 1900.[6] Also developed in the early 1900s were the first cogeneration systems such as the Pacific Lumber biomass combined heat and power plant in Scotia built in the 1920s, when industrial facilities generally produced their own electric power and used available thermal energy to provide or supplement process or building heat.[7] In the 1920s, the nation's first geothermal power plant, capable of generating 250 kilowatts, started operating at The Geysers geothermal resource area north of San Francisco, and in 1960, Pacific Gas and Electric Company subsequently developed the country's first large-scale geothermal plant at The Geysers.[8]

The transportation sector has also used renewable energy for more than a century. In 1900, electric cars were in their heyday, with about 28 percent of all cars produced in the United States powered by electricity.[9] In 1908, Henry Ford's first Model T left the factory with a flexible hybrid engine capable of using either ethanol – a renewable fuel – gasoline, or kerosene.[10]

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5 U.S. Department of the Interior, Bureau of Reclamation, History of Hydropower Development in the United States, http://www.usbr.gov/power/edu/history.html.

6 "The Suns Up Now On Solar Thermal Hot Water; Building on a Rich History," May 2011, http://www.bluepacificsolar.com/blog/?p=2548.

7 http://www.industcards.com/biomass-usa-ca.htm.

8 U.S. Department of Energy, A History of Geothermal Energy in the United States, http://www1.eere.energy.gov/geothermal/history.html.

9 PBS.org, "Timeline: History of the Electric Car," http://www.pbs.org/now/shows/223/electric-car-timeline.html.

10 "Ethanol History: From Alcohol to Car Fuel," http://www.ethanolhistory.com/.

Liquefied petroleum gas (propane) has also been used as an alternative transportation fuel since the 1930s.[11]

Renewable electricity development was relatively stagnant until the 1970s. Under the leadership of Governor Brown in his first administration, the Energy Commission began operation in 1975 with the purpose of assessing energy use and development in California, including the roles of energy conservation, energy efficiency, and alternatives to traditional oil, nuclear, and coal power plants. In 1976, the California Public Utilities Commission (CPUC) recommended changes to the Legislature for utility rate design and resource development to promote conservation, efficiency, and equity.

At the federal level, in 1978 Congress enacted the Public Utility Regulatory Policies Act (PURPA) to diversify and strengthen domestic electricity production and, in 1979, the CPUC issued orders requiring that CPUC-regulated utilities buy electricity from alternative suppliers (cogenerators and small power producers) using a standard contract with the price set at cost-based rates equal to the buyer's full avoided cost. [12] In 1980, the Federal Energy Regulatory Commission (FERC) adopted regulations to implement PURPA and followed California's lead by adopting the requirement for standard contracts priced at full avoided cost for utility purchases of electricity from qualifying facilities (QFs). California's QF program quickly resulted in a significant response. In less than five years, more than 15,000 megawatts (MW) of QF contracts were signed, representing about a third of the utilities' resource base.

The CPUC's adopted standard contracts for QFs during Governor Brown's first administration resulted in a resurgence of cogeneration fueled by natural gas and biomass. The QF contracts also encouraged geothermal development at The Geysers and commercialization of geothermal power in the Imperial Valley and Coso geothermal resource areas, and facilitated the largest wind development at the time at the Altamont Pass in the San Francisco Bay Area. The contracts also encouraged development and commercialization of the world's then-largest solar thermal electricity facility in California's Mojave Desert. By the end of 1991, standard offer contracts had resulted in more than 11,000 MW of QFs on-line in California, about half of which used renewable resources.[13] Today, operating QF capacity in California is about 7,300 MW, half of which is provided by renewable facilities, and about 95 percent of which was on-line before 1993.[14]

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11 California Energy Commission, *ABCs of AFVs: A Guide to Alternative Fuel Vehicles*, November 1999, http://www.sceneoftheaccident.org/erg/Alternative%20Fuel%20Vehicles%20Guidebook.pdf.

12 See also California Public Utilities Commission, Order Instituting Rulemaking No. 2, Decision 82-01-103, January 21, 1982.

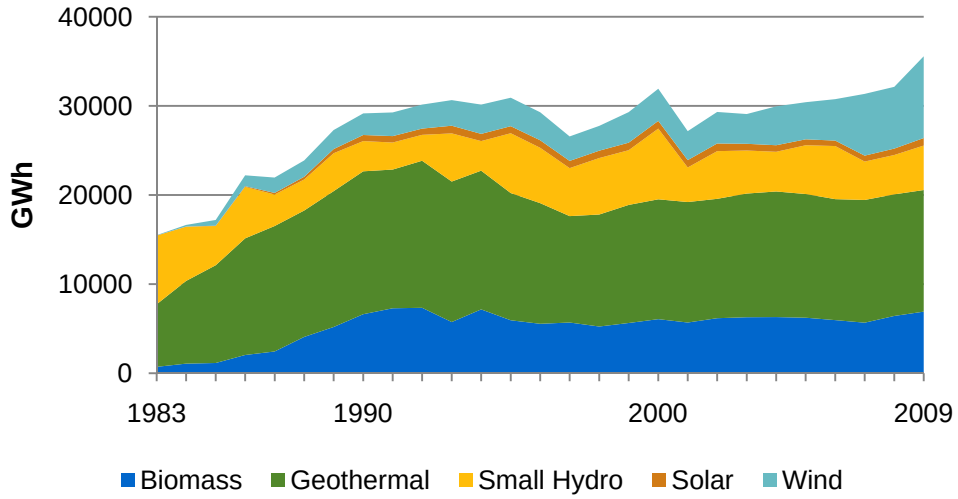
13 California Public Utilities Commission, Division of Ratepayer Advocates, *Analysis of the Impact of the End of the Fixed Energy Price Period Under Interim Standard Offer 4 Contracts*, October 1992.

14 Southern California Edison Company, *Qualifying Facilities Semi-Annual Status Report to the California Public Utilities Commission,* January 31, 2011; Pacific Gas and Electric Company, Cogeneration and Small Power Production Semi-Annual Report to the California Public Utilities Commission, January 2011.

PURPA required utilities to purchase power from renewable generators at the utilities' full avoided cost. In California, standard offer contracts provided escalating fixed energy payments over 10 years. Based on high oil price projections made in the early 1980s and expensive nuclear power, prices for these standard offer contracts often exceeded 10 cents per kilowatt-hour (kWh). As standard offer contracts expired and short run avoided costs declined to 3 cents per kWh due to falling oil and natural gas prices in the late 1980s and early 1990s, renewable electricity projects could not compete with new natural gas turbines, which led to shutting down 300 MW of renewable energy between 1993 and 1997.[15]

Figure 1 shows the drop in renewable generation during this period. Today, California is at a similar crossroads with the availability of cheap and plentiful natural gas.

Figure 1: California Renewable Energy Generation by Fuel Type, 1983-2010



Source: California Energy Commission

The oil embargoes of the 1970s also encouraged new interest in solar water heating, with federal and state tax credits offered to homeowners who wanted to conserve energy. Although the industry declined when tax credits expired in the mid-1980s, renewal of the federal tax credit in 2006 led to a resurgence of interest in these systems. More than 340 residential and commercial solar water heating systems were installed in the San Diego region due to the 2007-2009 California Solar Water Heating Pilot Program.[16] Based on the success of this program, in January 2010 the CPUC established a statewide solar water heating rebate program under the

15 California Energy Commission, *Renewable Resources Development Report*, November 2003, http://www.energy.ca.gov/reports/2003-11-24_500-03-080F.PDF.

16 Itron, *California Center for Sustainable Energy Solar Water Heating Pilot Program Final Evaluation Report*, March 30, 2011, http://www.cpuc.ca.gov/NR/rdonlyres/C1C7FD10-05AA-493B-8CD0-F2C24DCA955A/0/CCSE_SWHPP_Rpt.pdf.

California Solar Initiative with the goal of installing 200,000 systems in the state by 2017.[17] Solar heating technologies can also produce steam for industrial processes like enhanced oil recovery, in which steam is injected into reservoirs to increase the amount of oil that can be extracted. Replacing natural gas-fired boilers with solar technologies to produce steam for this and other industrial applications like food processing will reduce greenhouse gas (GHG) emissions and provide energy savings benefits to industry and the state.[18]

The 1970s oil crisis also led to increased focus on developing alternative transportation fuels to reduce dependence on foreign oil. In response to oil shortages, California assumed a national leadership role in encouraging fuel diversity and reduced tailpipe emissions through cleaner alternative fuels and vehicles and more stringent vehicle emission standards. In 1979, the California Legislature instructed the Energy Commission to "investigate the practicality and cost-effectiveness of alternative motor fuel."[19] Early programs at the Energy Commission included demonstration of vehicles using ethanol and methanol, infrastructure development for methanol/gasoline blends, and support for flexible fuel, natural gas, and electric vehicles. Since that modest beginning, California remains at the forefront of alternative fuel and vehicle development, working with automobile manufacturers, fuel providers, utility companies, universities, and research and development (R&D) organizations to advance alternative fuel vehicles.

In 2007, California established the Low Carbon Fuel Standard to reduce the carbon intensity of California's transportation fuels by at least 10 percent by 2020.[20] Also in 2007, the *State Alternative Fuels Plan,* jointly developed and adopted by the Energy Commission and the California Air Resources Board (ARB), presented strategies to increase alternative and nonpetroleum fuel use for transportation and set goals to reduce petroleum dependence 15 percent by 2020 and increase alternative fuel use to 26 percent of all fuel consumption by 2022.[21] Currently, the Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program invests in diverse projects including renewable fuel production, installing a robust network of fueling and charging stations for alternative fuel vehicles, and workforce training

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17 California Public Utilities Commission, CSI-Thermal Program, http://www.cpuc.ca.gov/puc/energy/solar/swh.htm.

18 For example, UC Merced developed an innovative and cost-effective high-temperature solar collector that can be used in production of heat for industrial processes (using funding from the Energy Commission's Public Interest Energy Research Program). See *Developing Renewable Generation on State Property*, April 2011, Appendix B, http://www.energy.ca.gov/2011publications/CEC-150-2011-001/CEC-150-2011-001.pdf, and UC Merced at https://ucmeri.ucmerced.edu/research-focus-areas/thermal-science/research.

19 California Energy Commission, "Fifteen Years of Fuel Methanol Distribution," staff paper, 1996, http://www.energy.ca.gov/papers/CEC-999-1996-017.PDF.

20 Executive Order S-01-07, http://www.arb.ca.gov/fuels/lcfs/eos0107.pdf.

21 California Energy Commission and California Air Resources Board, *State Alternative Fuels Plan*, October 2007, http://www.energy.ca.gov/2007publications/CEC-600-2007-011/CEC-600-2007-011-CTF.PDF.

that supports this burgeoning industry.[22] Renewable fuels comprise roughly 8.3 percent of California's transportation fuel supply.[23]

California's Renewable Resources

With its abundant natural resources and many different renewable electricity generation resources and technologies, California uses five primary renewable resource types represented by existing facilities:

- Biomass – fuel derived from organic sources (not fossil fuels), including solid biomass, digester gas, landfill gas, and biodiesel
- Geothermal
- Small hydroelectric – generally limited to facilities with a capacity no greater than 30 MW
- Solar – including solar thermal and solar photovoltaic technologies
- Wind

Other renewable resource types considered eligible under California's Renewables Portfolio Standard (RPS) include incremental hydroelectric generation from efficiency improvements, municipal solid waste with some restrictions, and ocean wave, thermal, and tidal current. But few of these facilities operate in California, and such facilities located outside California provide only a fraction of a percent of the renewable generation available to the state. However, it will be important to monitor technology improvements and new and emerging technologies so plan updates reflect these developments.

Background on California's Renewable Electricity Goals

California's electricity market was restructured in the late 1990s with the intent of promoting competition. However, the subsequent electricity crisis in 2000 and 2001 raised uncertainties about the reasonableness of that restructuring. In addition, uncertainty existed about what conditions were necessary to promote construction of new power plants, particularly in the absence of QF standard offer contracts for new facilities. Concerns also existed relative to global climate change and increasing oil prices. The California Legislature responded with several new laws to stabilize the market and provide the foundation for new development. In 2002, Senate Bill 1078 (Sher, Chapter 516, Statutes of 2002), created California's RPS to build on California's existing resource diversity, further diversify the state's electricity system, and reduce its growing dependence on natural gas by increasing the percentage of renewable electricity in the state's power mix to 20 percent by 2017.[24] Subsequently, Senate Bill 107 (Simitian, Chapter 464, Statutes of 2006) accelerated the RPS target by requiring retail sellers of electricity to increase

22 California Energy Commission, http://www.energy.ca.gov/drive/index.html.

23 Based on Energy Commission staff estimates of 2010 fuel demand and renewable fuel used. Includes E10, biodiesel, and E85.

24 Official California Legislative Information, http://www.leginfo.ca.gov/pub/01-02/bill/sen/sb_1051-1100/sb_1078_bill_20020912_chaptered.pdf.

renewable energy purchases by at least 1 percent per year with a target of 20 percent renewables by 2010.[25]

In 2011, Senate Bill X1-2 (Simitian, Chapter 1, Statutes of 2011) revised the RPS to require that renewable electricity should equal at least 20 percent of the total electricity sold to retail customers in California per year by December 31, 2013, 25 percent per year by December 31, 2016, and 33 percent by December 31, 2020.[26] This bill also extends these requirements to publicly owned utilities to make the RPS a statewide program.[27] When signing this legislation, Governor Brown indicated that the 33 percent target should be considered a floor rather than a ceiling, stating that "with the amount of renewable resources coming on-line, and prices dropping, I think 40 percent, at reasonable cost, is well within our grasp in the near future."[28]

In addition to reduced dependence on natural gas, renewable development is critical to achieving California's goals to reduce GHG emissions to 25 percent below 1990 levels by 2020 and 80 percent by 2050.[29] The ARB's *Climate Change Scoping Plan* report identifies the 33 percent RPS target as a foundational policy for meeting the 2020 GHG emission reduction goal.[30] Preliminary estimates of renewable electricity needed to achieve the 2050 GHG emission reduction goal suggest that California's renewable electricity percentage may need to increase to more than 70 percent, depending on the pace and policies affecting electrification of the transportation sector, retiring coal generation, and whether existing nuclear plants are relicensed. For more information on 2050 carbon reduction goals, see Chapter 2.

California also has goals for increasing solar photovoltaic (PV) capacity in the state. The Go Solar California campaign – which includes the CPUC's California Solar Initiative, the Energy Commission's New Solar Homes Partnership, and a variety of programs offered through publicly owned utilities – has a statewide goal of adding 3,000 MW of new solar generation capacity by 2017.

Investing in renewable energy is also central to rebuilding California's economy. As noted in Governor Brown's Clean Energy Jobs Plan, these types of investments will create jobs, build 21st

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25 Ibid, http://www.leginfo.ca.gov/pub/05-06/bill/sen/sb_0101-0150/sb_107_bill_20060926_chaptered.pdf.

26 Senate Bill X1-2 Simitian, Chapter 1, Statutes of 2011. Available at http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0001-0050/sbx1_2_bill_20110412_chaptered.pdf.

27 Before 2011, the Renewables Portfolio Standard law instructed the governing boards of publicly owned utilities to implement and enforce a renewable portfolio standard that recognized the intent of the Legislature to encourage renewable resources, but did not set any specific targets or years.

28 Office of Governor Jerry Brown, http://gov.ca.gov/news.php?id=16974.

29 Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006), Official California Legislative Information, http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf, and former Governor Schwarzenegger's Executive Order S-3-05, http://www.dot.ca.gov/hq/energy/ExecOrderS-3-05.htm.

30 California Air Resources Board, *Climate Change Scoping Plan*, December 2008, http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf.

century businesses, increase energy independence, and protect public health.[31] The Governor's plan calls for installing 20,000 MW of new renewable capacity by 2020, with 8,000 MW of large-scale wind, solar, and geothermal and 12,000 MW of localized generation, which includes small, on-site residential and business installations and intermediate-sized systems close to existing consumer loads and transmission and distribution lines. The Governor's plan also envisions accelerated development of energy storage capacity to support integration of renewable resources into the California grid.

The link between renewable and economic development underscores the need for a statewide plan to identify and address barriers to achieving California's renewable goals. California has seen a surge in the development of renewable generating facilities over the past few years, driven by state clean energy policies and incentives, federal stimulus funding, and the global transition to a clean energy economy. California receives more than 50 percent of the growing clean tech venture capital investment dollars.[32]

Investment in renewable development creates new jobs. According to a 2011 report by Next 10, from 1995 to 2009 the energy generation sector created the most jobs in California's green economy, adding nearly 20,000 jobs, 3,000 of which were added from January 2008 to 2009.[33] Nationally, in 2008 the American Wind Energy Association reported that the wind industry employed 85,000 workers, exceeding the 81,000 workers employed by the U.S. coal mining industry.[34] In addition, a 2011 Brookings Institution report concludes that, nationally, the clean economy employs more people than the fossil fuels and biotech industries, with four of the five fastest growing clean tech segments between 2003 and 2010 in renewable energy, which added about 50,000 jobs in the solar thermal, solar PV, wind power, biofuels, fuel cell production, and smart grid industries.[35]

Report Process and Structure

The IEPR Committee has worked closely with stakeholders to develop this draft *Renewable Power in California: Status and Issues* report, with eight public workshops held to date on the following topics:[36]

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31 http://www.jerrybrown.org/Clean_Energy.

32 http://www.ey.com/US/en/Newsroom/News-releases/US-VC-investment-in-cleantech.

33 Next 10, *Many Shades of Green: Diversity and Distribution of California's Green Jobs*, January 2011, http://www.next10.org/next10/publications/green_jobs/2011.html.

34 http://www.windustry.org/news/wind-energy-jobs-grew-70-in-2008.

35 Muro, Mark, Jonathan Rothwell, Devashree Saha, The Brookings Institution Metropolitan Policy Program, *Sizing the Clean Economy: A National and Regional Green Jobs Assessment*, July 2011, http://www.brookings.edu/~/media/Files/Programs/Metro/clean_economy/0713_clean_economy.pdf.

36 For information on specific the Energy Commission workshops, http://www.energy.ca.gov/2011_energypolicy/documents/index.html#12172010.

- Distributed generation (DG) issues, including development of renewable generation on state properties, lessons learned from the European experience on integrating large amounts of DG, R&D projects and strategies to address barriers to DG deployment, and setting interim targets toward the 12,000 MW DG goal.
- Methods for determining the amount of renewable electricity needed to meet the state's renewable targets and for estimating the costs of various renewable technologies.
- Transmission and distribution system additions and upgrades needed to bring renewable electricity from generators to customers.
- R&D on technologies that enable integration of large amounts of renewable electricity into the state's electricity grid, including smart grid and energy storage technologies.[37]
- Strategies to develop the extensive and well-trained workforce needed to support expansion of the state's clean energy economy.

In addition, the Governor's Office held a two-day conference in July 2011 in Southern California to explore challenges to achieving the 12,000 MW DG goal, including the need for financing tools, improvements in existing infrastructure, policies to measure and manage power demand and variable power sources, and efforts in local land use and building and fire codes to accelerate deployment.[38]

The *Renewable Power in California: Status and Issues* report incorporates valuable information gleaned from these events and from stakeholder comments. The report is organized as follows:

- **Chapter 2** describes California's renewable energy goals and targets, the contribution toward those targets by existing renewable electricity generating facilities, the technical potential for additional renewable development, estimates of the amount of renewable electricity that will be needed to meet RPS targets, and progress to date toward those targets.
- **Chapter 3** discusses environmental, planning, and permitting challenges facing renewable developers, including potential environmental consequences associated with renewable generating facilities such as impacts on habitat for sensitive species; bird and bat collisions with wind turbine blades; impacts on quantity and/or quality of local water supplies; loss of agricultural or recreational land; aviation and other transportation-related hazards; effects on areas of historic significance and on Native American tribes; and air quality impacts. This chapter also discusses issues with overlapping and cross-jurisdictional planning and permitting processes that can delay projects and increase developers' costs.

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37 "Smart grid" refers to a distribution system that allows for flow of information from a customer's meter in two directions: both inside the house to thermostats, appliances, and other devices, and from the house back to the utility. Smart grid can include a variety of operational and energy measures, like smart meters, smart appliances, renewable energy resources, energy efficiency resources, demand response measures, and energy storage.

38 Office of Governor Jerry Brown, http://gov.ca.gov/s_energyconference.php.

- **Chapter 4** focuses on issues with planning and building the electricity transmission and distribution infrastructure needed to bring renewable electricity from power plants to consumers.
- **Chapters 5 and 6** cover issues with integrating high levels of renewable electricity generation, particularly variable resources like wind and solar, into the state's electric grid at both the transmission and distribution levels while maintaining reliability and grid stability.
- **Chapter 7** discusses issues associated with securing financing for renewable development, particularly in earlier stages of development. Ultimately, anything that affects project viability – such as costs associated with renewable technology development, permitting, environmental mitigation, regulatory uncertainty, and the need for new or upgraded transmission or distribution infrastructure – adds risk to a project and can affect a developer's ability to secure financing.
- **Chapter 8** compares levelized cost estimates for renewable technologies, discusses declining cost trends in the renewable industry, particularly for solar PV, and describes the effects of tax benefits on renewable cost calculations, and other costs such as permitting and interconnection.
- **Chapter 9** describes the important role of R&D in addressing the issues identified in Chapters 3 through 8 and provides an overview of R&D efforts in these areas funded by the Energy Commission's Public Interest Energy Research Program.
- **Chapter 10** covers four cross-cutting issues associated with renewable development: 1) applying environmental justice – "the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies;"[39] 2) coordinating with local governments to implement statewide renewable energy policy goals; 3) developing California's workforce to ensure an adequate and well-trained workforce to support renewable goals; and 4) promoting public leadership to develop renewable electricity generating technologies on state-owned buildings, properties, and rights-of-way.

The issues discussed in each chapter overlap in many ways; for example, permitting delays and the need for environmental mitigation for both generating and transmission infrastructure can affect project costs and developers' ability to secure financing. Integrating renewable resources into the transmission and distribution system can increase project costs and will require innovative technologies, changes in system operation, and investment in R&D to overcome technical challenges and reduce integration costs. Addressing financing barriers will be of little use unless other barriers to project development are overcome. Environmental justice issues must be considered in permitting and building generation and transmission infrastructure. A well-trained workforce will be needed to help permit, build, install, and operate new renewable facilities and the technologies to integrate them seamlessly into the grid. Finally, coordination

39 Government Code Section 65040.12.

with local governments will be essential to permitting and building renewable infrastructure and to understand the unique challenges local jurisdictions face as they promote renewable development in their communities.

CHAPTER 2:
Achieving California's Renewable Electricity Goals

California has aggressive goals for increasing renewable electricity generation, with targets of 33 percent of the state's electricity retail sales met using renewable resources, 8,000 megawatts (MW) of utility-scale renewables, and 12,000 MW of renewable distributed generation (DG) by 2020. A wide variety of renewable resources will contribute toward these goals, with statewide technical potential (the amount of generating capacity theoretically possible given resource availability, geographical restrictions, and technical limitations like energy conversion efficiencies) at more than 18 million MW.

Translating this vast technical potential into operating projects is a major challenge. Project developers must secure financing, environmental and land-use permits, transmission, interconnection, and contracts to sell their facilities' output. Each element affects the market potential for renewable development and the amount of renewable capacity that will be available to meet statewide renewable goals.

While this report does not estimate economic or market potential, the amount of new renewable generating capacity proposed or being developed in California indicates the market potential for new renewable development. For example, the California Independent System Operator's (California ISO) Interconnection Queue[40] contains about 57,000 MW of renewable capacity and the utilities' Wholesale Distribution Access Tariff (WDAT) queue contains nearly 5,200 MW. And nearly 26,000 MW of proposed renewable capacity is tracked in the permitting process, [41] with 9,435 MW of renewable capacity permitted by state and local entities in 2010. Utilities have also signed contracts for about 10,000 MW of new renewable capacity.[42,43] However, challenges associated with financing, siting, permitting, interconnection, and the risk of contract failure, (discussed throughout this report) will affect the number of projects ultimately developed and result in less renewable capacity than is proposed.

About This Chapter

This chapter describes the status of achieving California's renewable electricity goals. Topics include:

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40 See Chapter 4, Figure 9: California ISO Queue Projects as of June 1, 2011.

41 California Energy Commission website, http://www.energy.ca.gov/33by2020/documents/renewable_projects/Tracking_Report_for_Renewable_Projects.pdf.

42 California Public Utilities Commission, Investor Owned Utilities Contract Database, http://www.cpuc.ca.gov/PUC/energy/Renewables/index.htm, updated November 2011. Includes only contracts approved by the CPUC.

43 California Energy Commission Publicly Owned Utilities Database, September 2010, http://www.energy.ca.gov/2008publications/CEC-300-2008-005/index.html.

- Renewable goals and targets. The Renewables Portfolio Standard (RPS) currently requires renewable electricity to equal an average of 20 percent of the total electricity sold to retail customers in California during the compliance period ending December 31, 2013, 25 percent by the end of 2016, and 33 percent by the end of 2020.[44]

  Energy Commission staff is working with the Governor's Office to develop regional and interim targets for the 12,000 MW distributed-generation (DG) goal and is examining regional targets for the 8,000 MW utility-scale goal. The Energy Commission is also participating in a collaborative, multiagency effort to identify a target of 2,500 MW of new renewables on state properties that could be economically developed by 2020.[45]

- The amount of renewable capacity and generation from existing renewable facilities in 2010, including biomass, geothermal, small hydroelectric, solar, and wind, and technical potential for new renewable development.
- Progress toward meeting the state's renewable targets and goals. California appears to be on track to achieve the 20 percent by 2013 RPS target, with nearly 16 percent of statewide retail sales from renewable generation in 2010.[46] In addition, the California Public Utilities Commission's (CPUC) Division of Ratepayer Advocates has stated that investor-owned utilities (IOUs) are well on their way to meet the 33 percent renewable target at current rates of contract execution and approval.[47] As of May 2011, enough renewable generation was on-line, contracted, or pending contract approval to achieve the estimated range of generation needed to reach the 33 percent RPS target by 2020.[48]
- Potentially higher renewable targets for 2050 to contribute toward meeting the state's greenhouse gas (GHG) emission reduction goals. Rough estimates indicate that if new

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44 For the compliance period of January 1, 2011, to December 31, 2013, investor-owned utilities and publicly owned utilities are required to procure generation from eligible renewable resources equal to an average of 20 percent of retail sales. For subsequent compliance periods, utilities must reflect "reasonable progress in each of the intervening years" to ensure procurement achieves 25 percent of retail sales by December 31, 2016, and 33 percent of retail sales by December 31, 2020. http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0001-0050/sbx1_2_bill_20110412_chaptered.html.

45 California Energy Commission, *Developing Renewable Generation on State Property*, staff report, April 2011, http://www.energy.ca.gov/2011publications/CEC-150-2011-001/CEC-150-2011-001.pdf.

46 Depending on the source of data, total renewable generation figures vary between 15 and 16.5 percent of statewide retail sales from renewable generation in 2010. Renewable procurement and generation sources include: The Power Source Disclosure Program, CPUC RPS Compliance Filings, Energy Commission RPS Tracking, and the Energy Commission's total system power.

47 CPUC, August 2010, RPS Compliance Reports and Project Development Status Reports, as cited in CPUC, Division of Ratepayer Advocates, February 2011, *Green Rush: Investor-Owned Utilities' Compliance with the Renewables Portfolio Standard*, http://www.dra.ca.gov/NR/rdonlyres/0CB0B986-E93B-462A-BA62-804EDAE43B82/0/RPSReportPublic_FINAL_2011_Feb_14_v2.pdf, page 7.

48 This assumes that all existing renewable generators remain on-line through 2020, low rates of contract failure, and that existing short-term contracts are renewed.

generation needed to serve expected electricity demand in 2050 is served only by new renewables, this supply would represent 67 to 79 percent of total electricity sales in 2050.[49]

California's Renewable Electricity Goals and Targets

Renewables Portfolio Standard Goals

Senate Bill X1-2 (Simitian, Chapter 1, Statutes of 2011) requires investor-owned and publicly owned utilities to procure generation from eligible renewable resources equal to an average of 20 percent of retail sales for the compliance period of January 1, 2011, to December 31, 2013. For subsequent compliance periods, utilities must reflect "reasonable progress in each of the intervening years" to ensure procurement achieves 25 percent of retail sales by December 31, 2016, and 33 percent of retail sales by December 31, 2020.[50] SB X1-2 also allows utilities to meet a portion of the RPS with tradable renewable energy certificates (TRECs),[51] but limits using TRECs for RPS compliance to not more than 25 percent for the compliance period ending December 31, 2013, 15 percent for the compliance period ending December 31, 2016, and 10 percent thereafter.[52]

The *renewable net short* is the estimated amount of renewable electricity needed in addition to generation from existing renewable facilities to meet the 33 percent RPS mandate in 2020. Energy Commission staff estimates for total renewable generation (existing plus the renewable net short) needed to meet the mandate range from 78.8 terawatt hours (TWh) to 90.5 TWh, equivalent to the generation from about 5,300 MW solar-thermal power plants.[53] Renewable net short estimates range from 35.3 TWh to 47.0 TWh. However, given the risk of contract failure in RPS contracts (discussed later in this chapter), it may be prudent for utilities to contract for some percentage greater than the estimated renewable net short. For example, if the historical RPS contract failure rate continues at 30-40 percent, utilities may need to sign contracts for generation in the range of 55 TWh to 85 TWh.

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49 Preliminary electricity supply and demand calculations: http://www.drecp.org/meetings/2011-05-17_meeting/documents/2050%20RPS%20and%20acreage%20calculator%20background.pdf.

50 http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0001-0050/sbx1_2_bill_20110412_chaptered.html.

51 A Renewable Energy Certificate or REC is a certificate of proof that 1 MWh of renewable energy has been generated. RECs used for RPS compliance must be tracked through the Western Renewable Energy Generation Information System and meet requirements of the California RPS program. http://www.cpuc.ca.gov/PUC/energy/Renewables/decisions.htm, http://www.energy.ca.gov/renewables/documents/index.html#rps , and http://www.wregis.org/.

52 See Senate Bill X1-2 for additional information about criteria related to the use of TRECs for RPS compliance.

53 One terawatt hour is equal to 1,000,000 megawatt hours.

The equation for estimating the renewable net short is:

> *Renewable Net Short (TWh) = ([Projected Retail Electricity Sales – Energy Efficiency Programs – Combined Heat & Power Customer Services – Self-Generation Additions – Other Demand Reduction Programs] x Policy Goal Percent) – Generation From Existing Eligible Renewable Facilities Likely to Be Generating in 2020*

An Energy Commission staff paper on renewable net short estimates was the subject of a March 8, 2011, workshop on the variables, methods, and data sources to consider when estimating the amount of new renewable generation needed to meet statewide policy goals.[54] The final staff paper responded to stakeholder comments and recommended a set of assumptions for the renewable net short calculation.[55]

Table 1 presents the input ranges and the sequence of calculations to estimate the renewable net short.

Table 1: Range of Renewable Net Short Estimates for 2020

	All Values in TWh for the Year 2020	Formula	Low Renewable Net Short	Mid-Case Renewable Net Short	High Renewable Net Short
1	Statewide (Retail Sales-Updated 5/2011)		292.6	297.9	305.3
2	NonRPS Deliveries (CDWR, WAPA, MWD)		13.6	13.6	13.6
3	Small LSE Sales (<0.2 TWh)		0.0	0.0	0.0
4	Retail Sales for RPS	1-2-3	279.0	284.3	291.7
5	Additional Energy Efficiency		19.9	17.1	15.2
6	Additional Rooftop PV		4.1	3.2	2.3
7	Additional Combined Heat and Power		16.2	7.2	0.0
8	Adjusted Statewide Retail Sales for RPS	4-5-6-7	238.8	256.9	274.2
9	**Total Renewable Energy Needed For 33% RPS**	**8 x 33%**	**78.8**	**84.8**	**90.5**
	Existing and Expected Renewable Generation				
10	Total Instate Renewable Generation		34.3	34.3	34.3
11	Total Out-of-State Renewable Generation		9.2	9.2	9.2
12	**Total Existing Renewable Generation for CA RPS**	**10+11**	**43.5**	**43.5**	**43.5**
13	**Total Renewable Energy Net Short to meet 33% RPS In 2020**	**9-12**	**35.3**	**41.3**	**47.0**

Source: California Energy Commission

54 California Energy Commission staff, *Proposed Method to Calculate the Amount of New Renewable Generation Required to Comply With Policy Goals,* March 2011, http://www.energy.ca.gov/2011publications/CEC-200-2011-001/CEC-200-2011-001-SD.PDF.

55 Staff renewable net short papers and workshop material: http://www.energy.ca.gov/2011_energypolicy/documents/index.html#03082011.

The table includes an upper, mid, and lower range of renewable net short estimates. Values are considered a floor for the amount of renewable generation that may be added to the California electricity supply mix over the next decade.

The Energy Commission will post updated renewable net short estimates on August 1 of each year, matching the expected date when information on new generation is submitted under data collection regulations. The Energy Commission will also update the renewable net short estimate over time as electricity demand forecasts are adopted, when questions regarding the RPS eligibility of customer-side generation are resolved, and when the amount of TRECs used for RPS compliance becomes clear.

Anything that reduces electricity retail sales – from changes to the economy to energy efficiency program savings and rooftop solar photovoltaic additions – will reduce the renewable net short. Renewable net short estimates will also change over time as forecasts of electricity demand change. Recently, these changes are more evident due to the effects of the economic downturn and the possible timing of a rebound. Similarly, uncertainties about meeting state goals for energy efficiency, combined heat and power, and rooftop solar will affect the amount of renewable energy ultimately needed. For details on these and other uncertainties, see Appendix D.

Target for 8,000 Megawatts of Utility-Scale Renewable Generation

The Governor's Clean Energy Jobs Plan sets a target to develop 8,000 MW of utility-scale renewable generating capacity by 2020. Determining where this capacity could be located will be informed by current land use and generation and transmission planning activities for large scale projects statewide and specifically in California's desert regions. The Renewable Energy Transmission Initiative (RETI) – a 2007-2010 statewide public agency and stakeholder process – identified the transmission projects needed to accommodate California's renewable energy goals. (For more detail, see Chapters 3 and 4). This effort identified Competitive Renewable Energy Zones (CREZs) with about 80,000 MW of broad, statewide resource development potential, including approximately 66,000 MW in California's Mojave and Colorado Desert regions.[56]

RETI's conceptual renewable potential for the desert areas and for the state as a whole can be refined by examining the California ISO's Interconnection Queue for transmission system study of proposed renewable projects. The 57,000 MW include renewable projects proposed throughout the balancing areas for San Diego Gas & Electric Company (SDG&E), Southern California Edison (SCE), and Pacific Gas and Electric Company (PG&E), with about 40,000 MW

56 *Renewable Energy Transmission Initiative Phase 2B Report*, April 2010, http://www.energy.ca.gov/reti/documents/index.html.

proposed in the desert regions of Inyo, Kern, San Bernardino, Los Angeles, Riverside, and Imperial Counties.[57]

These potential renewable capacity numbers are further distilled in the CPUC 33% Proposed Base Case scenario,[58] which the CPUC's Long-Term Procurement Planning staff developed for the California ISO's use in its 2011-2012 Transmission Planning Process (TPP). This scenario includes roughly 11,000 MW for the IOU balancing areas based on power purchase contracts. For the desert regions, about 8,400 MW of combined renewable project capacity were projected for nine CREZs based on signed contracts. The base case scenario serves as a starting reference point for assessing how much and where large, utility-scale renewable capacity could be built in California.

Land use assumptions and natural resource data being developed in the state and federal Desert Renewable Energy Conservation Plan (DRECP) process are used to refine projections of renewable capacity. For example, in July 2011, the Energy Commission worked with the California ISO and CPUC staff to evaluate the solar projects expected in the desert, particularly the Kramer Junction area in the West Mojave region.[59] As a result of this work, the CPUC's 33 percent base case scenario was increased for this area to reflect new land-use planning and resource information emerging from the DRECP.

In 2010, more than 9,000 MW of renewable projects were permitted in California, of which about 8,000 MW are associated with identified new California ISO transmission lines and upgrades. If these new lines and upgrades are permitted, built, and on-line before 2020, more than 16,000 MW of additional generation could flow to load centers at any point in time. With only half of the capacity to fill the lines permitted last year, another 8,000 MW of capacity could be sited in the CREZs associated with these lines in the future.

Table 2 shows the groups of new line additions that enable new generation from specific regions. It also identifies the CREZs associated with the lines and the total renewable capacity that could come from each region, capacity associated with projects permitted in 2010, and the remaining capacity that could come from that region. The far right column is a preliminary attempt to establish regional targets for the Governor's 8,000 MW goal.[60]

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57 California Independent System Operator Interconnection Queue Projects, locations and type as of June 1, 2011. Historically, not all of the proposed projects in the queue have reached the licensing, contract, and construction phases.

58 CPUC letter to Keith Casey of California ISO regarding 33% Proposed Base Case, June 2011.

59 Energy Commission July 15, 2011, letter to California ISO regarding Transmission 2011/2012 Planning Process. http://foliweb7.caiso.com/2b6d/2b6dd2991e570.html.

60 The analysis is limited to only California ISO identified lines and will need to be updated to include identified transmission lines for the Los Angeles Department of Water and Power and the Sacramento Municipal Utility District.

Target for 12,000 Megawatts of Renewable Distributed Generation

The Governor's Clean Energy Jobs Plan also sets a goal to develop 12,000 MW of localized electricity generation, or DG, by 2020. Achieving that goal is a major undertaking but setting regional targets will help provide a starting point for meeting the goal and measuring progress over time. Because DG development is linked to local jurisdictional and infrastructure issues, regional targets can help capitalize on opportunities to advance public benefits – such as those from job creation in low-income communities – and focus on addressing barriers to development. Local conditions that affect development include variations in local permitting requirements and the age of the distribution grid, which is new in some areas and 100 years old in others. Also, targeting development in low-income communities or other areas for job creation can affect the development of regional targets. Finally, resource potential for biofuels, geothermal, small hydro power, and wind are heterogeneous throughout the state, while solar insolation tends to be more homogeneous.

Table 2: Preliminary Regional Targets for 8,000 Megawatts of New Renewable Capacity by 2020

Identified Transmission Line (s)	CREZ Served	Total Additional Capacity with New/Upgraded Lines (MW)[A]	Project Capacity Permitted in 2010 Associated with the New/Upgrades (MW)[B]	Additional Project Capacity for 8,000 MW of New Large-Scale Renewables (MW)
Sunrise Powerlink	Imperial North and South, San Diego South	1,700	760	940
Tehachapi and Barren Ridge Renewable Transmission Projects	Tehachapi, Fairmont	5,500	2,810	2,690
Colorado River, West of Devers, and Path 42 Upgrade	Riverside East, Palm Springs, Imperial Valley	4,700	1,825	2,875
Eldorado-Ivanpah, Pisgah-Lugo, and Coolwater-Jasper-Lugo	Mountain Pass, Pisgah, Kramer	2,450[C]	1,470	980
Borden-Gregg	Westlands	800	145	655
South of Contra Costa	Solano	535	155	380
Carrizo-Midway	Carrizo South, Santa Barbara	900	800	100
TOTAL				8,620

[A] California Energy Commission data.
[B] Renewable Energy Action Team database. Only projects associated with the transmission projects specified were included.
[C] The total deliverability potential with these lines could be as high as 3,800 MW. However, the Eldorado-Ivanpah and the Pisgah-Lugo lines upgrade the same corridor, and the capacity associated with the new lines may not be additive. The 2,450 MW include the deliverability linked to the Pisgah-Lugo and the Coolwater-Jasper-Lugo lines.

Source: California Energy Commission

The Energy Commission staff's analysis of regional targets (for details, see Appendix E) defines localized generation as renewable DG projects 20 MW and smaller that are interconnected to the distribution or transmission grid. The scope includes behind-the-meter installations to serve on-site load as well as projects that produce excess energy for wholesale. Intended to be technology-neutral, the analysis includes solar, biomass, geothermal, wind, fuel cells using renewable fuel, and small hydropower, and uses data from the beginning of the California Solar Initiative in 2007 and extends to 2020. The analysis does not include an estimate of costs.

Table 3 shows estimates of regional targets for development of behind the meter, wholesale, and an undefined mix of behind-the-meter and wholesale projects.

Table 3: Proposed Regional DG Targets by 2020

Region	Behind the Meter (all technologies)	Wholesale	Undefined (mix of behind the meter and wholesale)	Total
Central Coast	280	90	0	370
Central Valley	830	1590	0	2,420
East Bay	420	30	0	450
Imperial	50	90	0	140
Inland Empire	480	430	0	910
Los Angeles (city and county)	970	860	2,170	4,000
North Bay	220	0	0	220
North Valley	120	50	0	170
Sacramento Region	410	170	220	800
San Diego	500	50	630	1,180
SF Peninsula	480	10	310	800
Sierras	30	40	0	70
Orange	420	10	40	470
Total	**5,210**	**3,420**	**3,370**	**12,000**

Source: California Energy Commission

These regional "soft targets" serve as a starting point for discussions on a local level and may be reevaluated annually by the Energy Commission. Staff presented this preliminary method at the Governor's Conference on Local Renewable Energy Resources and participants discussed it in breakout sessions.[61] Comments varied, with some parties questioning the need for regional targets, or for a 12,000 MW target. Many questioned what the targets include, for example, should existing renewables count, are non-PV technologies adequately included, and should other technologies such as storage or demand response count toward the targets. Others raised the concern that basing the analysis on market activity does not account for where local generation would be most beneficial, the political will to meet the targets, or cost issues. Some

61 http://gov.ca.gov/s_energyconference.php.

suggested that the percentage of statewide load should drive the method for calculating targets, while others suggested that targets should reflect capacity on the distribution system. Participants also stressed the importance of clearly articulating goals to regions so that local land-use planners are able to incorporate DG assumptions into the land use planning process. Kern County was offered as an example of a jurisdiction that successfully incorporates DG into land use planning assumptions.

Comments on the staff draft *Renewable Power in California: Status and Issues* report included a suggestion from the Clean Coalition that "distributed generation should be set by setting baseline numbers based on load..."[62] The Environmental Health Coalition points to testimony that it and the Communities for Better Environment made at the May 11 IEPR workshop. They state that investing in renewable DG in their communities can help address environmental justice issues to "… bring in prosperity and opportunity to local energy businesses and entrepreneurs."[63] PG&E's comments suggested that "net economic impact and job creation" are top priorities for targeting renewable energy development.[64] SCE suggested that the Energy Commission work with utilities to identify priority areas for distributed generation and utility-scale renewable development that are close to distribution infrastructure.[65]

The Energy Commission expects to revisit the DG targets and allocation in the next *IEPR* and have begun exploring approaches to better consider the comments received, particularly those from the Environmental Health Coalition and Clean Coalition.

Existing Renewable Power Plants Serving California

California's large fleet of existing renewable generating facilities will contribute toward meeting the state's renewable electricity generation goals and targets (Figure 2). These facilities provided 14.6 percent of total in-state electricity generation in 2010.[66] This fleet is the result of abundant renewable resources available in California, state and federal policies supporting renewable energy, and the commitment of the state's citizens to alternative energy sources. Three types of facilities provide electricity to California customers:

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62 http://www.energy.ca.gov/2011_energypolicy/documents/2011-09-14_workshop/comments/Clean_Coalitions_Comments_on_Draft_CEC_Staff_Report_TN-62527.pdf.

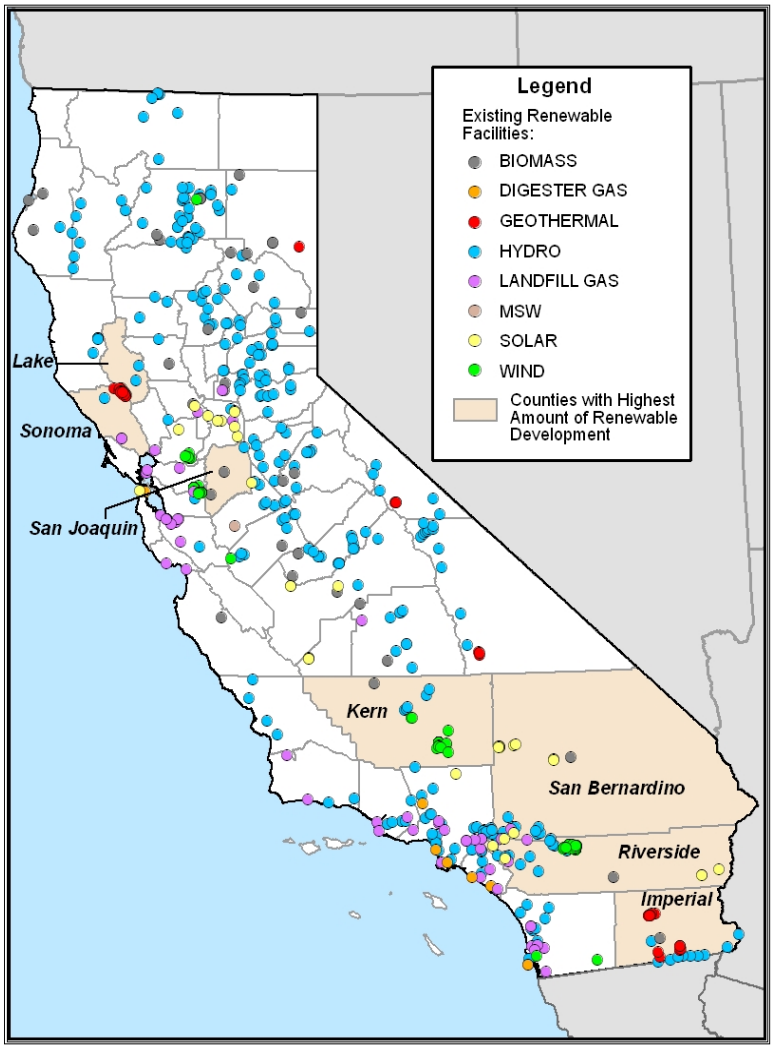
63 http://www.energy.ca.gov/2011_energypolicy/documents/2011-09-14_workshop/comments/EHC_and_CEJA_Comments_on_Renewable_Power-_Status_and_Issues_TN-62596.pdf.

64 http://www.energy.ca.gov/2011_energypolicy/documents/2011-09-14_workshop/comments/PGandE_Comments_on_the_CEC_Staff_Draft_Report_Renewable_TN-62521.pdf.

65 http://www.energy.ca.gov/2011_energypolicy/documents/2011-09-14_workshop/exec_summary_comments/Southern_California_Edison_Company_2011-11-08_TN-62821.pdf.

66 California Energy Commission, "2010 Total System Power in Gigawatt Hours," http://energyalmanac.ca.gov/electricity/total_system_power.html. This represents total renewable generation in California as a percentage of total generation for load. This value differs from other calculations showing progress toward achieving RPS targets because total system power does not take into account RPS eligibility of that generation and the percentage is based on total generation to meet load rather than total retail sales.

Figure 2: Existing Renewable Facilities in California



Source: California Energy Commission

- Utility-Scale: facilities with a nameplate capacity larger than 20 MW, typically interconnected at the transmission level, and designed to generate electricity for sale to a California utility.
- Wholesale DG: facilities with a nameplate capacity no larger than 20 MW, typically built near electrical load and may be interconnected to the transmission system or at the distribution level, and designed to generate electricity for sale to a California utility.
- Customer-Side DG: small facilities built in California to directly serve a customer load that would otherwise be served by a utility. Generation from these facilities may or may not be able to produce excess electricity exported to the distribution or transmission system, but all are connected to the grid.

Installed Capacity

During 2010, 88 utility-scale facilities provided 4,314 MW of renewable capacity, wholesale DG from 253 facilities provided 1,656 MW of capacity, and utility-scale and wholesale DG wind facilities combined represented 3,019 MW.[67] More than 95,000 customer side renewable DG systems provided roughly 813 MW of capacity (Table 4). The CPUC contracts data shows that renewable capacity has increased by 2,600 MW since the RPS program began in 2002 [68] and publicly owned utilities have added approximately 2,000 MW of renewable capacity.[69]

Table 4: Installed In-State Renewable Capacity Providing Electricity to California Customers

Renewable Resource	Utility-Scale Capacity (MW) [A]	Wholesale DG Capacity (MW) [B]	DG Generation Capacity (MW) [C]	Total
Biomass	1,070	458	25	1,553
Geothermal	2,521	127	0	2,648
Small Hydro	315	989	0	1,304
Solar	408	82	780	1,270
Wind[D]	No data	No data	8	3,027[A]
Total	**4,314**	**1,656**	**813**	**9,802**

A Capacity numbers represent the total capacity of facilities using renewable resources as the primary or only resource.

B Based on the Energy Commission's "California Power Plant Database." http://energyalmanac.ca.gov/electricity/index.html. A number of the facilities classified as Wholesale Distributed Generation may be grouped together and operated as one larger facility that would be more accurately classified as utility-scale facility.

C Solar data is taken from http://gosolarcalifornia.org/, biomass and wind data is from the Energy Commission's Emerging Renewables Program and the Self-Generation Incentive Program: https://energycenter.org/index.php/incentive-programs/self-generation-incentive-program/sgip-documents/sgip-documents, was also used.

D Includes 3019 MW of utility-scale and wholesale distributed generation wind capacity. Based on California ISO data on wind projects located in the California ISO and the California Energy Commission's "CEC-1304 QFER Database California Power Plant Database." http://energyalmanac.ca.gov/electricity/web_qfer/ for wind projects located outside the California ISO.

Source: California Energy Commission

Utility-scale and wholesale DG facilities are located in 53 of California's 58 counties (Figure 2). The top seven counties with installed renewable capacity include Sonoma, Kern, Imperial, San Joaquin, Riverside, Inyo, and San Bernardino counties. Counties with high amounts of geothermal capacity include Sonoma County with 1,601 MW of capacity (more than 60 percent of all geothermal capacity installed in California), Imperial County with 650 MW, and Inyo County with 302 MW. Kern, San Joaquin, and Riverside counties each have large amounts of wind capacity, about 800 MW, 600 MW, and 500 MW respectively.[70] San Bernardino County is

67 Accurate data regarding the number of wind facilities and the breakdown between utility-scale and wholesale DG was not available at the time of publication of this report.

68 California Public Utilities Commission, Investor Owned Utilities Contract Database, http://www.cpuc.ca.gov/PUC/energy/Renewables/index.htm, updated November 2011. Includes only contracts approved by the CPUC.

69 Based on data submitted to the California Energy Commission through the *Quarterly Fuel and Energy Report*.

70 Wind data from California Energy Commission Power Plant Database, available at http://energyalmanac.ca.gov/electricity/index.html.

home to 400 MW of solar capacity, which represents nearly 80 percent of all installed utility-scale and wholesale DG solar.[71]

Generation From Existing Renewable Facilities

In 2010, in-state and out-of-state renewable electric generating facilities provided 39,796 GWh of renewable electricity for California consumption, or about 16 percent of California's retail sales (Table 5).[72] In-state facilities provided around 75 percent of all the renewable generation claimed for the RPS by California load serving entities in 2010. Geothermal resources provided more than twice as much generation as any other in-state renewable resource.

Table 5: Total Renewable Generation to Serve California Load in 2010

Resource	California In-State Generation (GWh)	Percent of In-State Renewable Generation	Renewable Imports (GWh)	Total Renewable Generation for California (GWh)	Percent of Total Renewable Generation
Biomass	5,745	19.1%	1,149	6,894	17.3%
Geothermal	12,740	42.5%	673	13,413	33.7%
Small Hydro	4,441	14.8%	554	4,995	12.6%
Solar	908	3.0%	51	959	2.4%
Wind	6,172	20.6%	7,364	13,536	34.0%
Total	**30,005**	**100%**	**9,791**	**39,796**	**100%**

Source: 2010 Total System Power, http://energyalmanac.ca.gov/electricity/total_system_power.html.

Additional Renewable Potential

California also has significant technical potential for additional renewable development with estimates of more than 18 million MW (Table 6).[73] "Technical potential" in this context is the theoretical potential of renewable generating capacity, taking into account natural and climatic parameters, geographical restrictions, and technical limitations such as energy conversion efficiencies.

71 Four hundred MW of this solar capacity is from existing solar thermal facilities that were built in the 1980s. Appendix A provides tables listing renewable utility-scale, wholesale DG, and customer-side DG by California county.

72 Based on 2010 total system power renewable generation as a percentage of the 2010 retail sales (excluding water pumping load), http://energyalmanac.ca.gov/electricity/total_system_power.html. Appendix B shows how the use of different data sources may yield different percentages of renewable generation in California's electricity mix.

73 Technical potential estimates shown in Table 6 do not reflect recent increases in technical potential due to technology or other improvements. For specific technical potential data sources for each technology and the method used to estimate technical potential, see Appendix C.

In contrast, "economic potential" represents the technical potential at cost levels considered competitive, and "market potential" represents the total amount of renewable energy that can be implemented in the market after accounting for energy demand, competing technologies, costs and subsidies, and barriers. Rough indicators of the economic and market potential for additional renewable development include the number of renewable projects seeking interconnection, those in the permit review process or permitted during 2010, and the amount of renewable capacity with signed contracts with utilities:[74]

Table 6: California's Renewable Technical Potential

Technology	Technical Potential (MW)
Biomass	3,820
Geothermal	4,825
Small Hydro	2,158
Solar	
Concentrating Solar Power	1,061,362
PV	17,000,000
Wave and Tidal	32,763
Wind	
On-shore	34,000
Off-shore	75,400
TOTAL	**18,214,328**

Source: California Energy Commission. See Appendix C for specific data sources and methods used to determine technical potential estimates.

- There are 57,000 MW of renewable capacity in the California ISO queue and 5,168 MW of capacity in the Wholesale Distribution Access Tariff queue.[75]
- The Renewable Energy Action Team is tracking 25,900 MW of renewable projects being considered for development.[76]
- State and local governments permitted 9,435 MW of renewable capacity in 2010, about 4,100 MW of which were permitted in 2010 by the Energy Commission (Table 7), with about 1,440 MW of that capacity either operational or under construction.[77]
- IOUs have signed and pending contracts for about 9,100 MW of new renewable capacity,[78] and publicly owned utilities have signed contracts for roughly 1,100 MW of new renewable facilities.[79]

74 The amount of capacity associated with the renewable projects in each of these processes is not cumulative; for example, projects in the interconnection queue may be among those being tracked through the permitting process or those that have signed contracts with utilities.

75 Data from utility websites.

76 California Energy Commission website, http://www.energy.ca.gov/33by2020/documents/renewable_projects/Tracking_Report_for_Renewable_Projects.pdf.

77 In addition to the projects listed in Table 7, in 2010 the Federal Energy Regulatory Commission granted preliminary permits for up to 3,291 MW of ocean wave and tidal energy projects off the coast of California. These projects are not expected to contribute significantly to the 2020 goals but have the potential to lay the necessary groundwork through device testing and/or pilot projects for contributing to longer-term renewable goals.

Table 7: Renewable Projects Permitted in 2010 by California County (MW)

County	Bio	Cogen*	Geo	PV >20MW	PV <20MW	Solar Thermal	PV/ Solar Thermal	Wind	Total
Imperial			208	1,259					1,467
Kern	44			867	24	250		2,169	3,354
Kings				145					145
Los Angeles		85		337					422
Riverside				175		1,734			1,909
Sacramento					2				2
San Bernardino				20		770	633		1,423
San Diego				45					45
San Luis Obispo				250					250
Shasta								102	102
Solano								155	155
Stanislaus				50	1				51
Tulare				110					110
TOTAL	**44**	**85**	**208**	**3,258**	**27**	**2,754**	**633**	**2,426**	**9,435**

* Cogeneration refers to a pipeline biomethane facility that has applied for RPS precertification.
Source: California Energy Commission

Renewables Portfolio Standard Progress – 20 Percent by 2013

A report by the CPUC's Division of Ratepayer Advocates states "utilities are on track to achieve the 20% RPS goal by the end of flexible compliance in 2013…"[80] In 2010, renewable generation represented about 16 percent of statewide retail sales (IOUs and publicly owned utilities combined).[81] According to the CPUC compliance filings, the state's three largest IOUs collectively served 18 percent of their 2010 retail electricity sales with renewable power, with

78 California Public Utilities Commission, Investor-Owned Utilities Contract Database, http://www.cpuc.ca.gov/PUC/energy/Renewables/index.htm, as of November 2011. Includes only contracts approved by the CPUC.

79 California Energy Commission Publicly Owned Utilities Database, November 2011, http://www.energy.ca.gov/portfolio/index.html.

80 California Public Utilities Commission, Division of Ratepayer Advocates, February 2011, *Green Rush: Investor-Owned Utilities' Compliance with the Renewables Portfolio Standard*, http://www.dra.ca.gov/NR/rdonlyres/0CB0B986-E93B-462A-BA62-804EDAE43B82/0/RPSReportPublic_FINAL_2011_Feb_14_v2.pdf, page 4.

81 Based on 2010 total system power renewable generation as a percentage of the 2010 retail sales excluding water pumping load (252,746 GWh) . Appendix B shows how the use of different data sources may yield different percentages of renewable generation in California's electricity mix.
Total system power can be downloaded: http://energyalmanac.ca.gov/electricity/total_system_power.html.

PG&E procuring 17.7 percent, SCE 19.4 percent, and SDG&E 11.9 percent.[82] Preliminary data also suggests that California's publicly owned utilities as a whole procured 20 percent of their retail sales from Energy Commission-eligible renewable resources, with Los Angeles Department of Water and Power (LADWP) procuring 20 percent and Sacramento Municipal Utility District (SMUD) procuring 23 percent.[83]

Renewables Portfolio Standard Progress – 33 Percent by 2020

IOUs have made progress in securing contracts for renewable electricity needed in the future. As of May 31, 2011, enough renewable generation was on-line or contracted to achieve the estimated renewable net short range for 33 percent in 2020, assuming all existing renewable generating facilities remain on-line, with the caveats that (1) additional contracts may be needed to account for contract failure,[84] and (2) short-term contracts may not be available to deliver in 2020. IOU signed and pending contracts for new renewable generation not yet on-line are expected to deliver more than 41,000 GWh by 2020.[85] Publicly owned utilities have signed contracts for 1,100 MW of new renewable facilities not yet on-line that are expected to generate more than 3,800 GWh in 2020.[86] Figure 3 shows the renewable generation and forecasted targets for 2013, 2016, and 2020 and includes the IOU approved and pending contracts, publicly owned utility approved contracts, and existing renewable generation.[87]

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82 As reported by Pacific Gas and Electric, Southern California Edison, and San Diego Gas & Electric in their March 2011 RPS compliance filings, available at http://www.cpuc.ca.gov/PUC/energy/Renewables/compliance.htm. Data reported by the IOUs for RPS compliance may vary from data collected from generators, as presented in the total system power. Many factors contribute to the difference. One factor is flexible compliance. The IOUs are allowed to carry over generation from previous years and earmark future generation to meet their RPS compliance target. It is not clear how much generation from other years is included in the 2010 compliance reports. One additional cause for the variance is the tracking of generation from fossil fuel plants cofiring with renewable fuels such as biomass and biogas. The renewable portion of the generation from these sources is eligible for the RPS and is included in the CPUC compliance filings. However, the total system power does not break out the renewable portion of the generation.

83 Until 2010, publicly owned utilities defined which renewable resources were eligible to meet their RPS targets. As a result, renewable percentages from publicly owned utilities may contain renewable procurement from sources that are not considered renewable for purposes of the RPS, like large hydro, and are therefore not reflected in the estimate of statewide progress toward the RPS target.

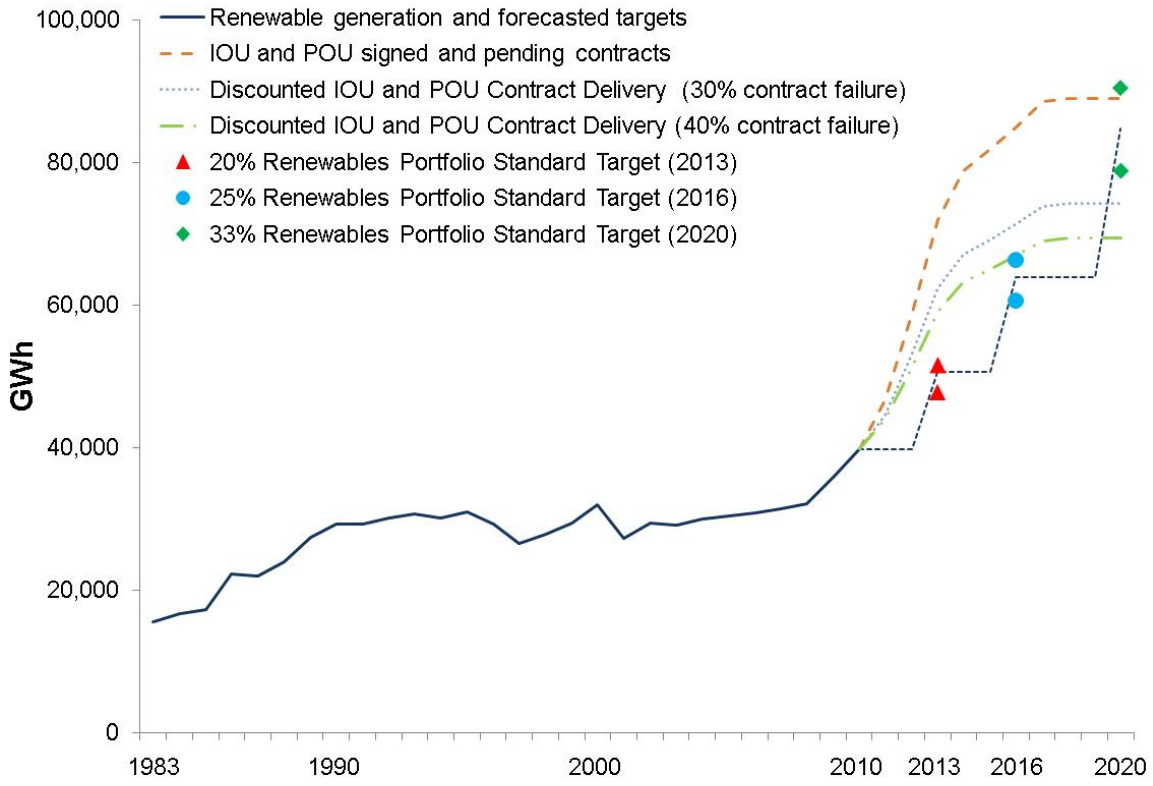
84 If the contract failure rate remains at 30 percent, the signed contracts for new projects plus expected generation from existing facilities will come close to achieving the lower bound of the estimated range for 33 percent in 2020. Energy Commission staff estimates that new contracts – assuming a 30 percent contract failure rate – added to the expected generation from existing facilities will generate 76,439 GWh in 2020.

85 California Public Utilities Commission, RPS Project Status (accessed November 8, 2011), http://www.cpuc.ca.gov/PUC/energy/Renewables.

86 Capacity data from California Energy Commission Publicly Owned Utilities Database, September 2010, http://www.energy.ca.gov/2008publications/CEC-300-2008-005/index.html; generation data from Form S-2 submittals by POUs as part of the *2009 Integrated Energy Policy Report* Proceeding.

87 The forecasted targets for 2013, 2016, and 2020 are based on the renewable net short method described in this report using 2009 data. The IOU contracts not yet on-line are from the CPUC RPS Project Status Table for May (May

Figure 3: Renewable Generation for California and RPS Goals



Source: California Energy Commission Total System Power data and staff estimate of forecasted RPS targets using IOU and publicly owned utility contract databases, CPUC RPS Project Status (May 31, 2011).

Bid-to-Selected Ratio

Renewable developers seeking power purchase contracts face the challenge of the ratio of bids to selected projects in utility solicitations. At the May 9, 2011, IEPR Committee Workshop on Renewable Localized Generation, PG&E stated that market interest in the 2009 solicitation was strong "and our expectation in 2011 based on the number of folks that have been approaching us bilaterally is that we will get an extremely robust response."[88]The CPUC reports that bids in the IOU's 2009 RPS solicitation represented 50 percent of the IOU's total load in 2020, while shortlisted bids equaled half of the generation needed to meet the 33 percent target in

31, 2011). Existing renewable generation from 1983-2009 is from total system power data: http://energyalmanac.ca.gov/.

88 California Energy Commission, May 9, 2011, Integrated Energy Policy Report Committee Workshop on Renewable Localized Generation, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-09_workshop/2011-05-09_Transcript.pdf, p. 27.

2020.[89]Market response to PG&E's program for wholesale DG PV systems was also high, with the utility receiving 20 times as many bids as what was actually signed up, but two-thirds of the projects were unable to pass PG&E's basic viability screens.[90]

Similarly, in SCE's 2010 RFO for the Solar Photovoltaic Program, the ratio of bids submitted to executed contracts was roughly 4 to 1, and SCE's 2010 Renewable Standard Contract program received bids from projects representing 10 times more capacity than the program goal of 250 MW.[91]

Contract Failure

As mentioned previously, contract failure can affect the amount of renewable capacity and generation ultimately developed. The Energy Commission first identified the risk of contract failure as a major factor affecting the state's ability to meet its RPS goals in the *2007 Integrated Energy Policy Report*.[92] The Energy Commission's IOU contract database indicates that currently about 30 percent of the CPUC-approved long-term contracts (10 years or more) for new renewable projects in California that are not yet on-line have been canceled. The contract failure rate increases to about 40 percent if contracts that have been delayed are also considered.[93] The 40 percent contract failure rate is also consistent with current utility assumptions discussed at the September 14, 2011, workshop on the draft *Renewable Power in California: Status and Issues* report.[94]

In an effort to screen projects to reduce contract failure, the CPUC requires IOUs to use a project viability calculator when evaluating bids responding to competitive RPS solicitations (Decision 09-06-018). The tool scores criteria including project development and ownership experience, technical feasibility, resource quality, manufacturing supply chain, site control, permitting

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89 CPUC, *Renewables Portfolio Standard Quarterly Report, 1st Quarter 2010*, http://www.cpuc.ca.gov/NR/rdonlyres/7DA38E61-9DB9-4B4E-A59C-D0776AF3B0BB/0/Q12010RPSReporttotheLegislature.pdf, p. 4.

90 California Energy Commission, May 9, 2011, Integrated Energy Policy Report Committee Workshop on Renewable Localized Generation, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-09_workshop/2011-05-09_Transcript.pdf, p. 26.

91 SCE, May 23, 2011, Written Comments, May 9, 2011, IEPR workshop, "California Energy Commission Docket No. 11-IEP-1G: Comments Related to Committee Workshop on Renewable, Localized Generation," http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-09_workshop/comments/SCE_Comments_on_Renewable_and_Localized_Generation_TN-60748.pdf, p. 7-8.

92 California Energy Commission, *2007 Integrated Energy Policy Report*, December 2007, http://www.energy.ca.gov/2007_energypolicy/index.html.

93 http://www.energy.ca.gov/portfolio/contracts_database.html, updated July 2011.

94 Transcript of the September 14, 2011, Integrated Energy Policy Report workshop on the Draft *Renewable Power in California: Status and Issues* report, comments by Valerie Wynn, Pacific Gas and Electric Company, (page 72) and Gary Stern, Southern California Edison (page 73), http://www.energy.ca.gov/2011_energypolicy/documents/2011-09-14_workshop/2011-09-14_transcript.pdf.

status, project financing status, interconnection progress, transmission system upgrade requirements, and reasonableness of the project's commercial on-line date.[95]

As part of the 2011 RPS procurement plan proceeding at the CPUC, stakeholders raised the concern that contracts would face difficulty finding financing if utilities are allowed unlimited ability to decline procurement due to economic reasons. The CPUC ruled that 2011 RPS contracts must contain provisions limiting the amount of economic curtailment. The CPUC also reiterated that if an IOU fails to meet its RPS targets due to "unreasonable administration" of contracts, the IOU could be subject to penalties.[96]

Another procurement mechanism soon to be available for renewable projects is the Renewable Auction Mechanism (RAM).[97] To reduce the risk of contract failure, the CPUC's RAM will require projects to meet the following viability requirements: site control, development experience, commercialized technology, and completed interconnection application. In addition, the bidder must have a complete System-Impact Study or Cluster Study Phase 1, or have passed the Fast Track screens.[98]

Progress Toward the 12,000 MW Localized Electricity Generation Goal

In addition to progress toward the 33 percent RPS, the state has also made significant steps toward Governor Brown's goal of installing 12,000 MW of localized electricity generation. The state has 2,469 MW of DG capacity installed,[99] and the following programs are underway:

- 3,000 MW of self-generation DG PV through the programs associated with Senate Bill 1 (Murray, Chapter 132, Statutes of 2006).
- 500 MW of wholesale generation DG PV through PG&E (half of the MW will be utility-owned; half will be provided by independent energy producers).
- 500 MW of wholesale generation DG PV through SCE (half of the MW will be utility-owned; half will be provided by independent energy producers).
- 100 MW of proposed wholesale generation DG PV through SDG&E (26 MW will be utility-owned; 74 MW will be provided by independent energy producers).
- 750 MW of wholesale generation (including non-PV DG, per SB 32) from existing feed-in tariff; plus an additional 66.5 MW contracted by SMUD.[100]

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95 http://www.cpuc.ca.gov/PUC/energy/Renewables/procurement.htm.

96 p. 14-18, http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/133893.pdf.

97 Resolution E-4414 implementing the renewable auction mechanism is scheduled to be considered by the CPUC on August 18, 2011. http://www.cpuc.ca.gov/NR/rdonlyres/C12060F4-F23F-4F7C-875B-49B943FF8EA4/0/E4414_Draft_Comment_Resolution.pdf.

98 http://www.cpuc.ca.gov/NR/rdonlyres/C12060F4-F23F-4F7C-875B-49B943FF8EA4/0/E4414_Draft_Comment_Resolution.pdf, p. 56.

99 See Table 4. Does not include wind DG capacity because disaggregated data regarding utility-scale versus wholesale DG capacity for wind was unavailable as of the publication date of this report.

- 1,000 MW of wholesale generation (including non-PV DG) for the RAM decision adopted by the CPUC.

As of June, 2011, under these programs California has installed almost 545 MW of DG capacity. If these programs are fully successful, another 5,400 MW or so of additional renewable capacity could be added in the next five years. Additional capacity may also be added through other programs such as the Self-Generation Incentive Program (SGIP) and Emerging Renewables Program (ERP), which do not have MW targets but do provide incentives for renewable capacity to serve on-site load. With 3,278 of DG already installed, if all programs are successful, a gap of about 3,500 MW would still exist, which may need additional programs or incentives to reach the 12,000 MW goal by 2020.

Renewable Goals Beyond 2020

There are currently no mandates for renewable targets beyond 2020. However, additional renewable generation will likely be needed to achieve the state's greenhouse gas (GHG) emission reduction target of 80 percent below 1990 levels by 2050.[101] In addition, the 33 percent renewable net short by 2020 is considered a floor estimate, allowing for the possibility that additional investments in these generation technologies may occur beyond the policy target. For example, electricity demand may increase beyond current forecasts due to the accelerated penetration of electric vehicles.

Renewable generation may also become a viable alternative to replace some of the generation expected to decline through the decade, such as the contracts for electricity from coal-fired power plants serving California's electricity demand (Table 8). The electricity from existing coal and petroleum coke plants currently represents about 10 percent of the total generation serving California load. The electricity from these coal plants is expected to decline 61 percent (17,600 GWh) and associated GHG emissions to drop from about 30 million tons of equivalent carbon dioxide (CO2e) to 12 million tons between 2010 and 2020 due to the constraints imposed by the Emission Performance Standard.[102] Five coal facilities (representing about 1,500 GWh/yr) located in California are expected to be repowered and converted to renewable biomass facilities within the next few years.

The remaining coal generation contracts are expected to expire between 2027 and 2030. The annual capacity factor for these coal plants ranges between 83 and 92 percent, so a mix of

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100 SMUD developed a feed-in tariff program for up to 100 MW. Part of the program was in response to Senate Bill 32, which increased the current feed-in tariff project capacity from 1.5 MW to 3 MW and included an obligation for POUs. SMUD calculated that their portion of the 750 MW would be 33.5 MW and so designed their feed-in tariff to have two "buckets:" 33.5 MW for projects 3 MW and below and an additional 66.5 MW for projects 5 MW and below. Therefore, the 66.5 MW are above what would be required under Senate Bill 32.

101 Executive Order S-03-05, http://gov.ca.gov/news.php?id=1861.

102 The Emission Performance Standard prohibits California utilities from renegotiating or signing new contracts for baseload generation that exceeds 1,100 lbs of CO2e emission per MWh. A number of contracts with coal generation facilities that exceed the Emission Performance Standard will expire within the decade and cannot be renewed with another long-term contract.

renewable and thermal generation with storage is needed to replace these facilities as well as meet possible targets beyond the 33 percent. For example, the renewable target could increase to 40 percent of retail electricity sales by 2030, consistent with Governor Brown's recent statement that "with the amount of renewable resources coming on-line, and prices dropping, I think 40 percent, at reasonable cost, is well within our grasp in the near future."[103]

Table 8: Contracts for Coal-Fired Generation (GWh)

Plant Name	2010	2020	Contract Status
Four Corners	4,738	0	Expires 2016
Intermountain	11,886	9,258	Expires 2027
Mohave	0	0	Expired 2006
Navajo	5,401	0	Accelerated Timeline in 2014
Reid Gardner	912	0	Expires 2013
San Juan	1,712	2,192	Expires 2030
Boardman	1,030	0	One contract expires 2013, the other 2018
Deseret	0	0	Expired 2009
CA Coal/Petroleum Coke	3,406	0	Expires between 2011 and 2020
Total	29,085	11,450	61% decline from 2010

Source: California Energy Commission

The primary policy driver for long-term renewable development evaluations is based on environmental goals. The ARB's AB 32 implementation plan includes an assumption that the electricity generation sector will need to surrender 108.6 million metric tons of CO2eq[2] (either allowances or offsets) by 2020. Additional emissions would be allowed to the extent that allowances or offsets can be purchased from other sectors of the economy in lieu of reductions by electric generators. The 2020 renewable generation targets will, in effect, reduce the need for fossil-fuel generation and ultimately reduce overall carbon emissions within the electricity industry to meet AB 32 targets.

To achieve California's long-term carbon reduction goals, additional renewable generation and other zero-carbon electricity resources will need to be developed. Energy efficiency programs and self-generation will also be needed to reduce overall energy consumption to limit the dependence on electricity generation facilities that burn fossil fuels. Technology advancements also hold great promise to enhance choices in how to reach the carbon reduction goal.

If the 80 percent carbon reduction goal were split evenly among the different energy sectors, carbon emissions from fossil fuel-fired generators would need to decline to 23.3 million metric tons (80 percent of 115.8 million metric tons in 1990). This means that California's electricity sector can release only the carbon emissions that would be produced by 50,000 GWh per year of generation from new efficient natural gas-fired power plants, assuming that coal-fired generation no longer serves California electricity demand and that the older, less efficient gas-

103 Office of Governor Jerry Brown website, http://gov.ca.gov/news.php?id=16974.

fired plants are retired. For comparison, reported electricity from specified fossil fuel generation sources (natural gas and coal) was about 150,000 GWh in 2009, with about 46,000 GWh from spot market imports mostly served by gas-fired power plants in the West. Coal fuel has a higher carbon content value than natural gas, which contributes to a high share of the electricity sector's GHG emission inventory. Older natural gas-fired power plants are also about 35 percent less efficient that the new combined cycle generators, so retiring the aging plants will contribute to the long-term carbon reduction targets.

Determining the amount of electricity needed from renewable generation to meet the 2050 goal can be estimated simplistically, but numerous uncertainties and system reliability requirements must be considered to determine feasibility. If the electricity demand, number of self-generation projects, and energy efficiency programs grow at currently expected rates, electricity retail sales may increase to about 344,000 GWh by 2050.[104]

If existing renewable, nuclear, and hydro generation continues to operate at the same levels in 2050, roughly 187,000 GWh of new zero-emission generation would be needed to meet electricity demand. If the nuclear facilities currently serving California demand are not relicensed, about 229,000 GWh of new generation will be needed. New renewable, nuclear, or fossil fuel-fired plants with carbon sequestration technologies could serve the new zero-emission generation need; however, if new generation is served only by new renewables, this supply would represent about 67 percent (with existing nuclear power plants) to 79 percent (without existing nuclear power plants) of total electricity sales in 2050.[105]

These estimates are not intended to be used to predict future California electricity supply, but rather to provide a starting point for evaluating technical options for attaining long-term carbon reduction goals. Significant uncertainty exists regarding the variables used for calculating the amounts and types of generation needed for the future. For example, the electricity demand may vary depending on changing demographics and consumer energy consumption patterns. The Energy Commission's Zero Net Energy program goals combine advanced energy efficiency standards and distributed generation so that residential and commercial buildings would be carbon neutral by 2030. On the other hand, the electrification of the transportation sector may significantly increase the need for generation beyond what is already assumed in these calculations. Advances in carbon sequestration technologies may also become commercially available and allow the use of different generation technologies rather than relying on zero-emission renewables.

The scope of studies underway to evaluate infrastructure requirements reveals even greater reason to examine the electricity system requirements for implementing an expanded policy goal for more renewable generation. Studies must compare potential changes to the daily and seasonal profiles for electricity consumption to the hourly generation patterns from different

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104 This assumes that electric vehicle use will increase in California, adding about 37,000 GWh of electricity demand for battery recharging.

105 Preliminary electricity supply and demand calculations can be found at: http://www.drecp.org/meetings/2011-05-17_meeting/documents/2050%20RPS%20and%20acreage%20calculator%20background.pdf.

renewable technologies. This will help determine whether additional thermal generation must operate, possibly beyond allowable carbon emission restrictions if sequestration technologies are not economically feasible. Energy storage, demand response, and other options like improved forecasting must also be considered to potentially displace the need to use fossil fuel-fired generation technologies to back up intermittent renewable generation.

Hydrogen Energy International, LLC, commissioned E3 to study scenarios that would meet California's GHG emission reduction goals for 2050. The high renewables scenario consisted of 74 percent renewable energy, 6 percent nuclear energy, 20 percent other (natural gas, large hydroelectric power, and unspecified net imports), and 12,000 MW of energy storage beyond the 1,200 MW of energy storage already in California.[106] The 2009 study states:

> "In order to balance the system in the High Renewables Scenario we will have to rely heavily on solar thermal with energy storage to shape solar output, 'smart charging' of electric vehicles to match demand with nondispatchable supply, exported or 'spilled' energy in some time periods, and utility-scale electricity storage. With all of these system balancing approaches in place, 74 percent generation is met with renewable energy in this scenario."[107]

The California Council on Science and Technology also prepared a report on the technology requirements for reducing carbon emissions by 2050.[108] This study examines the electricity system services needed to balance load growth including the electrification of the transportation sector and increased penetration of intermittent renewable generation. Advancements in energy efficiency, storage, and smart grid solutions will contribute toward meeting the carbon reduction goals. Carbon sequestration will also be needed to offset the use of fossil fuel generation needed to integrate renewables. Nuclear generation scenarios are also considered as an option toward reducing emissions, assuming that the legal issues associated with nuclear waste issues are resolved.

Further study is needed to examine electricity system reliability issues and possibilities for technological advancements for accomplishing environmental goals and securing a reliable and clean energy future.

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106 E3, November 2009, *Meeting California's Long-Term Greenhouse Gas Reduction Goals*, http://ethree.com/public_projects/greenhouse_gas_reduction.html.

107 Ibid.

108 California Council on Science and Technology, *California's Energy Future – The View to 2050*, May 2011, http://www.ccst.us/publications/2011/2011energy.pdf.

CHAPTER 3: Environmental, Planning, and Permitting Issues

California has an array of renewable electricity options at the large utility scale, and in many cases its unique, fragile environmental resources occupy the most promising energy regions. Similarly, the state has numerous opportunities for placing distributed generation (DG) in local communities, although siting such systems can be complex due to required changes and upgrades in existing building structures and electricity distribution lines and networks. Complying with federal, state, and local agency environmental and permitting requirements related to these resources can be a challenge for renewable developers. Renewable generating facilities, particularly large utility-scale solar facilities located in the California desert, face complicated environmental review and mitigation activities. Resolving these issues can lead to legal challenges to projects, causing delays and higher costs and potentially jeopardizing project approval. While the public is highly interested in developing renewable energy, resource advocates, local communities, and residents also want to see new projects developed in suitable locations where project impacts are minimal and appropriately mitigated.

About This Chapter

Chapter 3 describes key environmental, planning, and permitting challenges for developing:

- Utility-scale renewable power plants under the Energy Commission's power plant licensing jurisdiction, with focus on large renewable power plants in desert locations. These projects face environmental issues to a greater degree since desert locations often provide habitat for sensitive species, have limited water supplies, and are often on federal lands.
- DG renewable projects permitted at the local level, including nonthermal renewable facilities such as wind and solar PV, and thermal renewable utility-scale facilities smaller than 50 megawatts (MW). Inconsistent requirements across jurisdictions, multiple permit requirements, lack of zoning and permitting ordinances, and reduced staffing can complicate and delay project review and approval.

This chapter also describes some of the current efforts to improve permitting processes for utility-scale renewable facilities including:

- The Renewable Energy Action Team's (REAT) efforts to develop the Desert Renewable Energy Conservation Plan (DRECP), which will identify areas suitable for renewable energy project development and help conserve sensitive species and natural communities in the Mojave and Colorado Desert regions.[109,110] Another REAT effort is the *Best Management*

109 Executive Order S-14-08, November 2008, directs state agencies to create comprehensive plans to prioritize regional renewable projects based on renewable resource potential and protection of plant and animal habitat. The Energy Commission and the Department of Fish and Game signed a memorandum of understanding formalizing a Renewable Energy Action Team to implement and track progress of this effort. http://www.drecp.org/documents/2008-11-17_Exec_Order_S-14-08.pdf.

110 See Desert Renewable Energy Conservation Plan website at: http://www.drecp.org/.

Practices and Guidance Manual: Desert Renewable Energy Projects that helps project developers design projects that reduce environmental impacts for renewable desert projects.[111]

- State and federal agencies' efforts to streamline the permitting of utility-scale renewable energy projects in California by increasing cross-agency cooperation and coordination. This section discusses the Energy Commission's proceeding on "lessons learned" during the licensing of large-scale renewable energy facilities in 2010 that will identify new approaches to the Energy Commission's planning and permitting process based these lessons.[112]

Efforts to improve permitting of renewable DG projects are covered in Chapter 10.

Challenges for Utility-Scale Renewable Projects

Planning and permitting are a challenge for utility-scale renewable energy projects, especially solar projects, which tend to be massive industrial-scale developments on lands that are natural habitat or rural requiring considerable mitigation of biological resource impacts. Local residents may feel overwhelmed by multisquare-mile projects and view these industrial developments as an invasion into the solitude and isolation they sought by living there.

The planning and permitting process itself is also a challenge. In California, this process involves many federal, state, and local agencies that provide regulatory review and ultimately issue permits for electricity generation projects depending on their agency mandate or jurisdiction. Agencies may have varying codes, standards, and fees, and each agency is involved at varying degrees, depending on the projects' technology, size, location, and potential for environmental and system reliability impacts. If improperly coordinated, potentially overlapping levels of jurisdictional review can cause delays and add to uncertainty. Initiatives carried out by the REAT, as discussed later in this chapter, are intended to promote interagency coordination and ease the permitting process to avoid delays, reduce permitting costs, and improve the certainty of permitting decisions.

Many large solar energy projects are being proposed in California's desert area on U.S. Bureau of Land Management (BLM) land. The BLM has received requests for rights-of-way encompassing more than 300,000 acres for the development of 34 utility-scale solar thermal power plants totaling about 24,000 MW. Not all of these projects have reached the stage of an Application for Certification (AFC) with the Energy Commission. Table 9 provides a current list of renewable energy projects approved, withdrawn, or under review by the Energy Commission.

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111 Renewable Energy Action Team Report, *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects*, December 2010, http://www.energy.ca.gov/2010publications/REAT-1000-2010-009/REAT-1000-2010-009-F.PDF.

112 California Energy Commission, http://www.energy.ca.gov/siting_lessons/.

Table 9: Status of Large-Scale Renewable Projects under Energy Commission Jurisdiction

Project Name	Location	Size	Status
Abengoa Mojave Solar Project	San Bernardino Co.	250 MW	Approved 9/8/10, construction start 8/29/11
Beacon Solar Energy Project	Kern Co.	250 MW	Approved 8/25/10
Black Rock 1,2 and 3 Geothermal Power Project	Imperial Co.	159 MW	Approved 2/8/11
Black Rock 5 and 6 Geothermal	Imperial Co.	235 MW	Estimated AFC filing date Q4 2011
Ivanpah Solar	San Bernardino Co.	370 MW	Approved 9/22/10, construction start 11/2010
Calico Solar Project	San Bernardino Co.	663.5MW	Approved 10/28/10, petition to amend 3/25/11 to 563 MW PV and 100.5 MW thermal suncatcher
Carrizo Energy Solar Farm	San Luis Obispo Co.	177 MW	Withdrawn
City of Palmdale Hybrid Gas Solar	City of Palmdale	570 MW (50 MW solar)	Approved 8/10/11
Hidden Hills Solar Energy Generating System	Inyo Co.	500 MW	AFC filed 8/5/11
Imperial Valley Solar Project (Formerly SES Solar Two Project)	Imperial Co.	709 MW	Approved 9/29/10, license terminated 8/18/11 due to change from solar thermal to PV
Genesis Solar Energy Project	Riverside Co.	250 MW	Approved 9/29/10, construction start 4/2011
Rice Solar Energy Project	Riverside Co.	150 MW	Approved 12/15/10
Rio Mesa Solar Electric Generating Facility	Riverside Co.	750 MW	AFC filed 10/14/2011
San Joaquin Solar 1 & 2	Fresno Co.	106.8 MW	Withdrawn
Solar Millennium Blythe	Riverside Co.	1,000 MW	Approved 9/15/10, construction start 2/2011, construction stop 8/20/11 to convert to PV
Solar Millennium Palen	Riverside Co.	500 MW	Approved 12/15/10
Solar Millennium Ridgecrest	Kern Co.	250 MW	AFC filed 9/1/09. Applicant exploring switch from solar thermal to PV, filed 6/2011 for jurisdictional waiver asking for CEC review of project.
Victorville 2 Hybrid Power Project	City of Victorville	563 MW (50MW solar)	Approved 7/16/08

Source: California Energy Commission

Environmental Challenges

Renewable resources tend for the most part to be located in specific parts of the state.[113] Most large tracts of land that have the solar or wind resources needed to accommodate utility-scale renewable facilities in California are located in the Mojave and Colorado Deserts of Southern California, or in the South San Joaquin Valley. There is also wind potential in the Tehachapi and San Gorgonio passes. Geothermal power plants and associated steam and hot water fields are

113 See Appendix C for maps showing location of renewable resources in California.

typically utility-scale, industrial facilities with pipe networks located in rural areas on relatively large tracts of land primarily in Lake, Sonoma, Imperial, and Inyo counties. While biomass facilities can be located throughout the state, most biomass development occurs in the northern part of the state due to the availability of fuel from forest and agricultural waste.

Because the majority of new renewable project development is currently proposed in the California desert, this section focuses primarily on impacts from utility-scale renewable projects on desert environments. However, renewable energy facilities located in nondesert locations of the state also face environmental issues, depending on the technology, location, and size.[114] Solar PV facilities can cause potential glare and glint hazards to aircraft, trains, and highway traffic, and can impact agricultural lands and open space/habitat lands. Depending on their location, technology, and site design, wind farms have the potential for killing migrating or foraging raptors and bats, adversely affecting the visual landscape, creating aviation hazards, and causing noise problems if located near urban areas. Geothermal facilities can affect rare and endangered plant and animal species, cultural resources, the quantity and quality of local water supplies, and visual landscapes. Geothermal projects can also cause or contribute to local and regional air quality problems through emission of moderate amounts of regulated air pollutants, although they are required to use best available emissions control technology and provide emission offsets to comply with local air district regulations. Biomass plants can cause regional increases in criteria pollutants and particulate matter, post ash disposal and local land use concerns, and increase water use (if a facility uses water cooling towers or employs "wet scrubbers" to reduce hydrochloric acid emissions).

For renewable facilities in the desert, the primary environmental concerns are biological and cultural resources, water supply, visual impacts, transportation-related visual hazards, and land use, as discussed in the following sections. Depending on the project, there may also be air quality, hazardous materials, noise, public safety, and local community concerns.

Biological Resource Impacts

Proposed desert locations for utility-scale solar and wind energy projects often provide habitat for sensitive species like raptors, bats, desert tortoises, kit foxes, various reptiles and amphibians, Mohave ground squirrels, and sensitive plants. Solar PV and solar thermal projects generally cause greater habitat loss than wind farms and solar thermal heliostat and power tower projects because sites often need to be leveled to accommodate a linear design, which typically cannot be altered to avoid sensitive areas. Heliostat and power tower projects do not necessarily require that a site be leveled, so habitat impacts can be less. The site topography can

114 While no utility-scale ocean wind, wave, current, and tidal projects are operating at this time, there is industry and federal government interest in testing and pilot projects to address, among other issues, high electricity generation costs. The industry and federal interests may be partially addressed by projects licensed and permitted offshore Alaska, and in Maine, Massachusetts, New York, Oregon, and Washington. The Energy Commission, California Ocean Protection Council, and others are addressing regulatory challenges and have identified potential marine renewable energy project environmental impacts that may affect commercial and recreational fisheries, marine mammals, birds and transportation, ocean and coastal habitats, and recreational boating.

be maintained and some vegetation left intact since that technology has far greater flexibility regarding where the mirrors are located and do not always need to be in a line.

Wind energy projects, if located in key migration routes or foraging areas, can affect bird and bat species through collisions with turbine blades and through barotraumas (tissue damage and lung failure) caused by rapid air-pressure reduction when bats and some birds get too close to moving turbine blades. Wind farms generally cause less absolute habitat loss within a project footprint than utility-scale solar facilities because habitat for plant and wildlife species remains between turbines. Indirect impacts to wildlife outside the turbine footprint can result from roads, vehicles, and noise — possibly rendering a site generally unusable by wildlife depending on usage on the site and density of turbines. It may be easier to protect rare plant populations on a wind energy site. In addition to habitat loss, most large renewable generation projects (both solar and wind) can potentially affect wildlife movement patterns, particularly if they are proposed in or near migration corridors or impede the connections between sensitive species populations, which can be critical to the species' local and regional health and survival.

Research efforts under the Energy Commission's Public Interest Energy Research (PIER) Program are contributing toward reducing these and other environmental impacts (for details, see Chapter 9). Research areas include identifying ways to reduce the effects of desert solar and wind projects on sensitive plant and animal species and identifying low-risk sites for wind turbine installations to reduce impacts on birds and bats. In 2010 then-Attorney General Brown brokered an agreement among environmental groups, wind developer NextEra Energy Resources, and the state to replace 2,400 turbines at the Altamont Pass Wind Farm in Alameda and Contra Costa counties with newer, more bird-friendly models.[115] The project is expected to be complete by 2015, and, as part of the agreement, NextEra will pay $2.5 million to the PIER Program, the East Bay Regional Park District, and the Livermore Area Regional Park District for raptor habitat preservation.

Water Supply Impacts

Water is limited in the desert, and groundwater basins are often already in an overdraft condition.[116] Fresh water is an increasingly critical resource, not only in the desert regions, but throughout California. Increasingly, power plants may be competing with other local users for diminishing water supplies. As California's population and water demand continue to grow, the Department of Water Resources anticipates that the state will experience water supply shortfalls of more than several million acre feet within the next 10 years.

In the desert region, the majority of proposed utility-scale renewable energy facilities use either wind or solar technologies. The solar technologies are further categorized as either solar thermal or PV. Wind and solar facilities require large areas of open desert land to take advantage of higher wind speeds or to maximize the collection of solar radiation, but their water use can vary

115 CBS San Francisco, "Wind Turbines to be Upgraded in Altamont Pass," December 6, 2010, http://sanfrancisco.cbslocal.com/2010/12/06/wind-turbines-to-be-upgraded-in-altamont-pass/.

116 *Overdraft* refers to the condition of a ground water basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over time.

significantly. Solar thermal facilities, which use steam turbine generators, must dissipate waste heat. The preferred technology for heat dissipation (cooling) is evaporative cooling. Use of this technology requires a sizable volume of water during operation. Conversely, wind technologies and PV do not require thermal cooling equipment, resulting in significantly less water use. Activities such as grading and dust control for construction of both PV and solar thermal projects may require significant water use. Mirror washing throughout the life of a project may also contribute to significant water use. Water needs for PV panel washing are estimated as one-tenth of the requirements for solar thermal power mirror-washing values.[117]

Renewable energy facilities can take advantage of different strategies to reduce their water consumption. Solar thermal facilities can also use alternative approaches, such as dry cooling (air cooled condensers) and hybrid cooling, which are available and commercially viable. This can reduce a project's water demand by up to 90 percent, and simplify the analysis involved in the permitting process. For example, the Genesis Solar Energy Project estimated that changing the proposed 250 MW parabolic trough solar thermal power plant from wet cooling to dry cooling would reduce project water needs from 1,600 acre-feet per year to about 200 acre-feet per year.[118] This strategy involves an important trade off since the project requires a larger footprint and the use of dry cooling in the desert can decrease plant efficiency by 3 to 8 percent compared to wet cooling.

Rather than using fresh water, renewable projects can use degraded water, also known as non-potable water, which can be treated and reused for power plant process water. Some examples of degraded water include: contaminated surface water or groundwater; surface water impacted by agriculture activities; and treated municipal wastewater (recycled water). Improved treatment technologies are needed to make other sources of degraded water available in sufficient quantities for commercial viability.[119]

The Energy Commission adopted a water policy in the *2003 Integrated Energy Policy Report* that power plants' use of fresh surface water for cooling will be approved only where alternative cooling technologies are shown to be "environmentally undesirable" or "economically unsound."[120] In 2010 the Energy Commission's determination during the Genesis Solar Energy Project's licensing proceedings stated that projects seeking to use groundwater for cooling purposes are required to "use the least amount of the worst available water, considering all applicable technical, legal, economic, and environmental factors."[121] As alternative water

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117 *Draft Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States*, Table 3.1-1, http://solareis.anl.gov/documents/dpeis/Solar_DPEIS_Chapter_3.pdf.

118 California Energy Commission, *Genesis Solar Energy Project Commission Decision*, September 2010, http://www.energy.ca.gov/2010publications/CEC-800-2010-011/CEC-800-2010-011-CMF.PDF.

119 Past research on this topic by the Public Interest Energy Research Program is described in *Use of Degraded Water Sources as Cooling Water in Power Plants*, http://www.energy.ca.gov/pier/project_reports/500-03-110.html.

120 http://www.energy.ca.gov/reports/100-03-019F.PDF, p. 41.

121 http://www.energy.ca.gov/sitingcases/genesis_solar/notices/2010-02-02_Decision_Scoping_Order.pdf, p.3.

sources develop and technologies for process use improve, the Energy Commission may choose to update or enhance its water policy to reflect the changing dynamic of California's water use and supply. As part of the Energy Commission's "lessons learned" proceeding, discussed later in this chapter, a number of policy issues, including water, are under review as a result of staff, stakeholder, and agency experiences during the 2010 review of large solar projects.

Surface Water Impacts

Federal and state regulations protect many of the ephemeral and intermittent streams in the desert region because they are important sources of sediment, water, nutrients, seeds, and organic matter for downstream ecosystems and provide habitat for many species. Unlike other streams in California, desert streams typically have relatively long periods where no flow occurs, punctuated by episodic flows of relatively short duration and high intensity. For example, the Imperial Valley Solar project was originally proposed as a 750 MW facility on a 6,500 acre site that was later found to contain 880 acres of jurisdictional waters.[122,123] To avoid or minimize these impacts, the applicant redesigned the project, which reduced the amount of developable area and resulted in a lower generating capacity of 709 MW.

Site design must also be modified where important biological resources are identified and site drainage would have an impact. Diversion of high velocity flows through and around a site can be difficult where potential impacts up and downstream of a project site must be decreased and there is a need to mimic natural conditions. Temporary erosion and sediment protection measures should be installed to control soils disturbed by construction.

Visual Impacts

Utility-scale solar thermal power plants or wind farms can cover many square miles[124], including the power block facilities, access roads and transmission lines, and cause major visual changes in nonindustrialized desert or mountainous landscapes with scenic values. The steam plumes produced by the wet cooling towers of solar thermal power plants may also change the view of the landscape. Geothermal power plants, including well pads, steam pipelines, power generation facilities, access roads and transmission lines, may occupy as much as 350 acres, and power plant wet cooling towers can produce steam plumes – all potentially causing similar visual impacts on undeveloped desert or mountainous terrain.

Cultural Resources Impacts

State law defines cultural resources as buildings, sites, structures, objects, and historic districts. The Energy Commission's environmental impact assessment considers three kinds of cultural resources: prehistoric (related to prehistoric human occupation and use of an area); historical (associated with Euro-American exploration and settlement of an area); and ethnographic

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122 http://www.energy.ca.gov/2010publications/CEC-800-2010-006/CEC-800-2010-006-CMF.PDF.

123 The Army Corps of Engineers mapped 637 acres of primary streams and 244 acres of secondary streams, http://www.blm.gov/ca/st/en/fo/elcentro/nepa/stirling.html.

124 One square mile = 640 acres.

(materials important to the heritage of a particular ethnic or cultural group, such as Native Americans).

A major challenge to the development of lands in the southern desert and, to a lesser extent, anywhere in California, is the lack of comprehensive information regarding the locations and significance of cultural resources. While some archaeological sites are small and well-defined, historic and prehistoric landscapes can stretch for miles. For example, elements of the World War II Desert Training Center, a landscape of historic significance, encompass a large portion of southeastern California and southwestern Nevada. An extensive Native American prehistoric trails network extends throughout that same area, and historical Route 66 ties many small historic outposts together as it traverses the southern desert regions.

Many of the elements within these and other areas of historical significance have not been identified or evaluated. Information on both historical and archaeological sites is scattered among city, county, state, and private archives, multiple information centers, and state and federal agencies, such as the California Office of Historic Preservation, National Register of Historic Places, and the California Register of Historic Resources. Scarce and fragmented information, along with confidentiality requirements limiting access to cultural resource information, can make it difficult for developers to select sites that will avoid significant cultural resources. This can cause delays or inaccuracies in the resource analysis during the licensing process and create the need for more extensive site surveys, especially in remote desert areas.

Much of the land under consideration for solar and wind development includes Native American ancestral lands that are centuries old and contain artifacts, burials, historical villages, trails, plants, animals, landscapes, and vistas with cultural and spiritual significance. The spiritual value of these areas and artifacts is separate from the archaeological and historical value of these or other cultural resources and, from a Native American perspective, the loss of the use of these lands or their spiritual context within the landscape cannot be mitigated. Information regarding landmarks and other areas of significance to Native Americans is often known only to tribal elders or tribal historic preservation officers.

Another significant challenge to avoiding or mitigating cultural resource impacts, especially under the California Environmental Quality Act (CEQA), is the lack of flexibility in site location and design once a project reaches the application phase. Developers frequently fail to adequately consider the potential cultural sensitivity of a site through appropriate resource studies and discussions with knowledgeable technical specialists and Native American tribal representatives before settling on a final location. To avoid cultural resources, staff and tribal representatives must have the opportunity to identify resources before site finalization.

Land Use Impacts

Most desert lands in California are owned by the federal government and managed for multiple uses by the BLM and National Park Service. The Department of Defense also owns and manages large tracts of desert land for military purposes. Siting renewable energy facilities on BLM and National Park Service lands can affect existing and future multiple uses such as recreation, wildlife habitat, livestock grazing, and open space. For example, solar thermal

facilities within the BLM's California Desert Conservation Area Plan have significantly impacted or restricted other uses of the land. Similarly, siting renewable energy facilities on or near Department of Defense lands may affect military operations and related programs.

If located in productive agricultural areas, solar thermal or PV projects that require grading of many acres may result in the permanent loss of crop and grazing lands. In contrast, wind energy projects are generally compatible with agricultural land uses and may even help farmers preserve their farms with supplemental income received from leasing land to wind developers.[125] The average wind farm requires 5.5 acres of land to produce 1 MW of electricity, allowing land outside the turbine footprint to remain available for planting and grazing.[126] However, wind projects can affect agricultural resources through soil disturbance during construction and the loss of agricultural land from installing access roads, wind turbine towers, and transmission lines.

Geothermal facilities are usually land intensive and can result in permanent loss of productive agricultural land due to geothermal steam well field development, steam pipeline installation, construction of the power plant facilities and transmission line, and permanent access roads to develop and maintain all of the steam field and power plant facilities.[127]

Transportation-Related Visual Hazards

Solar thermal, PV, wind, and geothermal technologies may cause significant hazards to general aviation and military flight activities in California, as well as to motorists and railroad crews. Solar thermal and PV plants can emit glint and glare from mirrors or collectors that can pose a nuisance to pilots or even cause flash blindness, especially when plants are located near airports. The glint and glare may also temporarily blind or distract motorists and railroad crews. Wind turbines may cause aircraft turbulence due to airflow disruption. The evaporative and dry cooling towers of some solar thermal plants and cooling towers of geothermal plants may emit high velocity, hot air plumes, disrupting airflow and potentially causing severe turbulence to low-flying aircraft. The Department of Defense has also raised concerns about thermal plumes from power plants located near military flight areas and the effect on radar operations. All very tall structures, including wind turbines and solar power towers, have the potential to interfere with low-flying aircraft and with military flight zones that have structure height restrictions.

Planning and Permitting Process Challenges

All proposed generation facilities in California must go through an environmental review and permitting process subject to CEQA and may also be subject to the National Environmental Policy Act (NEPA). When utility-scale renewable energy generation facilities are proposed on federally owned land in California, both CEQA and NEPA processes are necessary. Permitting

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125 http://www.powernaturally.org/Programs/Wind/Wind%20Energy%20Toolkit.pdf.

126 California Energy Commission, *Energy Aware Facility Siting and Permitting Guide*, Consultant Report, December 2010, http://www.energy.ca.gov/2010publications/CEC-600-2010-007/CEC-600-2010-007-D.PDF.

127 http://geoscience.web.officelive.com/geothermal.aspx.

is done at the state, federal and local levels, depending on the size, location, and technology of the proposed facility.

State Permitting of Utility-Scale Thermal Plants

The Energy Commission's licensing process was established in 1974 to provide a comprehensive "one-stop" process for permitting thermal power plants larger than 50 MW, including renewable facilities that use solar thermal, geothermal, and biomass technologies. This streamlined process includes all other state and local permits that projects previously had to acquire individually. The process generally takes 12 to 18 months from application to final decision, unless there are significant changes in the proposed project technology or location or the applicant requests a suspension of the schedule, and includes independent environmental and engineering assessments by Energy Commission staff and coordinated review with federal, state, and local agencies as well as Tribal governments. The resulting staff assessment is the functional equivalent of a draft environmental impact report (EIR) and includes all proposed mitigation that would be required by other state, local, or federal permits. While federal agencies are not required to issue permits for renewable energy projects before or concurrent with the Energy Commission license review process, the Energy Commission cannot approve a project that does not meet federal requirements. Therefore, federal agency participation in the Energy Commission's power plant licensing process provides the best possible assurance that state actions are consistent with federal requirements.

A major challenge in permitting different types of renewable energy projects is that the licensing authority is fragmented among different state and local agencies. This causes inconsistent environmental reviews and standards and inaccurate and incomplete information for both biological and cultural resources, including the location and condition of previously identified cultural sites or surveyed areas. Fragmentation also unnecessarily complicates acquiring data to support the environmental analysis. Agencies may have limited expertise and resources for comprehensive cultural resources analysis, especially at the local level. Also, local agencies may not have up-to-date information on cultural resources, which can compromise information used by other agencies or for other projects in preparing a cumulative impact analysis.

Although state and federal protocols for analyzing impacts to biological and cultural resources are essentially the same, the extent of the evaluation, results interpretation, and mitigation requirements varies. When agencies at all levels of government are unable to agree on a set of conditions, project applicants may find it necessary to satisfy two or more sets of mitigation or licensing conditions, submit duplicative information, or face delays while opposing agencies struggle to retain control or find common ground. Moreover, resources may not be protected to the same extent.

Federal Permits

A number of key federal permit processes that involve multiple agencies and timelines can add uncertainty and delay to renewable energy facility licensing. Examples include:

- Biological resource permit processes under the Endangered Species Act (ESA), administered by the U.S. Fish and Wildlife Service (FWS).
    - When renewable resource projects are proposed on privately owned land with federally listed species found on the site or in the vicinity, the process for obtaining an ESA permit can be extended and difficult due to the lack of a "federal nexus." Without a federal agency such as the BLM involved in the project, there may not be a ready, timely avenue or "nexus" for the request for consultation, which the FWS needs. Another federal agency's request for consultation triggers the FWS Determination process regarding a project's impact on a listed species.
- Air quality Prevention of Significant Deterioration permits under the Clean Air Act, which require a permit or concurrence by the U.S. Environmental Protection Agency (U.S. EPA).
- Water quality permits related to the National Pollutant Discharge Elimination System (NPDES), which adds uncertainty due to changing U.S. EPA regulations and regulatory guidance.
- Federal Land Use Entitlements, which involve federal land management agencies like the BLM or the U.S. Forest Service (USFS) and NEPA compliance.
- Multidisciplinary permitting of interstate natural gas pipelines, which require Federal Energy Regulatory Commission (FERC) approval along with NEPA compliance.
- Multidisciplinary permitting of transmission lines, which involve permits from the Western Area Power Administration (WAPA) and/or the California Public Utilities Commission (CPUC), and associated NEPA and CEQA compliance documents.

In the past, federal agencies have been responsive to the state's needs for timely review of power plant licensing applications. However, in 2009 the timing of federal permits became especially important because of specific build and timing conditions for federal stimulus funding under the American Recovery and Reinvestment Act (ARRA). Challenges in coordinating federal permits in the Energy Commission licensing process include ensuring that necessary information needed by federal agencies is developed and presented early in the process, including the project application prefiling phase. Complex biological mitigation measures like desert tortoise relocation plans must be consistent with measures likely to be required by federal agencies. And to help identify and address critical issues, federal agencies need sufficient staff to write comments and participate in workshops, scoping meeting, and hearings.

Timing of federal permits can affect the licensing process in a variety of ways, including:

- Limiting or delaying information needed to establish project compliance with laws, ordinances, regulations, and standards before licensing.
- Delaying information needed to establish mitigation measures before licensing decisions, which can result in significant changes to proposed projects, a need for additional analyses, and schedule delays.

- Subjecting projects to future appeals when federal permit decisions are made after the Energy Commission has approved a power plant license, appeals over which the Energy Commission may have limited influence.

Permitting at the Local Level

Local governments, primarily larger counties through their planning and redevelopment agencies, also review and permit utility-scale renewable electrical generating facilities (nonthermal projects such as solar PV and wind energy, and thermal projects less than 50 MW). These permits typically require a multidisciplinary CEQA analysis and a public comment and hearing process. Many local governments do not include utility-scale renewable energy facilities in their general plans or zoning ordinances so developers may have to apply for general plan amendments or rezoning, [128] which can complicate and delay the review and approval of renewable generation projects under county jurisdiction (for details see Chapter 10). Local governments also face resource constraints as planning departments are being downsized following the economic downturn.

As part of its "lessons learned" proceeding, the Energy Commission is reviewing the licensing processes for several PV and wind projects both in California and out of state to compare and contrast other jurisdictions' environmental documents with the Energy Commission's siting process.

Local government participation and involvement are also important for projects permitted at the state level. For example, in 2010 the Energy Commission and the BLM permitted numerous large solar thermal projects, for which county fire departments were involved with worker safety and hazardous material management analyses and associated mitigation and conditions of certification. Local agencies have expressed fiscal and environmental concerns about large renewable energy projects and have sometimes formally participated in the Energy Commission's permitting process. Their input and participation have generally led to conditions of certification addressing some of their resource concerns and requirements for local review and comment on various plans such as construction traffic control.

Challenges for Distributed Generation Renewable Projects

Renewable DG projects (20 MW or smaller) also face challenges associated with environmental impacts and planning and permitting processes.

Environmental Challenges

Depending on the technology and the site location, DG projects can cause a range of environmental impacts similar to those of utility-scale projects. DG projects in California must comply with a number of environmental requirements including permits for air quality, water discharge, building standards (for systems that potentially impact the building environment)

128 In California, cities and counties comply with the requirements of Government Code 65300 by adopting a general plan that establishes policy statements that guide how communities prefer to develop. To implement a general plan, communities use their authorization in Government Code 65850 to translate broad general plan policy statements into zoning ordinances or codes regulating specific uses of property and land development standards.

and waste discharge permits (for DG facilities that process solid materials or have disposable wastes).[129] Because of their smaller size, there is greater opportunity to relocate or redesign renewable DG projects to avoid or reduce environmental impacts. In addition, renewable DG technologies like small PV can be located in industrial areas on already disturbed land or on existing residential, industrial, or commercial buildings, which reduces their environmental impact. Similarly, individual or small groups of wind microturbines can be sited and designed to avoid or minimize land use, noise, visual, or habitat impacts.

Biomass DG projects using forest or agricultural waste have smaller footprints than utility-scale facilities and are typically located at or near existing lumber mills or agricultural facilities to maximize fuel access and avoid or minimize land-use conflicts or other environmental impacts. However, these projects can face challenges in securing air permits, particularly in areas with significant air quality issues.

Small hydroelectric projects cause fewer and less severe impacts than large hydroelectric projects. Many new facilities are and will be located in conduits.[130] These projects involve replacing older turbines at existing dams with more efficient equipment; take advantage of pumped storage opportunities; operate to minimize fish mortality; and make use of run-of-river turbines placed in river, stream, and conduit flowing water. In general, using existing disturbed locations and avoiding construction of new impoundments eliminate impacts or keeps them to acceptable levels. However, some existing facilities located on natural waterways designated for critical habitat restoration (such as those located on Battle, Kilarc and Cow creeks, the Klamath River, and in the Trinity River Basin), and new facilities designed with on-stream impoundments adversely affect water resources by changing stream flows, reservoir surface area, the amount of groundwater recharge, water temperature, turbidity (the amount of sediment in the water), and oxygen content. Potential biological impacts include new lakes that can flood terrestrial habitat and changes in water quality and quantity flowing downstream that may alter fish migration patterns and cause other aquatic life impacts. New reservoirs can also damage or inundate cultural, tribal, archaeological, or historical sites. Scenic or wilderness resources can be lost or degraded, and projects can increase landslides and erosion.

Planning and Permitting Process Challenges

Through a review of relevant literature and informal discussions with stakeholders from the private and public sectors, Energy Commission staff identified the following permitting challenges related to renewable DG. Although these are not exhaustive, they represent the variety of permitting challenges facing renewable DG deployment:

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129 Itron, Inc., *Impacts of Distributed Generation: Final Report*, January 2010, http://www.cpuc.ca.gov/NR/rdonlyres/750FD78D-9E2B-4837-A81A-6146A994CD62/0/ImpactsofDistributedGenerationReport_2010.pdf.

130 Conduits are defined in Public Utilities Code Section 399.12, Subdivision (a) as pipelines, aqueducts, irrigation ditches, flumes, siphons, tunnels, or other human-made water distribution infrastructure that operate to distribute water for a beneficial use.

- **Planning:** If a parcel is not zoned for electricity generation, the process to obtain permission to install renewable DG can be quite lengthy and cumbersome, especially for facilities that require large amounts of land. The impact of zoning is less of a problem for rooftop PV because the Solar Rights Act requires local land-use authorities to allow roofs to be used for solar electric facilities. Precedent is less clear regarding the application of the Solar Rights Act to ground-mount solar electric facilities.[131] Similarly, Government Code 65893-65899 establishes regulatory limits that local governments must follow when planning for and permitting small wind turbines.[132] Physical interconnection of DG units to the local distribution network may be complicated, depending on the electricity infrastructure in each community, and upgrades to the distribution system can require local permits.
- **Zoning:** Many cities and counties do not have zoning ordinances that permit and guide the development of renewable DG systems. Without a preferred development pattern for renewable DG projects, developers must request general plan amendments and/or rezoning of developable parcels. General plan amendments and rezones are lengthy and involved processes, and are not preferred choices for expeditious permitting. For example, developers have requested approval to construct larger-scale distributed PV facilities in Alameda County. In response, Alameda County is developing codes and standards for such facilities.[133] Another effort to address this issue is the California County Planning Directors Association (CCPDA) development of a statewide model ordinance for solar electric facilities.[134]
- **Varying codes, standards, and fees:** Stakeholders indicate the land-use permitting process for identical renewable DG systems varies significantly from jurisdiction to jurisdiction.[135] This inconsistency makes it difficult for developers to create an efficient process to meet permit requirements and increases the risk associated with securing project approval. Moreover, permit fees and calculation methods vary statewide.[136] In 2010 and 2011, the Sierra Club, Loma Prieta Chapter, conducted surveys on permitting costs and processing

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131 See Section 4 beginning on page 12 of "California's Solar Rights Act: A Review of the Statutes and Relevant Cases: http://www.sandiego.edu/epic/research_reports/documents/100426_SolarRightsAct_FINAL.pdf.

132 Though GC 65893-65899 does not establish a "right" to wind resource access the same way that the Solar Rights Act does for solar resources, GC 65893-65899 does place limits on local regulatory agencies. See http://www.leginfo.ca.gov/cgi-bin/displaycode?section=gov&group=65001-66000&file=65893-65899.

133 See the county staff memo to the Board of Supervisors detailing the county's approach to permitting solar PV. http://www.co.alameda.ca.us/cda/planning/landuseprojects/documents/Board_Transportation_&_Planning_solar_memo_6-6-11.pdf.

134 http://www.ccpda.org/en/model-sef-ordinance/130-ccpda-model-sef-ordinance-development-progress-report.

135 Sun Run's comments to the Energy Commission's solicitation for comments regarding the Renewable Planning and Permitting Program and Large-Scale Solar Association's comments on the proposed RP3 program. Docket 02-REN-1038.

136 Little work has been done in regard to determining the permitting costs of larger renewable DG systems; however, the Sierra Club's Loma Prieta Chapter has completed extensive work to determine the permitting costs of rooftop PV systems in most California jurisdictions. http://lomaprietaglobalwarming.sierraclub.org/solar.php.

times for solar PV systems in various jurisdictions throughout California.[137] The range of fees in the municipalities surveyed in each county varied widely; in Los Angeles, for example, fees for commercial PV projects 131 kW in size ranged from $0 to $46,000. In general, the surveys found that the cost of a PV project does not correlate with the staff hours a municipality must devote to plan review and inspection. In addition, basing a permit fee on the valuation of a PV system tends to generate higher fees than the actual cost to service a permit, since the time involved for review and inspection does not appear to be linear; for example, it does not take 10 times as long to evaluate a 100 kW system as a 10 kW system. In the counties surveyed, the percentage of municipalities that exceeded maximum estimated cost recovery fees for commercial systems ranged from 17 to 65 percent.

- **Williamson Act issues:**[138] Many land owners have Williamson Act contracts on rural parcels that can easily accommodate distributed or utility-scale renewable energy systems. However, it can be cumbersome to complete the process needed to allow nonagricultural use of Williamson Act land. If renewable energy is not considered "a compatible use," land owners must cancel, non-renew, or rescind their contracts to develop renewable energy facilities on Williamson Act land. Senate Bill 618 (Wolk, Chapter 596, Statutes of 2011) provides another way to rescind a Williamson Act contract for the purpose placing a solar use easement on unproductive and nonprime agricultural land. The process requires local government approval of the rescission as well as approval by the state Department of Conservation in consultation with the state Department of Food and Agriculture. However, challenges remain to balance the need to conserve farmland with the development of renewable energy in California. For example, on October 31, 2011, the California Farm Bureau Federation sued the Fresno County Board of Supervisors , arguing that the county violated the Williamson Act when it approved a partial cancellation pertaining to 90 acres of a 156-acre parcel of prime agricultural soil to allow the land to be opened to development of the 18 MW Westlands solar project.[139]

- **Vague, duplicative, and uncoordinated permitting processes:** Permit approvals typically require renewable DG builders to secure approval from local fire departments, building and electrical code officials, and local air districts before receiving a zoning clearance to build a facility. If the proposed site for renewable DG development is not privately held, the public land holding body (for example, the BLM or the Department of Defense) may impose additional permitting requirements. The permit application process is inefficient, and efforts

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137 Sierra Club Loma Prieta Chapter Website, http://www.lomaprietaglobalwarming.sierraclub.org/solar.php.

138 The California Land Conservation Act of 1965 (Williamson Act) allows local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural, open space, or compatible uses for 10 years. These contracts automatically renew each year. In return, landowners receive lower than normal property tax assessments based on farming and open space uses as opposed to full market value. For more information, see California State Department of Conservation, http://www.conservation.ca.gov/dlrp/lca/Pages/Index.aspx.

139 *The Fresno Bee*, "Farm Bureau Sues to Block Fresno Co. Solar Project," October 31, 2011, http://www.fresnobee.com/2011/10/31/2598067/state-farm-bureau-sues-to-block.html#storylink=mirelated.

are duplicated because many agencies are involved in reviewing and approving development applications. According to stakeholders, the lack of coordination among permitting bodies is a barrier for developing all scales of renewable DG, including residential rooftop PV.[140]

- **Unknown environmental review and mitigation requirements:** Similar to utility-scale renewable facilities, DG development in California is subject to an environmental review under CEQA and, in some cases, NEPA. On a project-by-project basis, the environmental review requirement adds uncertainties to renewable DG projects. If a lead permitting agency determines that an EIR is necessary to assess potentially significant project impacts, additional time and mitigation requirements may make a project infeasible. Stakeholders comment that lead permitting agencies have thorough environmental screening and review processes in place for traditional development, but many lead agencies are not prepared to assess environmental impacts associated with renewable DG.[141]

Efforts to Address Environmental, Planning, and Permitting Challenges

The importance of streamlining renewable permitting processes is widely recognized; therefore a number of efforts are either completed or underway to help promote the development of utility-scale renewable electricity generating facilities in California. This section describes these efforts and status. For details on efforts to address challenges associated with DG renewable facilities, see Chapter 10.

Renewable Energy Transmission Initiative

In 2007, the Renewable Energy Transmission Initiative (RETI) was initiated as a joint statewide effort combining land use and transmission planning factors among the CPUC, the Energy Commission, the California ISO, and investor-owned and publicly owned utilities.[142] The primary goals of RETI were to (1) help identify the transmission projects needed to accommodate California's renewable energy goals; (2) ease the designation of corridors for future transmission line development; and (3) facilitate transmission line and renewable generation siting and permitting. The stakeholder-driven process identified Competitive Renewable Energy Zones throughout the state with the greatest potential for cost-effective and environmentally responsible renewable energy development. For more information on the transmission aspects of the RETI process, see Chapter 4.

Renewable Energy Action Team

To address challenges with permitting renewable projects in sensitive California desert regions, the Renewable Energy Action Team (REAT) was formed in 2008 to streamline and expedite the

140 Comments by SunRun regarding the Renewable Planning and Permitting Program, Docket 02-REN-1038.

141 Comments by San Diego County regarding the Renewable Planning and Permitting Program , Docket 02-REN-1038.

142 For more information about the RETI process and results, see http://www.energy.ca.gov/reti/index.html.

permitting processes for renewable energy projects while conserving endangered species and natural communities at the ecosystem scale.[143] Based in part on recommendations from the RETI project, the REAT is developing a Desert Renewable Energy Conservation Plan (DRECP) for the Mojave and Colorado Desert regions (for details on this project, see the next topic).

The REAT also published the multidisciplinary *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects* in December 2010 to help project developers design projects that minimize environmental impacts for renewable desert projects.[144] The manual provides guidance on initiating permitting processes, conducting land-use assessments and surveys, decisions on water use and quality, roadway planning, avoiding conflicts with aviation, and grid interconnection issues.

Figure 4: Desert Renewable Energy Conservation Plan Area

Source: California Energy Commission, Hhttp://www.drecp.org/maps/H.

Desert Renewable Energy Conservation Plan

In conjunction with other federal, state, and local agencies and stakeholder groups, the REAT is developing the DRECP to identify areas in the Mojave and Colorado Desert regions suitable for renewable energy project development and areas that will contribute to the conservation of sensitive species and natural communities.[145] The DRECP encompasses about 22 million acres in Kern, Inyo, Los Angeles, San Bernardino, Riverside, San Diego, and Imperial counties (Figure 4). It

143 Executive Order S-14-08), which established accelerated RPS targets (33 percent by 2020), also called for the formation of the Renewable Energy Action Team, composed of the Energy Commission, California Department of Fish and Game, U.S. Department of the Interior Bureau of Land Management, and U.S. Fish and Wildlife Service. These organizations signed a memorandum of understanding in November of 2008; in July 2011, the California Public Utilities Commission and the State Lands Commission signed on as well.

144 Renewable Energy Action Team, *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects*, December 2010, http://www.drecp.org/documents/index.html.

145 http://www.drecp.org/.

will promote development of solar thermal, utility-scale solar PV, wind, and other forms of renewable energy along with associated infrastructure like transmission lines. The DRECP will be a Natural Community Conservation Plan (NCCP) and will serve as the basis for one or more Habitat Conservation Plans (HCP).[146] As required by state and federal law, the environmental impact of the DRECP will be analyzed in a joint environmental impact report and statement anticipated to be completed by December 2012, along with the NCCP.

In October 2011, the draft *Preliminary Conservation Strategy* was released for comment.[147] The draft report identifies proposed principles to guide covered activities proposed for "take" authorization under the DRECP[148] and regional maps identifying possible renewable resource development areas, and existing and potential transmission corridors. The Energy Commission's multidisciplinary staff is refining an acreage calculator based on inputs of variables such as load growth, available zero- and low-carbon resources and distributed generation, and desired greenhouse gas reductions or Renewables Portfolio Standard mandates.[149]

Solar Energy Development Programmatic Environmental Impact Statement

At the federal level, the U.S. Department of Energy, Energy Efficiency and Renewable Energy Program, and the U.S. Department of the Interior, Bureau of Land Management, are preparing a Solar Energy Development Programmatic Environmental Impact Statement (PEIS) to assess environmental impacts from programs intended to promote environmentally responsible utility-scale solar energy in six Western states.[150] The draft PEIS was issued December 16, 2010, and in May 2011 the Energy Commission and the California Department of Fish and Game (DFG) submitted joint comments on the draft with the following recommendations: [151]

- Abandon further consideration of the Iron Mountain Solar Energy Zone (SEZ).
- Consider designating and studying additional SEZs on previously disturbed lands in the western Mojave Desert.

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146 See Department of Fish and Game, http://www.dfg.ca.gov/habcon/nccp/ and U.S. Fish and Wildlife, http://www.fws.gov/endangered/what-we-do/hcp-overview.html.

147 Dudek and ICF International, Draft Preliminary Conservation Strategy, October 2011, http://www.drecp.org/documents/preliminary_conservation_strategy/index.php.

148 The Endangered Species Act prohibits the "take" of listed species through direct harm or habitat destruction. In 1982, congress authorized the U.S. Fish and Wildlife Service to issue permits for the "incidental take" of endangered and threatened wildlife species, and requires a permit applicant to design, implement, and secure funding for a Habitat Conservation Plan to minimize and mitigate harm to the impacted species during the proposed project. For more information, see http://www.fws.gov/Endangered/permits/index.html.

149 As described in Chapter 2, the acreage calculator was used to develop estimates of the amount of zero-emission generation needed to achieve 2050 greenhouse gas reduction goals.

150 States include Arizona, California, Colorado, New Mexico, Nevada, and Utah, http://solareis.anl.gov/.

151 http://www.energy.ca.gov/siting/solar/peis/agency_comments/.

- Delay final PEIS-triggered amendments to the affected Land Use Management Plans until the DRECP process is complete in 2012.
- Fully consider and address all Energy Commission and DFG comments made previous to and in response to the publication of the draft PEIS.

A supplement to the draft PEIS was released in the fall of 2011.

Proceeding on Siting "Lessons Learned"

In December 2010, the Energy Commission initiated an Order Instituting an Informational (OII) Proceeding on issues critical to the licensing of thermal power plants. This proceeding is examining "lessons learned" from the review of ARRA solar projects and natural gas-fired power plants during 2009 and 2010. The proceeding is assessing the Energy Commission's power plant siting processes and examining critical issues common among solar thermal and/or conventional power plants. The "lessons learned" process is considering information from power plant siting cases, publications such as the *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects*, other agencies, stakeholders, and the public.[152]

The OII Proceeding began with a scoping workshop to solicit written and oral comments from various stakeholders including project proponents, project intervenors, environmental organizations, local government officials, advocacy organizations, elected officials, and the public. Furthermore, staff distributed a questionnaire to more than 1,000 individuals and organizations that had either been involved or had a stake in the Energy Commission's siting program during 2010, including both renewable and fossil-fueled projects. Figure 5 identifies those issues that were of most concern to respondents.

The Energy Commission's OII Proceeding will hold a public workshop in December 2011. The Energy Commission will continue to seek input from stakeholders and the public on ways to improve and streamline the siting process. Recommended changes and revisions of current siting regulations would occur through an Order Instituting Rulemaking (OIR) proceeding, which will most likely take place in early to mid-2012.

Cross-Agency Coordination

State and federal agencies are working to streamline the permitting of renewable energy projects in California by increasing cross-agency cooperation and coordination, with several multi-agency agreements already in place:[153]

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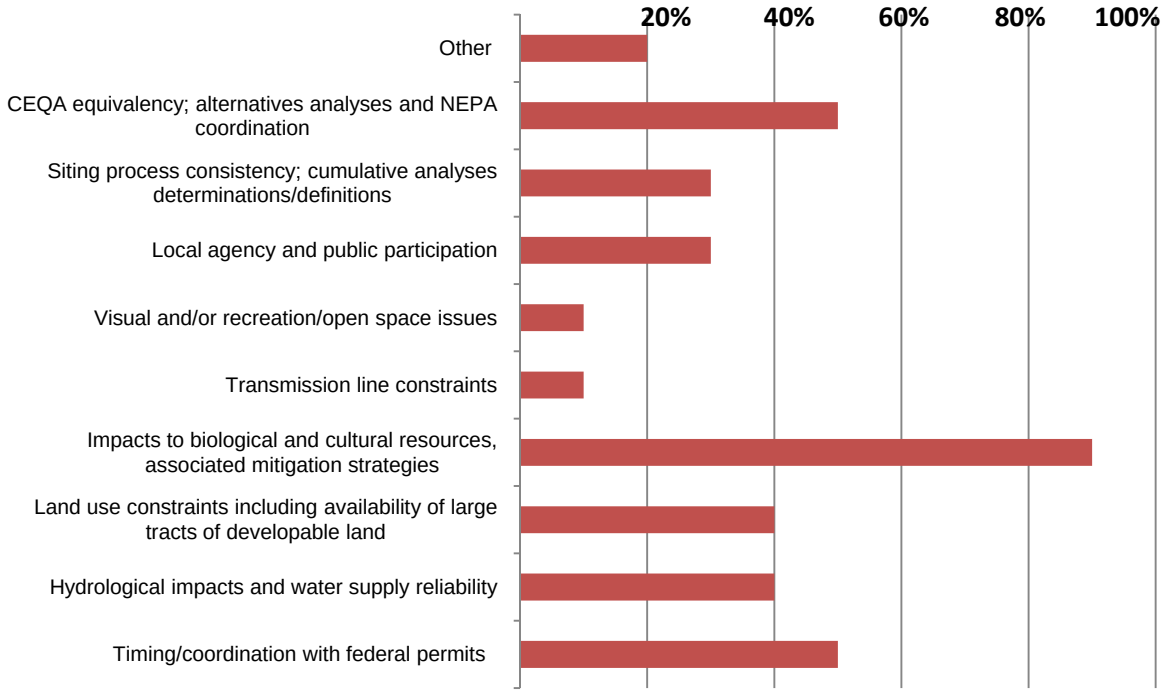
152 At this time, the Energy Commission is not planning to update the *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects* based on the "lessons learned" or other proceedings. Future updates may be warranted as new information becomes available.

153 The Energy Commission and Governor's staff are also working on a Memorandum of Understanding with the Department of Defense to facilitate renewable resource development and related environmental protection at the numerous military bases located in California, including several in the Mojave and Colorado Desert regions.

Figure 5: Responses to Questionnaire on Siting Process Issue Priorities



Source: California Energy Commission

- In 2007, the Energy Commission, the U.S. Department of the Interior, and the BLM signed a memorandum of understanding (MOU) on agency roles, responsibilities, and procedures for joint environmental review of solar thermal projects proposed on federal land.
- In 2009, the Energy Commission entered into an MOU with the California State Lands Commission to ensure timely and effective coordination during the Energy Commission's thermal power plant review process.
- In 2010, the State of California and FERC signed an MOU to coordinate and share information for reviewing offshore wave and tidal energy projects.
- In 2010, the Energy Commission and the Departments of General Services, Corrections and Rehabilitation, Transportation, Water Resources, and Fish and Game signed an MOU to promote the development of renewable energy projects on state buildings, properties, and rights-of-way. The State Lands Commission and University of California subsequently joined the MOU. For details, see Chapter 10.

CHAPTER 4:
Transmission Infrastructure Issues

In addition to the environmental, planning, and permitting issues identified in the previous chapter, California also faces challenges to planning and permitting power lines and other transmission infrastructure needed to bring electricity generated by large-scale renewable facilities to consumers. Governor Brown's Clean Energy Jobs Plan states that the Energy Commission "should 'fast-track' projects based on their anticipated ability to deliver clean energy to market. The permitting time for these projects – which now can take six to eight years – should be dramatically reduced, and in no case be longer than three years." Furthermore, the Plan states, "As Governor, I will ensure that all agencies involved work together with a sense of urgency to permit the new transmission lines without delay."[154]

About This Chapter

This chapter explains key transmission challenges to achieving California's renewable goals, including the need for:

- A fully coordinated and effective statewide transmission planning process that comprises both transmission and land-use planning.
- Better use of the grid and strategic upgrades to the state's transmission system.
- Completion of licensing and construction for transmission projects and upgrades that have already been identified as necessary for meeting RPS targets, particularly interconnection of renewable generation projects receiving funding through the American Recovery and Reinvestment Act (ARRA) of 2009.
- Transmission projects and upgrades necessary to accommodate new renewable generating facilities throughout the state (with a detailed status of each project provided in Appendix F).

This chapter also describes efforts underway to address such challenges, including:

- Improved transmission planning in California, including the 2007-2010 Renewable Energy Transmission Initiative (RETI) process;[155] the Renewable Energy Action Team (REAT) and Desert Renewable Energy Conservation Plan (DRECP);[156] transmission planning efforts by the California Transmission Planning Group;[157] and the 2010-2011 California Independent System Operator (California ISO) transmission plan that identifies upgrades needed to meet grid reliability, bring economic benefits to consumers, and meet California's RPS mandate.

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154 http://www.jerrybrown.org/Clean_Energy.

155http://www.energy.ca.gov/reti/index.html.

156 Desert Renewable Energy Conservation Plan website at: http://www.drecp.org/.

157 *Final 2010 California Transmission Planning Group Statewide Transmission Plan* February 9, 2011, http://ctpg.us/public/images/stories/downloads/2011-02-09_final_statewide_transmission_plan.pdf.

- A stakeholder process for better integration of transmission planning and generation interconnection spearheaded by the California ISO,[158] and issues associated with resource adequacy (RA) requirements for renewable projects that could adversely affect developers' ability to obtain power purchase agreements needed to support project financing.
- Western region system planning and projects to support renewable development.

Description of Challenges

Many entities have a role in bulk transmission planning and permitting in California (Table 10). Multiple players, each with complex and unique responsibilities, make it difficult and time-consuming to reach coordinated transmission planning decisions that result in permittable, appropriate transmission projects for interconnecting renewable generation projects. This section describes the major planning, permitting and interconnection, and Western regional coordination challenges that will affect California's ability to achieve its renewable energy goals.

Planning Challenges

Lack of Coordinated Land Use and Electric Transmission System Planning

With Governor Brown's characterization of the 33 percent RPS by 2020 mandate as a floor rather than a ceiling, it is imperative to streamline and coordinate transmission planning processes so that the most appropriate transmission projects to interconnect renewables are sited, permitted, and constructed. This must be accomplished while avoiding duplication, eliciting opportunities for joint projects among investor-owned and publicly owned utilities and/or independent transmission developers, and ensuring appropriate consideration of land-use and environmental issues.

In the *2008 Integrated Energy Policy Report Update*, the Energy Commission assessed major transmission barriers to achieving the state's renewable energy and greenhouse gas emission reduction goals. The report states that "most notable is the lack of a fully coordinated and effective statewide transmission planning process that includes broad stakeholder support and targets the most cost-effective and environmentally acceptable transmission additions and upgrades to access renewables." In response, the *2009 Strategic Transmission Investment Plan* emphasizes the need for statewide coordinated transmission planning and effective ways to resolve environmental and land-use conflicts that emerge when permitting transmission lines.[159]

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158 See California ISO's July 21, 2011, straw proposal on Integration of Transmission Planning and Generation Interconnection Procedures, http://www.caiso.com/Documents/StrawProposal-TransmissionPlanning-GenerationInterconnectionIntegration.pdf.

159 *2009 Strategic Transmission Investment Plan*, p. 1, California Energy Commission, Sacramento, California, December 2009, Publication Number CEC-700-2009-011-CMF, http://www.energy.ca.gov/2009publications/CEC-700-2009-011/CEC-700-2009-011-CMF.PDF, posted December 16, 2009.

Table 10: Agencies with Bulk Electric Transmission Planning and Permitting Authority

Agency	Planning and Permitting Authority
Federal Energy Regulatory Commission (FERC)	Planning: FERC Order No. 890 (February 16, 2007) requires FERC jurisdictional (IOU) transmission providers, including independent system operators and regional transmission organizations, to participate in a coordinated, open, and transparent transmission planning process at both a local and regional level, and file revisions to their *pro forma* Open Access Transmission Tariffs to conform to the rule. Each transmission provider's planning process must meet nine planning principles: coordination, openness, transparency, information exchange, comparability, dispute resolution, regional coordination, economic planning studies, and cost allocation. NonFERC jurisdictional (publicly owned utility [POU]) transmission providers voluntarily comply with Order No. 890 as members of regional planning groups. The Western U.S. has four regional planning groups, including the California ISO under FERC jurisdiction. Planning: FERC Order No. 1000 (July 21, 2011) reforms FERC's electric transmission planning and cost allocation requirements for FERC jurisdictional (IOU) transmission providers, including independent system operators and regional transmission organizations. FERC jurisdictional transmission providers must: (1) participate in a regional transmission planning process that satisfies the requirements set out in FERC Order No. 890 and produce a regional transmission plan; (2) establish procedures to identify transmission needs driven by public policy requirements established by state and federal laws or regulations; and (3) coordinate with neighboring transmission planning regions to determine if there are more efficient or cost-effective solutions to mutual transmission needs. There are three requirements for transmission cost allocation: (1) Each public utility transmission provider must participate in a regional transmission planning process that has a regional cost allocation method for new transmission facilities; (2) neighboring transmission planning regions must have a common interregional cost allocation method for new interregional transmission facilities; and (3) participant funding of new transmission facilities cannot be adopted as regional or interregional cost allocation method. The ruling also eliminates the federal right of first refusal for facilities subject to regional cost allocation. Permitting: Per the Energy Policy Act of 2005 (EPAct-05), Section 1221, the FERC may issue a construction permit for electric transmission facilities in a designated national interest electric transmission corridor if a state does not have permitting authority or does not have the authority to consider interstate benefits expected of proposed facilities. The FERC may also issue a construction permit if a state has authority to permit proposed facilities but has withheld approval for more than one year after the filing of an application, or after designation of a corridor, or has conditioned approval in such a way that the proposed construction will not significantly reduce congestion.
United States Department of Energy (DOE)	Planning: Under ARRA, the DOE provides direction and funding for production of the first Western Interconnection 10-year regional transmission plan in September 2011. A 20-year plan is due to DOE in 2013 as well as a 2013 10-Year Regional Plan. Permitting: DOE issues permits to locate transmission facilities on DOE-controlled lands. DOE issues presidential permits to construct transmission lines that cross the U.S. border.
Federal Land Management Agencies	Planning: Perform corridor identification on federal lands. U.S. Bureau of Land Management (BLM) identified corridors for transmission lines in its California Desert Conservation Area Resource Management Plan. The U.S Department of Agriculture Forest Service must address utility corridors in forest land-use plans. BLM and U.S. Fish and Wildlife Service are parties to the DRECP Planning Agreement (along with the Energy Commission and the California Department of Fish and Game.) Permitting: BLM and Forest Service act as lead agencies for environmental impact statements on federal lands and issue land use permits.

Agency	Planning and Permitting Authority
Energy Commission	Planning: Assesses electricity supply and demand trends and potential impacts of electricity infrastructure and resource additions on electricity systems, public health and safety, the economy, and the environment. (Public Resources Code section 25300 et seq.), with assessment used by other agencies in their planning and permitting procedures. Prepares biennial *Strategic Transmission Investment Plan* (STIP) identifying transmission projects necessary for the state's electric transmission grid. (Public Resources Code section 25324). Designates transmission corridors on its own or proposed by others for future transmission lines, consistent with the STIP. Participates in the Renewable Energy Action Team in developing the DRECP. Permitting: Energy Commission licenses transmission lines associated with thermal power plant projects in its jurisdiction. Also evaluates transmission grid impacts and upgrades needed as a result of the power plant's interconnection with the grid. The Energy Commission permit is in lieu of all other state and local permits, and the process is a certified California Environmental Quality (CEQA)-equivalent process.
California Public Utilities Commission (CPUC)	Planning: Approves IOUs' biennial long-term procurement plans (LTPPs), which establish authority to contract for new power supplies. (Competitive bids to supply power must include transmission costs; LTPPs are based on Energy Commission demand forecasts and must reflect "loading order" resource preferences.) Participates in the Energy Commission collaborative *Integrated Energy Policy Report* process. Has the authority to order IOUs to build transmission. Permitting: CPUC issues certificates of public convenience and necessity (CPCNs). This process considers California ISO findings of need and reviews CEQA compliance for IOU transmission lines greater than 200 kV. Issues a permit to construct (which includes CEQA compliance) for projects between 50 kV and 200 kV. CEQA requires other state agencies to use the CPUC's completed environmental document to decide whether or not to grant their required permits for a transmission project. Thus, transmission projects may require other permits after completing the CPUC process.
California Independent System Operator (California ISO)	Planning: Serves as planning authority for the California ISO balancing authority area. Conducts annual stakeholder transmission planning process to determine the need for projects to maintain reliability and/or promote economic efficiency of the California ISO-controlled grid by evaluating reliability projects for each IOU, as well as reliability projects for the California ISO-controlled grid. Functions as the planning authority for its footprint (primarily IOU service areas), and provides FERC with findings of project need prior to FERC determination on whether a utility can recover transmission costs. Uses Energy Commission demand forecasts. Identifies projects needed to meet California's policy goals. Evaluates local capacity requirements annually. Studies specific areas for potential economic projects. Participates in the California Transmission Planning Group (CTPG), along with IOUs and POUs, to develop a California statewide transmission plan to meet the state's 33 percent by 2020 RPS mandate. Has a memorandum of understanding with the CPUC that seeks to coordinate the California ISO's revised transmission planning process and identification of needed transmission infrastructure with the CPUC's subsequent siting and permitting process. Permitting: None. However, California ISO provides testimony in CPUC CPCN transmission proceedings in support of IOU-sponsored projects. In collaboration with Energy Commission staff, provides transmission grid impacts assessment related to power plant interconnections in Energy Commission power plant licensing cases. While the California ISO does not have statutory siting authority, as the grid operator it does approve or disapprove generation projects for interconnection with the grid.

Agency	Planning and Permitting Authority
Publicly Owned Utilities (POUs) (Municipal, cooperatives, and federal power marketers)	Planning: Voluntarily comply with FERC Order No. 890 as members of regional planning groups that conduct coordinated, open, and transparent transmission planning at both a local and regional level. California municipal utilities participate in the CTPG, along with IOUs and the California ISO, to develop a California statewide transmission plan to meet the state's 33 percent by 2020 RPS mandate. Permitting: As local agencies, POUs can act as CEQA lead agencies for their own transmission projects.
Local Agencies	Planning: When the Energy Commission has designated a transmission corridor in one or more local agency's jurisdiction, the affected cities and counties must consider whether each subsequent land-development proposal within or near the corridor would threaten future transmission line construction there. If so, the local jurisdiction must notify the Energy Commission. If the land-development project is approved over the Energy Commission's objections, it must provide written justification for rejecting the Energy Commission's comments and recommendations. Permitting: Local agencies issue permits for projects not subject to CPUC jurisdiction.

The greatest opportunity for shortening planning and permitting processes and increasing the quality of decisions lies with coordinating land-use and transmission ("wires") planning. For example, the California ISO transmission planning process (Figure 6) takes 16 months to finalize a comprehensive transmission plan and seven months to select project sponsors, if applicable.[313] The subsequent utility project development process (Figure 7) can take more than two years. These two timelines are essentially sequential because the California ISO planning process focuses only on wires planning, and the identification of routing issues and constraints begins after the wires approval. The construction time needed for a large transmission project is typically two years, for a total of roughly six years from project planning to commercial on-line date. However, as shown in Figure 7, Southern California Edison (SCE) identifies communication "touch points" with agencies through which it can achieve a shorter processing and approval time frame for CEQA/NEPA licensing and cooperating agency permits.

A statewide coordinated planning process that includes both land-use and wires planning has not yet been addressed. At the May 17, 2011, IEPR Committee workshop on transmission needed to meet state renewable policy mandates and goals, participants identified specific planning challenges. Comments included:

- The state needs "to better coordinate planning across the various entities."[314]
- The state needs "to raise the stakes and raise the engagement levels of the agencies so that, at some point, … we have ISO Board members, PUC Commissioners, and CEC Commissioners, all on the same dais, all hearing about these problems, and at that level getting a higher level of commitment to engage with each other."[315] There is a need for "greater linkages between the federal agencies … that have a piece of this, particularly BLM and U.S. Fish and Wildlife Service and, again, that gets back to the land use – that one agency, as we've learned throughout this process, can delay everybody else's successful work if they're not brought in, and somehow accommodated. And it's not so much a matter of changing or giving in as a matter of people need to understand what these constraints are and we need to not marginalize them."[316]

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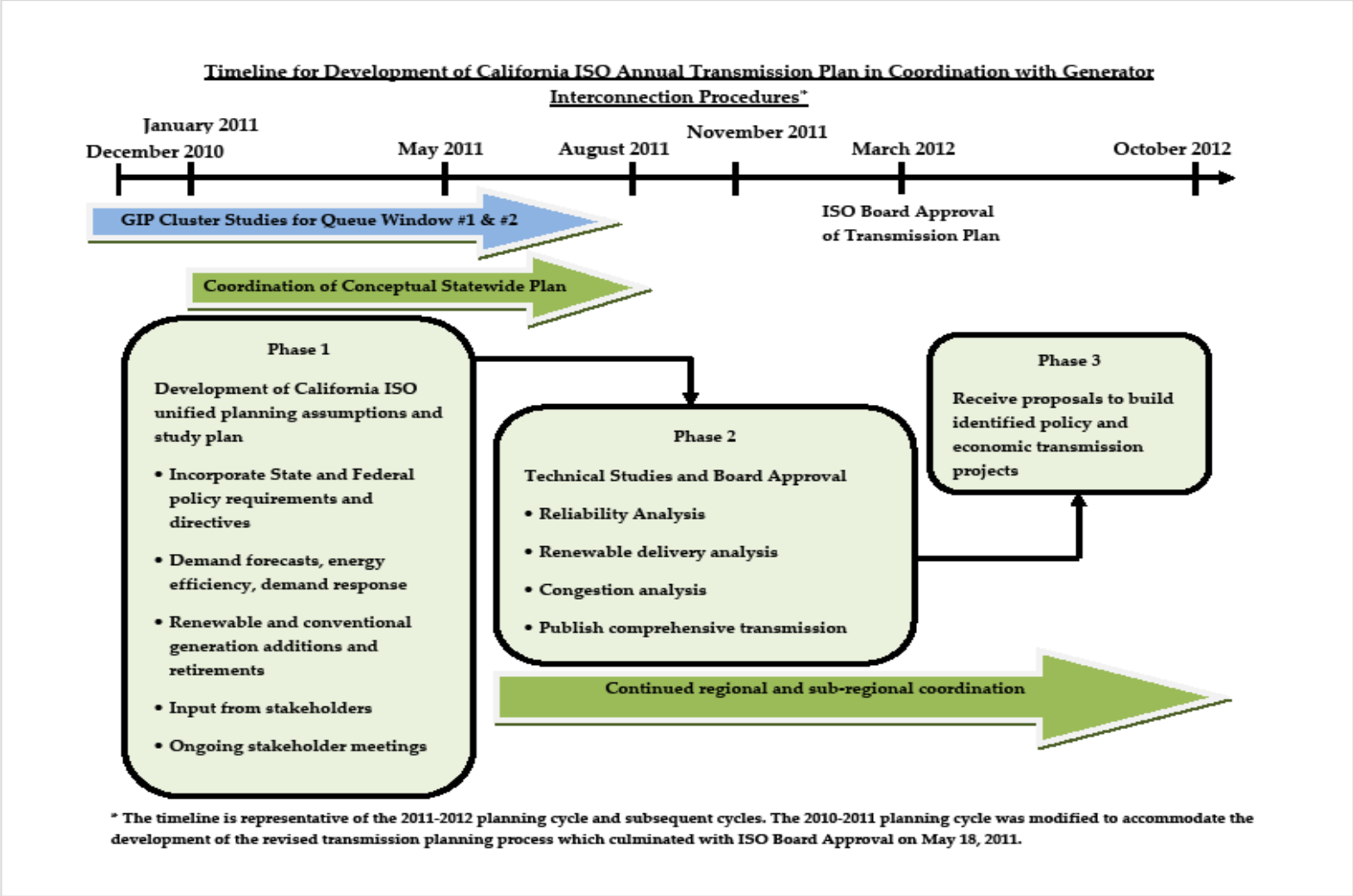
313 This seven-month process applies to economically driven and Category 1 policy-driven elements identified in the comprehensive transmission plan.

314 Zichella, Carl, Natural Resources Defense Council, Transcript of the May 17, 2011 *IEPR Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, p. 144, California Energy Commission, Sacramento, California, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/2011-05-17_Transcript.pdf .

315 White, V. John, Center for Energy Efficiency and Renewable Technologies, Transcript of the May 17, 2011 *IEPR Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, p. 157, California Energy Commission, Sacramento, California, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/2011-05-17_Transcript.pdf.

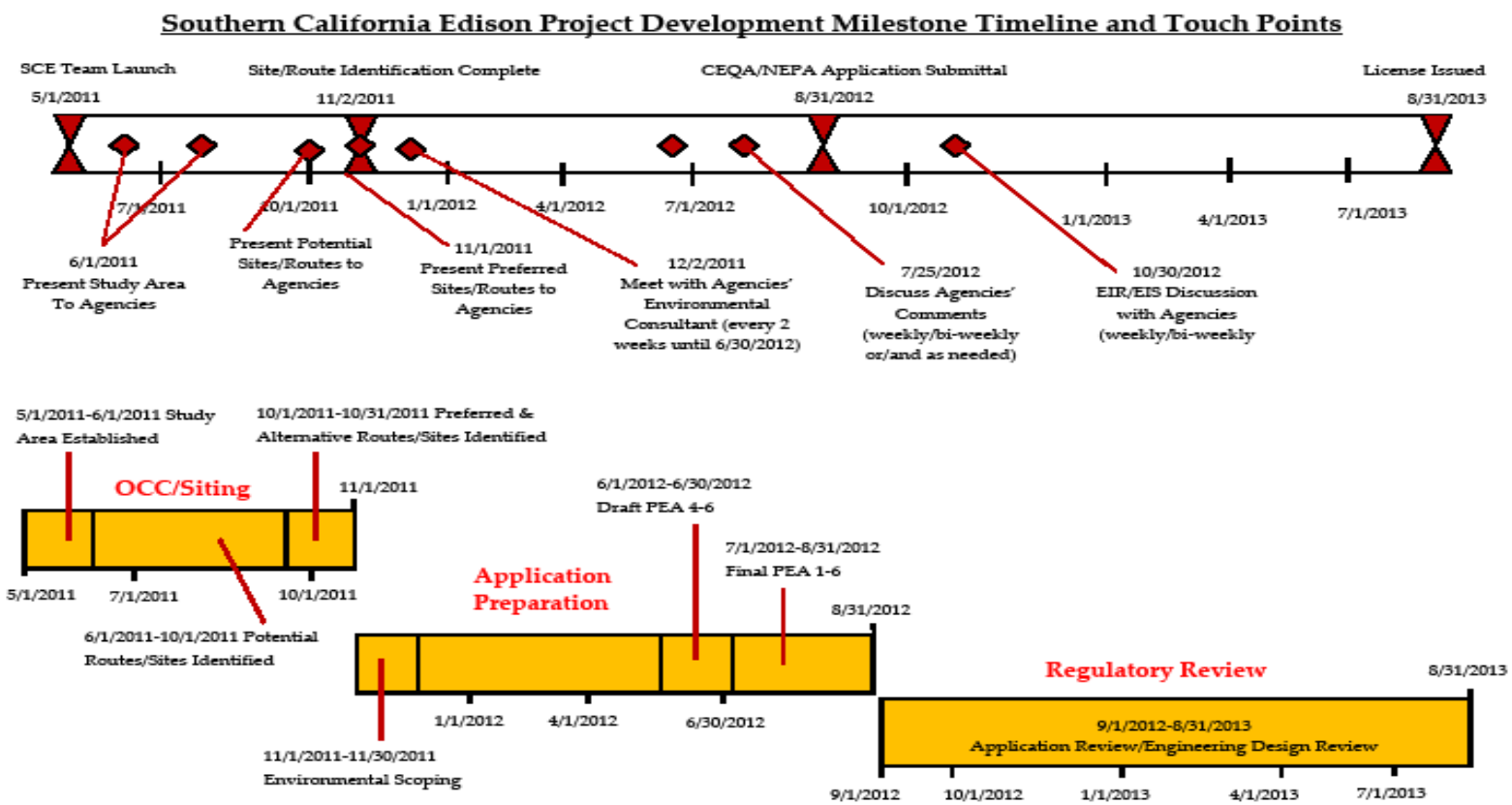
316 White, V. John, Center for Energy Efficiency and Renewable Technologies, Transcript of the May 17, 2011, *IEPR Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, p. 157, California Energy Commission, Sacramento, California, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/2011-05-17_Transcript.pdf.

Figure 6: Timeline for Development of California ISO Annual Transmission Plan



Source: July 8, 2011, PowerPoint presentation, slide 8,: "California ISO 2011/2012 ISO Transmission Plan Renewable Portfolios" and November 2, 2010, Board of Governors PowerPoint Presentation, slide 6,: "Generation Interconnection Queue and ARRA Projects Update."

Figure 7: Example of Southern California Edison Transmission Project Development Milestone Timeline



Source: SCE Project Milestones and Agency Coordination: CEQA/NEPA Application and Approval Process Presentation to California REPG on May 20, 2011

- "[I]t's difficult to get to a decision point without participating in a number of different processes."[317]
- Results from the DRECP process must be directly usable in the CPUC permitting process.[318]
- The assumptions and processes used by transmission planning organizations are not always transparent and/or consistent.
- The large number of transmission planning forums makes it difficult for stakeholders to participate effectively.
- Streamlining and accelerating the process must not hamper effective environmental consideration.
- Independent transmission project developers need to be able to compete on a level playing field with incumbent utilities.

Another area where coordination of land-use and wires planning is important is the designation of transmission corridors ahead of need. Senate Bill 1059 (Escutia, Chapter 638, Statutes of 2006) authorizes the Energy Commission to designate suitable transmission corridors for future high-voltage electricity transmission projects, consistent with the state's electricity needs. However, a barrier to the successful implementation of the corridor designation program is the uncertainty of cost recovery for land purchased within an Energy Commission-designated corridor for future transmission projects. To qualify for cost recovery, FERC requires IOUs to obtain a certificate of public convenience and necessity from the CPUC for a specific transmission project within a designated corridor. The *2009 Integrated Energy Policy Report* identified this barrier and stated, "FERC should allow an IOU to qualify for cost recover if land is set aside for one or more transmission projects that may be constructed 10-15 years in the future and is within an Energy Commission-designated corridor."

In written comments submitted after the September 14, 2011, IEPR workshop on the draft *Renewable Power in California: Status and Issues* report, SCE reiterated concerns about this issue, noting that "a key element to corridor designation will be an extension of the time that utilities are allowed to hold undeveloped land in rate base. Until that is clearly established, SCE is unlikely to apply for corridor designation at the Energy Commission."[319]

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317 Zichella, Carl, Natural Resources Defense Council, Transcript of the May 17, 2011 *IEPR Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, p. 144, California Energy Commission, Sacramento, California, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/2011-05-17_Transcript.pdf.

318 Alvarez, Manuel, Southern California Edison, *California Energy Commission Docket Nos. 11-IEP-1E and 11-IEP-1G: Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, May 24, 2011, p. 4, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/comments/SCE_Comments_on_Renewable_Policy_Mandates_and_Goals_TN-60905.pdf.

319 Alvarez, Manuel, Southern California Edison, *California Energy Commission Docket Nos. 11-IEP-1E and 11-IEP-1G: Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, May 24, 2011, p.

Better Use of the Grid and Strategic Upgrades

In 1988 the California Legislature passed Senate Bill 2431 (Garamendi, Chapter 1457, Statutes of 1988), which directed the Energy Commission to prepare a report outlining recommended policies and actions to facilitate effective, long-term transmission line corridor planning.[320] The report states that utilities should take appropriate mitigation measures to reduce the environmental impacts of approved projects.[321] The report also identified that the absence of coordinated transmission and land-use planning is a major impediment to transmission development in California. It called for a process to identify environmentally sensitive areas, acceptable areas, and areas where urban encroachment into transmission rights-of-way could pose problems.[322] The basic principles and policies expressed in this effort, emphasizing existing line upgrades and the use of existing rights-of-way whenever possible,[323] formed a sound foundation for assessing and designating transmission corridors then and are still persuasive today.

At the May 17, 2011, IEPR Committee transmission workshop on transmission (and in subsequent filings), participants identified specific challenges regarding greater grid use and strategic upgrades. Comments include:

- Allow the California ISO to "upsize" proposed projects beyond the current need demonstrated by individual interconnection requests. "When longer-term needs are readily apparent, this will create value for customers because approved transmission projects will eventually be utilized fully by least-cost best-fit sources of power."[324]
    - An example of "upsizing" is construction of a double circuit line that has unused capacity available for future use when only a single circuit would suffice based on the

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4, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/comments/SCE_Comments_on_Renewable_Policy_Mandates_and_Goals_TN-60905.pdf.

320 California Energy Commission, *Transmission System and Right of Way Planning for the 1990's and Beyond*, p. 1, March 1992, Publication Number P700-91-005.

321 Ibid, p. 7.

322 Ibid, p. 15.

323 The "Garamendi Principles" are expressed as (1) Encourage the use of existing rights-of-way by upgrading existing transmission facilities where technically and economically justifiable; (2) When construction of new transmission lines is required, encourage expansion of existing rights-of-way, when technically and economically feasible; (3) Provide for the creation of new rights-of-way when justified by environmental, technical, or economic reasons, as determined by the appropriate licensing agency; and (4) Where there is a need to construct additional transmission, seek agreement among all interested utilities on the efficient use of that capacity.

324 Alvarez, Manuel, Southern California Edison, *California Energy Commission Docket Nos. 11-IEP-1E and 11-IEP-1G: Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, May 24, 2011, p. 1, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/comments/SCE_Comments_on_Renewable_Policy_Mandates_and_Goals_TN-60905.pdf.

current queue. This may also provide expanded access to low-cost competitive renewable energy zones (CREZs).[325]

  - "This type of pre-emptive investment can maximize the value of the land associated with already necessary transmission investment, avoid future, costlier upgrades needed to accommodate additional renewable development, and expedite the schedule for interconnecting future resources."[326]

- Identify, develop, and deploy technological fixes that increase either the capacity or the capacity factor of transmission lines. "We need to be thinking about innovative ways to increase the capacity of existing assets … [W]e need to be thinking about the next technology that allows us to better use the assets we have."[327]

- Ensure coordination of IOU and POU decision making about both procurement and transmission. "Having better grid utilization and strategic upgrades to the grid, to facilitate that, it seems to me is one of the fastest things we can do to get transmission to happen."[328]

Permitting/Interconnection Challenges for Key Transmission Projects

Licensing and constructing the necessary transmission facilities are key hurdles to the interconnection and delivery of renewable generation. Some facilities are needed to reliably interconnect generators; others are necessary to allow for delivery of the generation to load centers, which is often a requirement in power purchase agreements (PPAs). Currently the highest priority transmission infrastructure challenge is the successful completion of the transmission upgrades needed to meet the 33 percent by 2020 mandate. In particular, interconnection of ARRA-funded renewable generation projects is an important component to achieve this overall goal. As mentioned earlier, Governor Brown has directed the relevant agencies to work together to permit needed transmission lines to connect these generation projects without delay.

Figure 8 shows the 13 major transmission projects critical to the interconnection and deliverability of renewable generation in California for meeting the 2020 mandate. For details, see Appendix F.

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325 Alvarez, Manuel, Southern California Edison, *California Energy Commission Docket Nos. 11-IEP-1E and 11-IEP-1G: Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, May 24, 2011, p. 1, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/comments/SCE_Comments_on_Renewable_Policy_Mandates_and_Goals_TN-60905.pdf.

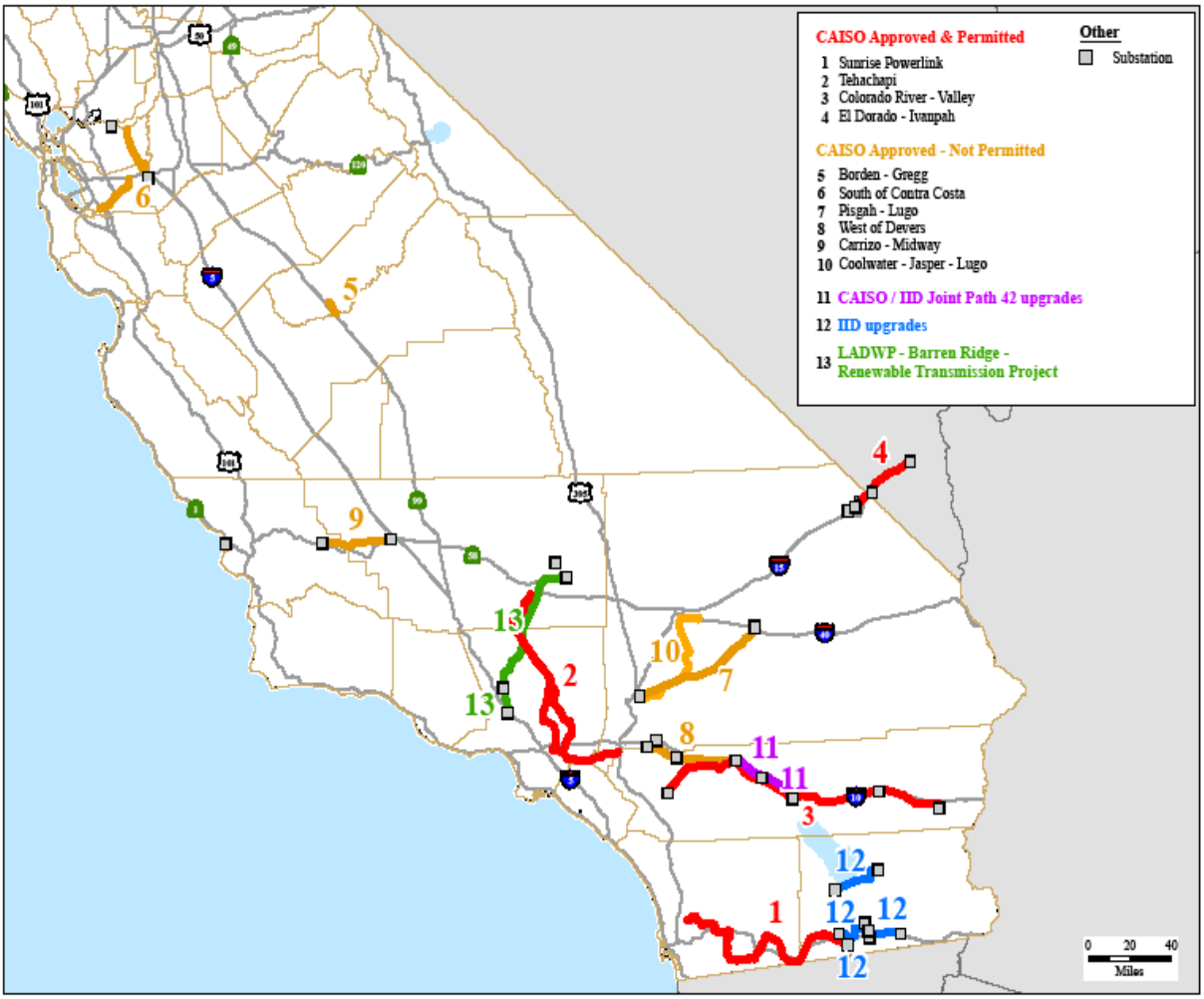
326 Ibid.

327 Jenkins, Robert, First Solar, Transcript of the May 17, 2011, *IEPR Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, p. 199, California Energy Commission, Sacramento, California, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/2011-05-17_Transcript.pdf.

328 Zichella, Carl, Natural Resources Defense Council, Transcript of the May 17, 2011, *IEPR Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, p. 148, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/2011-05-17_Transcript.pdf.

Table 11 identifies the transmission projects needed to deliver renewable energy from ARRA-funded generation projects under the Energy Commission's power plant licensing jurisdiction (indicated in italics), and the CREZs served by each transmission project. The column labeled "Cumulative Renewable Deliverability Potential (MW) With Upgrade" shows the total renewable capacity that can be delivered from the served CREZs with the addition of the specified transmission project. The appropriate balancing authority assessed the deliverability potential of each upgrade although there is not necessarily a direct correlation between the rated capacity of the upgrade and its contribution to the deliverability potential. Figure 9 shows the geographic location, amount, and type of renewable and conventional generation in the California ISO generation queue as of June 1, 2011.

Figure 8: Statewide Transmission Projects Supporting Renewable Energy Mandates



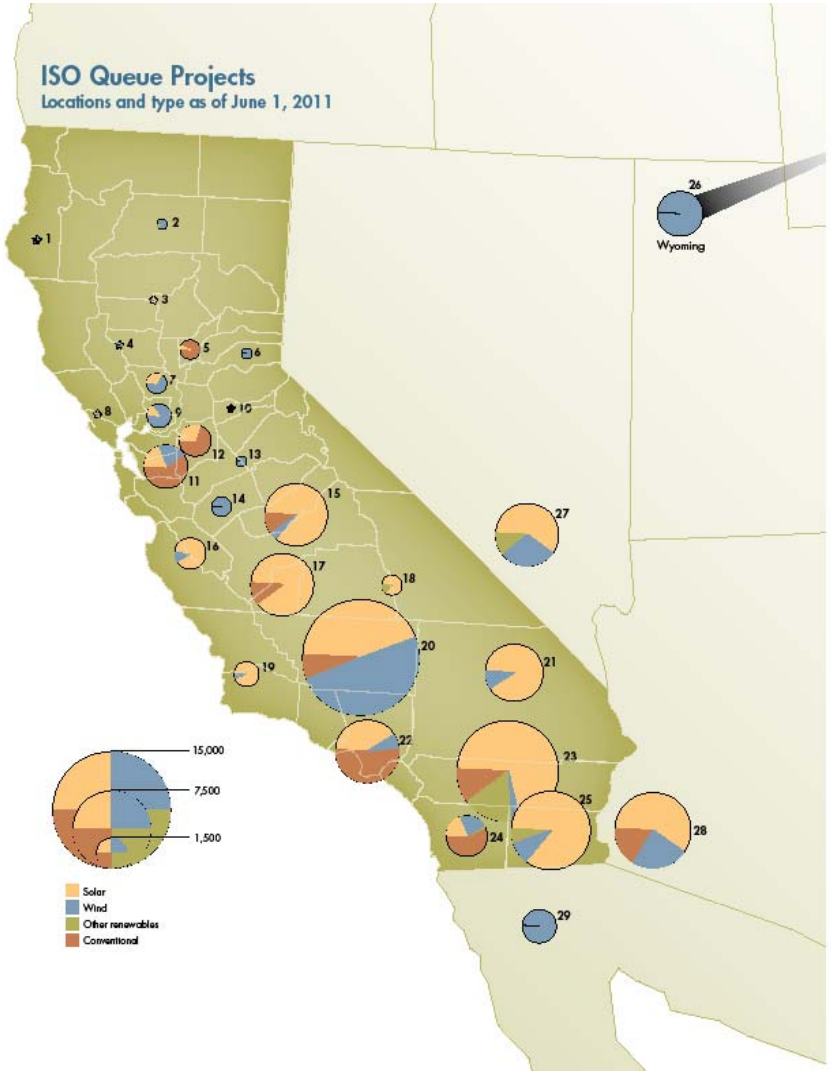
Source: California Energy Commission

Table 11: Major Transmission Projects for Interconnection and Deliverability of Renewable Generation in California

Balancing Authority	Transmission	Served CREZ	Cumulative Renewable Deliverability Potential (MW) With Upgrade	Expected Commercial On-line Date
California ISO	Sunrise Powerlink (new 500 kV and 230 kV lines)	Imperial North and South, San Diego South	1,700	2012
California ISO	Tehachapi Renewable Transmission Project	Tehachapi, Fairmont	4,500	2015
California ISO	*Colorado River –Valley Transmission Project and new Colorado River and Red Bluff 500 kV substations.*	*Riverside East, Palm Springs*	*4,700 combined with West of Devers project*	*2013*
California ISO	*Eldorado - Ivanpah 115 to 230 kV conversion*	*Mountain Pass*	*1,400*	*2013*
California ISO	Borden - Gregg (230 kV line reconductoring)	Westlands	800	2015
California ISO	South of Contra Costa (reconductoring)	Solano	535*	2015
California ISO	*Pisgah - Lugo 230 kV to 500 kV conversion*	*Pisgah, Mountain Pass*	*1,750*	*2017*
California ISO	*West of Devers 230 kV reconductoring*	*Riverside East, Palm Springs*	*4,700 combined with Colorado River- Valley Project*	*2017*
California ISO	Carrizo - Midway sections of Morro Bay - Midway (230 kV lines reconductoring)	Carrizo South, Santa Barbara	900	2012
California ISO	*Coolwater – Jasper – Lugo (new 230 kV line and other upgrades)*	*Kramer*	*700**	*2018*
California ISO/Imperial Irrigation District (IID)	Path 42 Upgrades	Imperial Valley	1,400	2015
IID	Internal IID Upgrades	Imperial Valley	See above	2011+
Los Angeles Dept. of Water and Power	*Barren Ridge-Renewable Transmission Project*	*Tehachapi, Barren Ridge*	*1,000***	*2016*

Sources: Millar, Neil, presentation to Energy Commission IEPR Committee, May 17, 2011, Transmission needed to meet State Renewable Policy Mandates and Goals, slide 9, http://www.energy.ca.gov/2011_energypolicy/documents /2011-05-17_workshop/presentations/02_CalISO_Presentation.pdf, posted May 13, 2011.
* CPUC Staff Letter to Keith Casey (California ISO) Attachment 1: Description of the Scenario Recommended by CPUC Staff for Use as the Base Case in the California Independent System Operator's 2011-2012 Transmission Planning Process, revised June 26, 2011, page 3,http://www.caiso.com/2bad/2bada1882500.html,
** LADWP March 28, 2008 Fact Sheet for the Barren Ridge Renewable Transmission Project, http://www.ladwp.com/ladwp/cms/ladwp009509.pdf.

Figure 9: California ISO Queue Projects as of June 1, 2011



Interconnection queue by county

County	Number of Projects	Renewables MW	Conventional MW	Total MW
1 Humboldt	1	50		50
2 Shasta	2	165		165
3 Butte, Glenn, Tehama	5	122		122
4 Lake, Colusa	1	66		66
5 Sutter, Yuba	2	20	600	600
6 Placer	1	220		220
7 Yolo	5	587		587
8 Marin, Sonoma	3	92		10
9 Solano	11	908		908
10 Amador	1	18		18
11 Alameda, Contra Costa Santa Clara	16	1,110	1,698	2,808
12 San Joaquin	11	325	1,020	1,345
13 Stanislaus, Tuolumne	5	202		202
14 Merced	7	612		612
15 Fresno, Madera	79	4,474	594	5,067
16 Monterey, San Benito	4	1,550		1,550
17 Kings	38	4,614	625	5,239
18 Inyo, Tulare	13	625		625
19 San Luis Obispo, Santa Barbara	6	896		896
20 Kern	109	13,802	1,100	14,902
21 San Bernardino	21	4,395		4,395
22 Los Angeles, Orange	50	2,390	2,650	5,040
23 Riverside	34	10,667	1,420	12,087
24 San Diego	29	1,094	1,453	2,545
25 Imperial	27	7,683		7,683
In-state Totals	481	56,787	11,159	67,947
26 Wyoming	1	3,000		3,000
27 Nevada	18	5,252		5,252
28 Arizona, New Mexico	10	1,094	1,250	7,128
29 Mexico	3	1,628		1,628
Out-of-state Totals	33	10,974	1,250	12,224
TOTAL ALL PROJECTS	**514**	**67,761**	**12,409**	**84,955**

as of 06/01/2011

Source: California Independent System Operator

Western Region Challenges

California will rely largely on in-state resources to meet its 33 percent target for renewables. However, abundant and high-quality renewable resources also exist outside California. Major market and planning initiatives in the Western region can facilitate development, integration, and transfer of renewable energy to Western load centers, including those in California. The challenges for California are to provide information for regional and sub-regional planning processes and subsequent plans in the Western Interconnection to ensure plans are consistent with state policies, and to remain open to potential regional opportunities that can complement and harmonize with California goals.[176]

Efforts to Address Transmission Infrastructure Challenges

This section describes the status of efforts to successfully complete transmission upgrades needed to meet the 33 percent by 2020 RPS mandate, improve transmission planning processes, identify technological fixes to maximize existing transmission system use, and incorporate California's renewable energy goals and progress into Western regional transmission planning forums.

Permitting/Interconnection Efforts

Many projects shown in Figure 8 and described in Table 11 have been licensed or are under construction, including:

- San Diego Gas & Electric (SDG&E) Sunrise Powerlink
- SCE Tehachapi Renewable Transmission Project
- SCE Colorado River – Valley transmission line (including the Colorado River Substation and Red Bluff Substation)
- SCE Eldorado – Ivanpah Upgrade
- Imperial Irrigation District (IID) upgrades
- Los Angeles Department of Water and Power (LADWP) Barren Ridge Renewable Transmission Project.

Several key projects that do not yet have active licensing applications include:

- Pacific Gas and Electric Company (PG&E) Borden – Gregg 230 kV reconductoring
- PG&E South of Contra Costa reconductoring
- SCE Pisgah – Lugo 500 kV upgrade
- SCE West of Devers upgrades

176 Letter from Michael Picker, Senior Advisor to the Governor for Renewable Energy Facilities, to Brad Nickell, Director, WECC Transmission Expansion Planning, August 3, 2011, "Reflecting Current California Trends and Policies in Regional Transmission Planning."

- PG&E Carrizo – Midway 230 kV reconductoring
- SCE Coolwater – Jasper – Lugo 230 kV line
- California ISO/IID Joint Path 42 upgrades.

Getting these identified projects licensed and constructed is a key part of California utilities' ability to interconnect and deliver the renewable generation required to meet the 33 percent RPS by 2020. The state's north-south 500 kV "backbone" system must also be strengthened to address bottlenecks between desert renewable energy resource areas in Southern California and load centers in Central and Northern California. For example, the proposed Midway – Gregg 500 kV line in the Fresno area could improve access to renewables, increase reliability, and meet future load growth by better integrating solar, wind, and existing pumped hydro resources in the region. In its 2010-2011 planning cycle, the California ISO identified the Midway – Gregg line as one of eight "Category 2" projects that will be evaluated further in the 2011-2012 planning cycle.

Improving Transmission Planning to Facilitate Renewable Development

Renewable Energy Transmission Initiative – 2007-2010

RETI established the precedent for incorporating land-use planning into the statewide transmission planning process by bringing together representatives of the state, federal, and local agencies and entities responsible for permitting transmission projects as well as environmental community representatives, developers of renewable technologies, investor- and publicly owned utilities, Native American tribes, U.S. military, and consumers.

The RETI effort identified 30 CREZs, and their corresponding transmission interconnections and lines, for the most cost-effective renewable generation development with the least environment impact. RETI produced maps of CREZs and related conceptual transmission line segments that helped guide potential developers, for the first time, to areas screened[177] for environmental concerns, and combined these screens with assessments of the CREZs renewable energy potential.[178] RETI employed a "least regrets" planning approach that identified additions to California's transmission system that are likely to be needed regardless of how demand for electricity changes, and when and where renewable generation develops. The least regrets planning approach is unique when compared to traditional planning approaches used by California utilities. The RETI effort also led to development of the ongoing metric, the "renewable net short." For more information, see Chapters 2 and 3.

Renewable Energy Action Team and Desert Renewable Energy Conservation Plan

Through the REAT, the Energy Commission is continuing to work with federal, state and local partners to develop the DRECP.[179] The DRECP has built on RETI's work, both refining it with

177 RETI's pioneering use of environmental screens to inform transmission planning, by necessity, relied on limited data and did not constitute a detailed environmental analysis.

178 http://www.energy.ca.gov/reti/index.html, accessed July 7, 2011.

179 See Desert Renewable Energy Conservation Plan website at: http://www.drecp.org/.

the most recent biological resource survey and land-use data and expanding it in the Mojave and Colorado Desert areas of California. To develop an integrated framework for balancing natural resource conservation and renewable energy development, the DRECP is coordinating with existing desert conservation plans within the Mojave and Colorado Deserts, renewable energy development project plans, the BLM Solar Programmatic Environmental Impact Statement (PEIS), and transmission planning efforts. The DRECP will identify renewable generation areas and potential transmission corridors needed to access them to promote future transmission and generation siting and permitting. This coordinated approach, overseen by the REAT, will facilitate better consolidation of land-use and transmission wires planning, for example, by providing new data on desert tortoise (and other species) connectivity, plant surveys, Mohave ground squirrel surveys, and migration corridor information to transmission planners. The DRECP also supports consolidated development rather than scattered "leap frogging" development and "upsizing" proposed transmission projects as explained earlier in this chapter. For information on REAT, and DRECP's process and calculator tool for estimating needed levels of renewable generation capacity and related acreage, see Chapter 3.

The Energy Commission, CPUC, and California ISO are meeting to develop a future memorandum of understanding (MOU) to ensure the integration of land-use planning from the DRECP into the California ISO's annual transmission planning process. The agencies are also working together to ensure that the DRECP land-use planning assumptions are incorporated into the CPUC's Long-Term Procurement Planning decisions so that renewable and transmission development occurs in preferred areas identified by federal, state, and local agencies. In addition, various stakeholder groups and constituencies with interests in natural resources remain engaged in helping to make the best locational decisions from a geospatial perspective.[180,181]

2010 California Transmission Planning Group Statewide Transmission Plan

In early 2009, the California Transmission Planning Group (CTPG) was formed as a result of FERC-facilitated discussions to address coordinating California's transmission needs within the state's balancing authority areas (BAAs).[182] The role of the CTPG is to coordinate transmission planning studies and develop a Conceptual Statewide Transmission Plan that identifies transmission infrastructure needed to reliably and efficiently meet the 2020 RPS goal. The

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180 Zichella, Carl, Natural Resources Defense Council, Transcript of the May 17, 2011, *IEPR Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, p. 145, California Energy Commission, Sacramento, California, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/2011-05-17_Transcript.pdf.

181 White, V. John, Center for Energy Efficiency and Renewable Technologies, Transcript of the May 17, 2011, *IEPR Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, pp. 157-158, California Energy Commission, Sacramento, California, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/2011-05-17_Transcript.pdf.

182 For example, the area served by the California ISO is a balancing authority area.

California BAAs assess this plan in detail as part of their own respective transmission planning processes since the CTPG is not a decision-making body.

CTPG members include:

- Publicly owned utilities: IID, LADWP, Sacramento Municipal Utility District (SMUD), and Turlock Irrigation District
- IOUs: PG&E, SCE, and SDG&E
- Other planning organizations: Southern California Public Power Authority, and the Transmission Agency of Northern California

Nonmember participants include:

- California ISO
- Western Area Power Administration

CTPG's 2010 planning cycle was completed in four phases with each phase building upon the previous based on input from RETI, state agencies, and other interested parties. Throughout the 2010 planning cycle, CTPG continued to improve its coordinated, open, and transparent transmission planning process consistent with FERC Order No. 890.[183] On February 9, 2011, CTPG completed the final *2010 Statewide Transmission Plan*.[184] The goal was to identify high-potential transmission needs for further consideration by BAAs within California and medium-potential transmission needs to be studied further in the next planning cycle. The plan identified 26 high-potential transmission upgrades and/or additions (23 in Southern California and 3 in Northern California), 34 medium-potential transmission upgrades/additions (17 in Southern California and 17 in Northern California), and 3 high-potential transmission corridors in the Western states (Pacific Northwest, Northwest Nevada, and Southwest). The corridor identifications provide potential options for accessing future in-state and out-of-state renewable resources and are intended to provide information for load-serving entities (LSEs) and state policy makers.

CTPG's overall 2010 study process revealed a key observation – the need to improve its stakeholder process by receiving early input from state agencies and interested parties in developing the baseline study scenario, identifying feasible alternatives that satisfy policy objectives, and drafting study plans and reports. During this study process, CTPG also identified other lessons learned provided by stakeholders that will be considered in future planning cycles.

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183 See Table 10 for a description of FERC Order No. 890. Because CTPG includes both FERC jurisdictional and nonFERC jurisdictional transmission providers, it seeks to conduct a transparent transmission planning process as outlined in Order No. 890.

184 *Final 2010 California Transmission Planning Group Statewide Transmission Plan* February 9, 2011, http://ctpg.us/public/images/stories/downloads/2011-02-09_final_statewide_transmission_plan.pdf.

California Independent System Operator's Role in Facilitating Renewable Development

In 1998, the California ISO assumed operational control of 25,526 circuit-miles of transmission lines from the state's three major IOUs. The California ISO's control area includes more than 80 percent of the state's electric load and serves more than 30 million residents. As the planning authority for its footprint, a core responsibility of the California ISO is an annual transmission planning process that identifies the transmission needs of the system over a 10-year planning horizon. The California ISO also provides findings of project need to FERC, as FERC considers whether a transmission provider can recover its transmission costs.

In addition to the Transmission Plan, other California ISO transmission planning activities include the Generator Interconnection Procedures (GIP), a parallel process that provides results as input to its transmission planning process, and assessing the eligibility of renewable resources to provide resource adequacy capacity.[185]

- **2010-2011 Transmission Plan:** In 2009, due to California's adoption of new environmental policies and goals, particularly increasing renewable energy resources, the California ISO initiated a stakeholder process to design needed changes in its transmission planning process. This comprehensive evaluation of the California ISO transmission system identified upgrades needed to meet grid reliability requirements, economic projects that could bring economic benefits to consumers, and projects needed to meet California's 33 percent mandate. FERC approved the revised transmission planning process tariff amendment on December 16, 2010.[186] The California ISO 2010-2011 Transmission Plan was the first plan produced under the revised transmission planning process and the first to include transmission upgrades needed to meet California's policy mandates.[187]

  For the 2010-2011 Transmission Plan, the California ISO focused on the policy-driven category, used the best available information, and worked with the Energy Commission, CPUC, RETI, and CTPG[188] to develop four 33 percent RPS portfolios. The four portfolios comprise: (a) high in-state, (b) high out-of-state, (c) high distributed generation, and (d) hybrid, which served as the base case for the study. The 10 transmission projects included in the study were either approved in previous transmission planning cycles or the GIP [189]

185 The California Public Utilities Commission's Resource Adequacy program is intended to ensure that sufficient generating capacity is available to meet the peak load and reserve requirements of CPUC jurisdictional load serving entities, which include all investor-owned utilities, electricity service providers, and community choice aggregators. See http://www.cpuc.ca.gov/PUC/energy/Procurement/RA/ for more information.

186 The FERC approved the California ISO's Revised Transmission Planning Process on December 16, 2010 subject to certain modifications to the tariff, with an effective date of December 20, 2010.

187 The Board of Governors Approved California ISO 2010/2011 Transmission Plan dated May 18, 2011 can be found on the California ISO website at: http://www.caiso.com/2b88/2b8872c95ce10.pdf.

188 The California ISO, after conducting its own independent analysis, found that the high-potential transmission elements within its BAA identified in CTPG's *2010 Statewide Transmission Plan* were found to be needed in its 33 percent RPS transmission plan.

189 The Generator Interconnection Procedures is a FERC-approved process that is not required to be FERC Order 890 compliant and is therefore not required to be open for stakeholder review.

network upgrades were permitted for construction or far enough along in the GIP approval process to have executed or tendered Generator Interconnection Agreements (GIAs).

To identify the transmission projects needed, the California ISO used the renewable net short calculation (developed by RETI and CTPG with input from Energy Commission staff) and the Energy Commission's electricity demand forecast published in 2009. Renewable generation projects were ranked and assigned to potential transmission connections in the following order: Energy Commission-permitted projects, CPUC "discounted core"[190] projects, and projects selected by most favorable environmental score. For the 2010-2011 planning cycle, the California ISO developed renewable portfolios with the CPUC without stakeholder input due to time constraints. For the 2011-2012 planning cycle, the California ISO and CPUC developed renewable portfolios that were presented for stakeholder input at the July 8, 2011 California ISO 2011-2012 TPP Renewable Portfolio Assumptions meeting.

The California ISO identified 32 reliability-driven projects and one Category 1 policy-driven transmission project in the 2010-2011 Transmission Plan.[191] Category 1 policy-driven elements are needed and recommended for approval as part of the Comprehensive Transmission Plan in the current cycle based on the criteria set forth in the California ISO's tariff.[192] The Category 1 Mirage to Devers upgrade complements IID's approved Coachella to Mirage 230 kV upgrade, which is a critical path to deliver renewable energy from IID's service area to the California ISO-controlled grid. The California ISO also identified eight additional projects as Category 2 that will be further evaluated in the 2011-2012 planning cycle (Table 12).[193]

- **GIP:** For the 2010-2011 cycle, the California ISO received a one-time waiver from FERC exempting GIP upgrades associated with ARRA generators (with a construction start requirement of December 31, 2010) from further study in the 2010-2011 transmission planning process (TPP)[194]. For the 2011-2012 cycle, network upgrades and additions originally identified in the GIP Phase II studies will be reassessed in Phase 2 of the TPP to analyze whether expansion of these upgrades/additions could provide public policy benefits

190 CPUC "discounted core" includes projects having a signed power purchase agreement and an application for a permit to construct the project from the responsible permitting entity (Energy Commission and/or U.S. Bureau of Land Management.) The discounted core is the set of projects used by the CPUC in the development of its portfolios for its Long-Term Procurement Plan.

191 The list of reliability-driven projects and one policy-driven transmission project is located on pages 522-524 of the Board of Governor Approved California ISO 2010/2011 Transmission Plan dated May 18, 2011.

192 See the California ISO's Fifth Replacement FERC Electric Tariff, p. 466-467, available at: http://www.caiso.com/Documents/CombinedPDFDocument-FifthReplacementCAISOTariff.pdf.

193 Policy-driven transmission upgrades are identified as Category 1 and Category 2. Category 1 upgrades are presented for Board of Governor approval, and Category 2 upgrades are identified for further review in the next planning cycle.

194 Order Conditionally Accepting Tariff Revisions and Addressing Petition for Declaratory Order Issued December 16, 2010, Docket No. ER10-1401-000, FERC.

and can be approved as a policy-driven project.[195,196] Any upgrades/additions identified in Phase 2 of the TPP will be open to independent transmission developers to build and own.

Table 12: California ISO 2010-2011 Category 2 Projects

Category 2 Transmission Upgrades	Lead Time for Implementation
400 MVAR reactive power support at Sycamore, Mission, and Talega 230 kV substations (SDG&E area)	36 months for reactive power support
Third Miguel 500 kV transformer (SDG&E area)	60 months for the third Miguel 500 kV transformer
Upgrade Eldorado – Pisgah 500 kV series capacity to higher emergency rating (2700 Amp) (SCE area)	24 months for Eldorado – Pisgah 500 kV series capacity upgrade
Fresno area (PG&E area): 1) Build the new Midway – Gregg 500 kV line 2) Reconductor Gregg – Herndon 230 kV line 3) Reconductor Warnerville – Wilson 230 kV line 4) Reconductor Barton – Herndon 115 kV line 5) Reconductor Manchester – Herndon 115 kV line	72 months for Midway – Gregg 500 kV line 36 months to reconductor multiple 230 kV lines

Source: California Energy Commission

Although FERC approved this one-time exemption from the competitive process, going forward the California ISO recognizes the need for greater integration between the GIP[197] and the TPP. To further integrate these two parallel processes, the California ISO initiated a Generator Interconnection Procedures Phase 2 (GIP 2) stakeholder process in February 2011.[198]

- **Resource Adequacy (RA):** The California ISO's deliverability assessment was adopted as part of the CPUC's Resource Adequacy Program and accepted by FERC for implementation of GIP as outlined in California ISO Tariff Appendix U, Section 3.3.3. For the CPUC's RA Program, the California ISO performs an annual deliverability assessment for resources located inside the California ISO BAA to determine the Net Qualifying Capacity (NQC), which is the MW amount that can be relied upon for satisfying RA requirements. In

195 Section 24.4.6.5 of California ISO's tariff defines the criteria for evaluating LGIP network upgrades in the TPP as: (1) new lines 200 kV or above with capital costs of $100 million or greater; (2) new 500 kV substation facility with capital costs of $100 million or greater; and (3) those having capital costs of $200 million or greater.

196 "Phase II" refers to the interconnection study of the LGIP and "Phase 2" refers to the second phase of the California ISO's TPP.

197 In 2010, the California ISO combined its Large Generator Interconnection Procedures and Small Generator Interconnection Procedures into a single set of procedures, which is now called the Generator Interconnection Procedures (GIP). The GIP initiative is located at: http://www.caiso.com/275e/275ed48c685e0.html. The California ISO's tariff amendment filed and approved by FERC became effective on December 16, 2010.

198 The California ISO's new stakeholder initiative, Transmission Planning and Generator Interconnection Integration, held its first stakeholder meeting July 28, 2011, and will present a proposal for Board of Governors' approval in December 2011.

addition and as part of the deliverability assessment, the California ISO also determines the maximum import capability (MIC) at the interties connecting the California ISO to adjacent BAAs for RA purposes. The California ISO also performs deliverability assessments twice a year in the GIP Phase I study for generators requesting interconnection to the California ISO's BAA. The generator deliverability assessment identifies delivery network upgrades required to provide the generating facility with full capacity deliverability status that is needed to participate in the CPUC's RA Program.

Two RA deliverability issues limit a renewable resource developer's ability to provide RA capacity to load-serving entities (LSEs) within the California ISO BAA. The concern is that the resource's limited ability to provide RA capacity will adversely affect the developer's ability to obtain contracts with LSEs that provide a revenue stream to support project financing. The California ISO and CPUC presented the following proposal in response to a request from Governor Brown's Senior Advisor.[199]

- *Issue 1: Deliverability of Resource Adequacy Capacity on Interties*. Issue 1 pertains to resources located outside the California ISO BAA. The total amount of RA capacity these resources can offer is limited to the maximum import capability (MIC), which is a quantity determined annually by the California ISO based on a historical snapshot of net schedules at the intertie points during selected hours of the year. Stakeholders raised concerns that the historical approach results in excessively low MIC values for a few selected ties. One primary example is the intertie between the California ISO and IID at the Imperial Valley Substation. At this intertie point, the MIC is set to zero because IID generally imports from the California ISO at that intertie. Thus, under the historical method, renewable resources seeking to deliver at the Imperial Valley Substation to the California ISO cannot count for RA capacity for LSEs within the California ISO.

  To address the issue of excessively low MIC values at selected intertie points, the California ISO is implementing a proposed solution[200] to revise the MIC methodology and expand the amount of import capacity available to LSEs for obtaining RA capacity from external resources. The proposal contains two elements: (1) revise the California ISO procedure for determining MIC values to expand RA import capacity on the identified interties beyond the historical amounts; and (2) use the California ISO's annual TPP to identify targeted resource areas and associated interties that require expanded RA import capacity, along with required transmission needed to ensure deliverability.

199 See California ISO and CPUC Letter to Michael Picker dated April 18, 2011, "Resource Adequacy Deliverability Issues for New Renewable Generation," California Energy Commission Docket No. 11-IEP-1E, available at: http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/comments/California_ISO_Comments_Regarding_Resource_Adequacy_Deliverability_Issues_TN-60856.pdf.

200 The California ISO initiated a stakeholder process in April 2011 that culminated with the completion of the California ISO Draft Final Deliverability of Resource Adequacy Capacity on Interties Proposal on May 5, 2011, http://www.caiso.com/2b42/2b42b9378530.html.

The California ISO's new approach to the MIC methodology will apply to its annual RA import allocation process in 2012 for the 2013 RA compliance year. Stakeholders, including IID, have expressed concerns that this approach is a long-term solution that does not address the immediate need. IID was concerned that the IOUs would use the existing criteria for RA in request for offers (RFO) solicitations, which would hinder the development of renewable resources in the Imperial Valley.[201]

In response to IID and other entities affected by the current MIC methodology, CPUC Assigned Commissioner Mark Ferron ruled that it was unreasonable for PG&E, SCE, and SDG&E to use an MIC of zero or near zero for imports from the IID BAA for the 2011 RPS solicitation underway under Decision 11-04-030. Instead, the three utilities should use an MIC of 1,400 MW for imports from projects within the IID BAA in the 2011 RPS solicitation or provide clear and convincing evidence why they did not.[202]

- *Issue 2: For some renewable resources connecting to the California ISO grid, there is a lag of up to five years between the start of commercial operation and the completion of the transmission upgrades required to make them fully deliverable for RA purposes.* The California ISO and CPUC propose the following solution that would apply only to projects that meet the terms for the ARRA cash grants and have contracts with LSEs that are under renegotiation as a result of additional deliverability analysis by the California ISO.

  The proposal is for these LSEs to agree to provide replacement RA capacity for up to three years after the date of full deliverability agreed to in the signed GIA. To determine the amount of replacement capacity required, the LSE will apply the CPUC rules for determining RA capacity. The LSE would provide this RA capacity and in turn bill the developer the market price for the replacement capacity at a cost not to exceed the per-MW price of the California ISO's backstop procurement authority of $55 per kW/year. For any months the LSE is short of its RA requirement, the California ISO could procure backstop RA capacity under its tariff provisions and bill the cost of the capacity to the deficient LSE, which would in turn bill the renewable generator at the tariff defined backstop level. In these instances, the LSE can ask the CPUC to waive any associated RA deficiency charges.

Improving Use of the Existing Grid

Building double-circuit lines rather than single-circuit lines under specific circumstances is another method for enhancing transmission system utilization. Recent technological advancements offer additional opportunities to enhance the use of the existing transmission system by increasing transfer capability in existing rights-of-way. The Energy Commission's

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201 See TN-60874 05-24-11 Comments of the Imperial Irrigation District in Docket 11-IEP-1E (pages 2-3), http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/comments/.

202 California Public Utilities Commission, *Assigned Commissioner's Ruling Regarding Resource Adequacy Value of RPS Projects in the Imperial Irrigation District Balancing Authority Area*, June 7, 2011, in Rulemaking 11-05-005, http://docs.cpuc.ca.gov/efile/RULINGS/136670.pdf.

Public Interest Energy Research (PIER) Program has funded a wide variety of research projects to improve operation and use of the state's transmission system, and will continue to evaluate new technologies to promote connection of renewable generation projects to the state's transmission grid. For more details, see Chapter 9.

Western Region Planning and Projects

Background

The West has an abundance of renewable resources that can be used to meet state and provincial policy goals for developing carbon-free electricity generation. Nine of eleven Western states have statutory RPS requirements and are generally procuring in-state or "close-to-home" resources to meet these requirements.[203] Many states would also like to export their resources to other states, particularly interior Western states such as Wyoming, Montana, and New Mexico, which have high-quality wind resources but limited electricity demand. Arizona also seeks to provide high quality solar for the Western Interconnection and beyond. More work is needed to address risk and benefit tradeoffs of local versus remote resources for both wind and solar. This will shed light on critical economic development values, risks of rapid technology cost shifts and cost risks, and benefits of lines, such as Canada to Northern California or other ties with Wyoming, Montana, Nevada, and New Mexico.

California hopes to exceed its 33 percent RPS requirement and become a net exporter to the North and East, relying not only on large, in-state central station projects, but also on distributed local resources. Several recent developments point to an increased ability for California to meet its 33 percent RPS goals with in-state resources:[204]

- Significant reductions in the technology cost of solar generation and the availability of investment tax credits have resulted in large-scale resource development within California's borders.
- The Brown Administration has put into place strong policies supporting additional in-state and distributed local generation.
- In 2010, the state approved 11 large solar and wind projects totaling more than 5,000 MW of renewable generation capacity.
- In 2011, the state has thus far permitted an additional 1,000 MW of solar PV projects. By the end of 2011, the state expects to permit another 5,000 MW of solar and wind.

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203 Western Utility Resources Planners Forum(s), 2009 and 2010. Economic development and job creation are key drivers of in-state resource procurement policies. Load serving entities also have concerns regarding the economic risks and uncertainties on the timely availability (and cost) of remote resources and the transmission needed to move energy to load centers.

204 Letter from Michael Picker, Senior Advisor to the Governor for Renewable Energy Facilities, to Brad Nickell, Director, WECC Transmission Expansion Planning, August 3, 2011, "Reflecting Current California Trends and Policies in Regional Transmission Planning."

California and its neighbors' interest in export as well as the immediate need to integrate significant amounts of renewables into the Western system, have focused Western Region system planning on renewable integration and transmission additions that could make delivery of renewable easier. The following discusses regional transmission plans and proposed regional projects. Western market and integration initiatives are discussed in Chapter 5.

Regional Transmission Plans for Renewables

In December 2009, the U.S. DOE awarded the WECC $14.5 million in ARRA funding to conduct the first-ever interconnectionwide transmission planning studies in the Western Interconnection. The funding allows WECC to significantly expand existing regional transmission planning activities and broaden stakeholder involvement in planning processes through the Regional Transmission Expansion Planning (RTEP) Project. The RTEP is developing 10- and 20-year transmission plans for the Western Interconnection, which will be provided to the DOE in 2011 and 2013, respectively. These new transmission plans largely limit the study of new fossil-fueled generation to plants already under construction and instead focus the effects of RPS requirements, energy efficiency goals and other low-carbon public policies on transmission needs throughout the Western Interconnection.

Proposed Regional Transmission Projects

Many Western states seek to export renewables to load centers, particularly to those in California seen as large and lucrative. Wind resources with high capacity factors (for example, 40 to 45+ percent in Wyoming) in remote locations drive interest in long lines connecting to California. Utility and independent developers rely on FERC's Order 890 framework to position their projects for evaluation in RTEP.[205] WECC expansion cases show the benefits of developing remote resources for some locations and transmission alternatives. However, the CPUC staff pointed out that these conclusions are not consistent with results found in CPUC procurement analyses and utility power purchase contracts. Others argue remote development can offer wind profile diversity, lower cost, competition, and risk reduction with potential delays in large solar deployment.

Figure 10 identifies major projects reviewed in WECC studies.

Completing the initial development stages of transmission projects is essential to ensure potential projects are poised for investment when/if continuing procurement activities indicate benefit from a portfolio of both in-state and out-of-state generation. Developers who are willing to pursue full permitting at their own cost and risk will be best positioned to compete successfully to meet California renewable procurement goals.[206]

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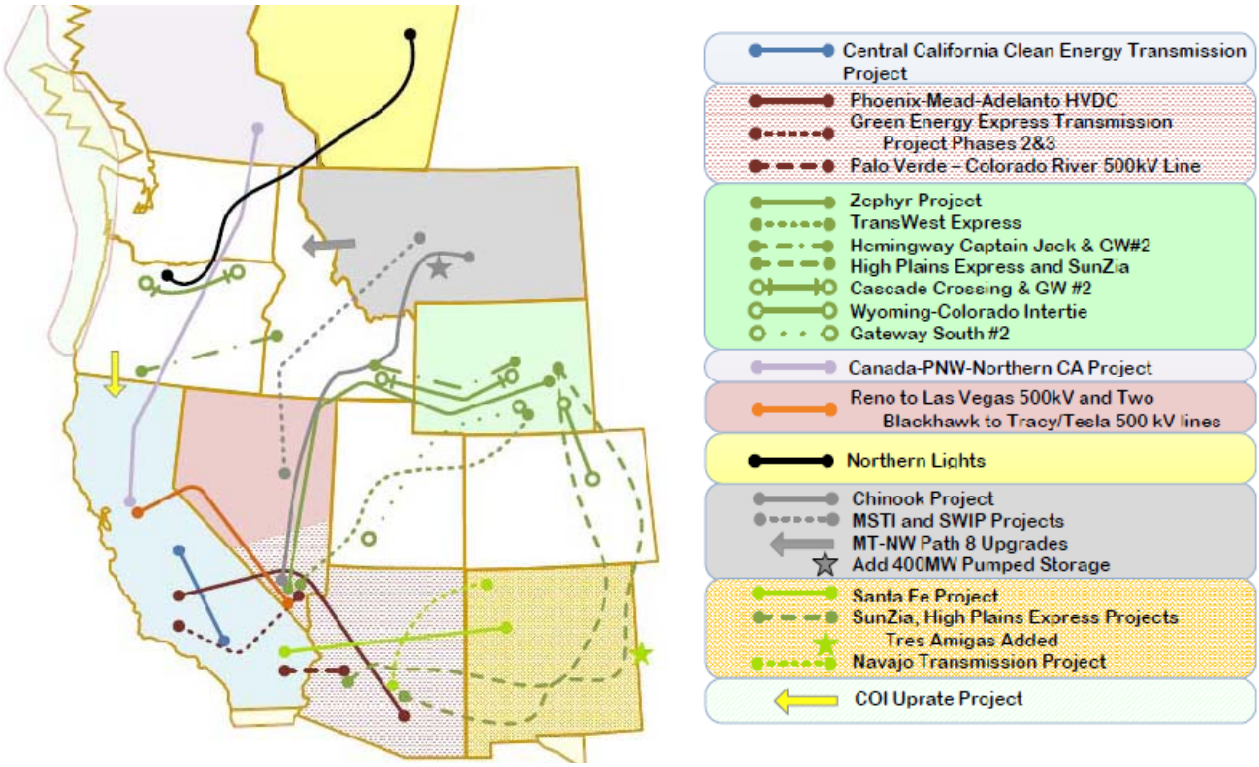
205 FERC Order 890 requirements allow any stakeholder to request expansion studies in the "open window" process.

206 See comments of TransWest Express, David Smith.

Figure 10: Sustained Interest Multistate Expansion Projects



Source: WECC Staff, Brad Nickell presentation to CREPC SPSC, April 12, 2011, "10-Year Plan," slide 20, available at http://www.westgov.org/wieb/meetings/crepcsprg2011/briefing/present/b_nickell2.pdf.

CHAPTER 5:
Grid-Level Integration Issues

In California's complex system of power resources, generation must match demand instantaneously and continuously. Balancing electricity generation to load – while maintaining the voltage and frequency within operational tolerances – is achieved through resource commitment and dispatch. Fitting any particular generating unit into that process, whether conventional or renewable, is called "integration." Integration is generally invisible to the consumer and allows generation and load to be in harmony.[207]

Electricity system operators routinely plan for outages of significant resources such as nuclear plants or transmission lines and the need to bring grid frequency back into balance within minutes. As more intermittent renewable electricity generating resources, like wind and solar, are added to California's electricity resource mix, it becomes more challenging to integrate variable resources while maintaining grid reliability, safety, and security.[208] Wind and solar output can rise or drop from moment to moment, across hours, and over days or months. Solar resources begin production after sunrise and more or less shut down at sunset. High variability, or intermittency, means that operators must forecast what renewable generation will be provided, what services from other sources will be needed, the options to provide these services and their costs, and how to make good choices among the available options.

About This Chapter

This chapter explains the following key challenges to integrating increasing amounts of renewable resources into California's electricity system:

- Intermittent renewable resources that increase the minute-to-minute and hourly variability of the electric system require more ancillary services and ramping capabilities for the grid to operate reliably.
- Better weather and operational forecasting will be necessary to reduce the uncertainty over the availability of and need for resources.
- Market incentives must align with new technical operating requirements to ensure that sufficient resources are made available.
- While integration across a mix of generation resources is not a new problem, the scale and diversity of resources are increasing. Going forward, the system may no longer be able to rely on current excess capacity and special rules for variable renewable resources. Integrating variable resources will require increased operational flexibility.

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207 Grid integration refers to integrating generation at the transmission level, rather than at the distribution level.

208 Variable energy resource is the term FERC uses to describe renewable resources that have variable or intermittent production. Geothermal, biogas, and biomass resources generally follow fixed hourly schedules and are not considered variable. Intermittency and variability are used interchangeably in this chapter. They both refer to changeable nature of renewable resource output.

- Maintaining a reliable electricity system while adding increasing levels of variable resources will require complementary generation, energy storage, and demand response that can be turned up or down as needed, as well as increasingly sophisticated controls and new market designs.

This chapter also describes the efforts underway to address these challenges:

- The California Independent System Operator (California ISO) is evaluating new tools and methods to improve integration-related forecasting. California ISO is also reviewing new market products and market rules for renewable integration.
- The Federal Energy Regulatory Commission (FERC) is undertaking several initiatives and efforts to promote new renewables and emerging technologies.
- Several Western Regional market and integration initiatives are underway.
- The California Public Utilities Commission (CPUC) is addressing resource planning and integrating policy direction in its Long-Term Procurement Plan (LTPP).
- Publicly owned utilities are developing integration strategies for procuring renewable generation while maintaining a stable electricity supply.

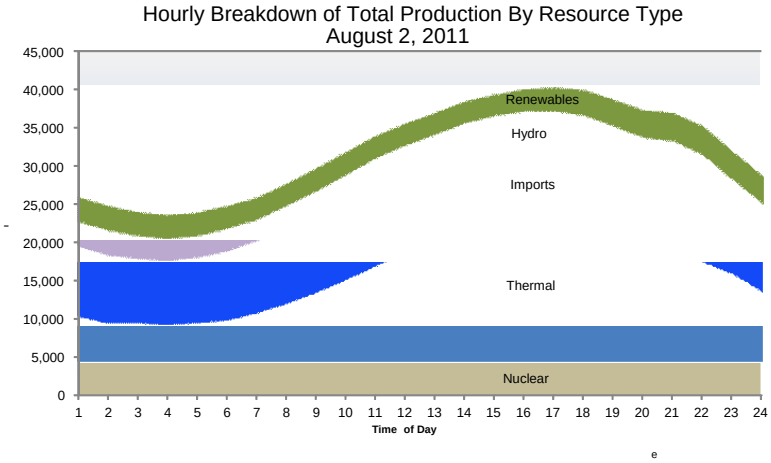
Description of Integration Needs

Grid operators must plan not only for hourly, daily, and seasonal fluctuations in electricity demand and the available supply of electricity, but also for unplanned outages of operating power plants and transmission lines. Each electricity supply source has unique operating characteristics, constraints, costs, and environmental impacts. At any given moment, system operations must consider these combined characteristics to commit or dispatch resources to meet demand, and have additional reserves to deal with unplanned contingencies.[209]

In general, a load pattern is forecasted each day. Figure 11 shows an example hourly demand (need) and the resources used to meet it. Units with the best operating features are selected to serve load at the least cost while maintaining reliability. This is called "merit order" or "economic" dispatch. Some units, such as nuclear and coal, are baseload units that function best at a steady state without multiple stops and starts, and may take days to start up. Others, such as "load-following" natural gas generating units, can slowly increase or decrease their operating levels. A third group can respond rapidly to quick changes from a generator outage or sharp increase or decrease in demand, and may start up within as few as 10 minutes.

209 Federal and industry reliability standards require each grid operator to maintain frequency and voltage levels within tight standards for every 10 minutes.

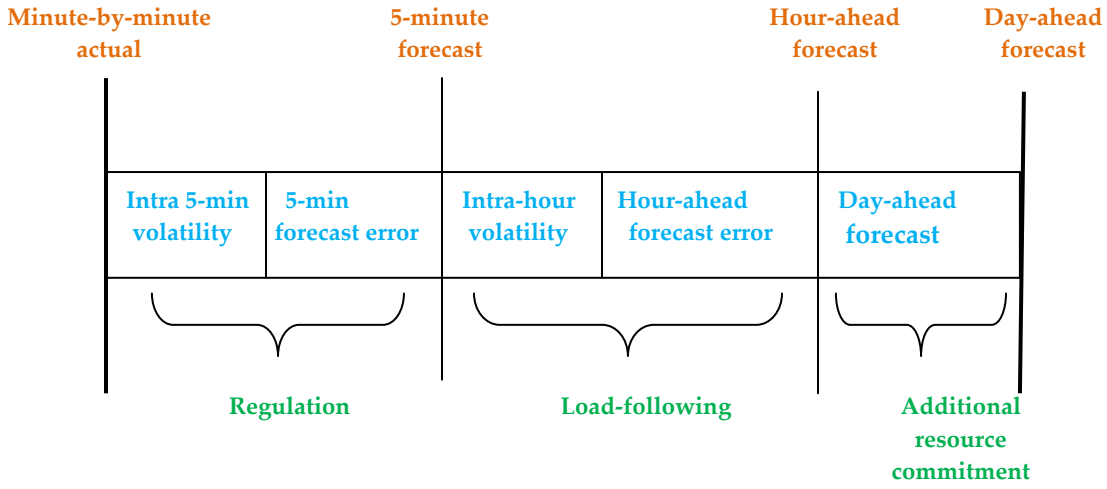
Figure 11: Daily Load Curve and Resources



Source: California ISO

Scheduled power generation for the day-ahead and hour-ahead rarely matches the actual load. Integrating variable energy resources requires increased operational flexibility — notably the ability to provide services to match real-time upward and downward movements and at ramp rates faster than what is generally provided today. Anticipated load growth to 2020 will drive the overall system flexibility needs from the present level of about 4,300 MWh to about 6,000 MWh.[210] Impacts of large-scale variable generation should be considered in terms of time frames: seconds to minutes, minutes to hours, hours to days, and days to a week and beyond. Figure 12 illustrates this flexible pattern of forecasts and associated services.

Figure 12: Flexible Services and Time Frames



Source: California Energy Commission

For seconds to minutes, automatic equipment and AGC systems manage the system. From minutes to days, operators commit and/or dispatch needed facilities to rebalance, restore, and

210 California Energy Commission, *Intermittency Analysis Project: Appendix B Impact of Intermittent Generation on Operation of California Power Grid*, July 2007, CEC-500-2007-081APB, p. 5.

position the system to maintain reliability through normal load variations or contingencies and disturbances.

Ancillary services help balance demand and supply fluctuations, maintain grid conditions within prescribed limits, and provide reserves for unexpected events over different time horizons (Table 13).[211] Together they support the transmission of energy while maintaining reliable operation. Ancillary services may be procured through a market or awarded through a contract. The California ISO procures regulation and spinning and nonspinning reserves as ancillary services, paid for by all customers. Ancillary service types and needs may change at higher levels of wind and solar penetration and may vary more by season.

Operating reserves are a combination of two categories: regulating reserves and contingency reserves for unexpected deviations in load or generation. The California ISO, for example, maintains sufficient capacity (about 1.0 – 1.5 percent of load) under automatic generation control (AGC) to continuously balance generation and imports in real time – this is regulating reserve.[212] Ancillary services manage various fluctuations over different time horizons:

- Regulation services address normal short-term up and down fluctuations (second-to-second and minute-to-minute) in the aggregate output of generation resources, voltage, or frequency. This requires dispatchable generation under AGC.

Table 13: Ancillary Services and Related Terms

Regulation	Units can change output in response to signals every four seconds provided through automatic generation control (AGC) to maintain a balance between load and generation in real time.
Load Following	Similar to Regulation, but slower (10 minutes to a few hours).
Spinning Reserve	On-line (synchronized) and available to increase output immediately; reach full output within 10 minutes and maintain for 30 minutes.
Nonspinning Reserve	Similar to above, but unit may be offline and capable of quickly restarting.
Black Start	Generation able to come on-line without an external source of electricity following a system blackout; energize transmission and start other units.
Voltage Control	Adding or subtracting reactive power to keep system transmission voltages in required range for stability.
Inertia/Frequency Response	Sufficient spinning mass to dampen changes in frequency to avoid Area Control Error (also called "ride-through").

Source: California Energy Commission

- Ramping capabilities address predictable changes in aggregate generation output over the course of the day, which requires generation resources designed to cycle on a daily basis.

211 California Energy Commission, *Framework for Evaluating Greenhouse Gas Implications of Natural Gas-Fired Power Plants in California*, Consultant Report, May 2009, http://www.energy.ca.gov/2009publications/CEC-700-2009-009/CEC-700-2009-009.PDF.

212 California Independent System Operator, *Integration of Renewable Resources*. November 2007, http://www.caiso.com/1ca5/1ca5a7a026270.pdf, p. 78.

- Spinning reserves deal with unexpected fluctuations in generation output over a 10-minute to 30-minute range and must operate for at least 30 minutes to several hours from the time the needed level is reached. A cost-effective provision of this service requires operation without a substantial drop in efficiency.
- Nonspinning reserves handle changes in aggregate generation output over the 30-minute to two-hour range. The response does not need to be instantaneous but still must reach maximum output in 10 minutes. Fast-start units are necessary to provide nonspinning reserves.
- Inertia maintains system stability and reduces frequency deviations or oscillation. Inertia is provided through sufficient spinning mass (rotating turbines, for example) that effectively dampens (reduces) frequency changes and is addressed in detail in the following section.

According to recent analysis by the California ISO and CPUC in the Long-Term Procurement Plan Proceeding (Trajectory Case), the share of California's electricity provided by variable energy resources is expected to rise to 22 percent in 2020.[213] At this higher level, large, fast ramps up or down that are difficult to forecast are of particular concern.

Renewable Intermittency

Building large amounts of intermittent renewable technologies introduces challenges that did not exist when geothermal and biomass were California's dominant renewable resources. While geothermal and biomass have fuel availability issues, they are much more like large, baseload units that run at a steady state or units that can ramp up or down as needed. They also can provide some level of system inertia.

Variable renewable energy resources such as wind and solar share several characteristics that require increased operational flexibility:

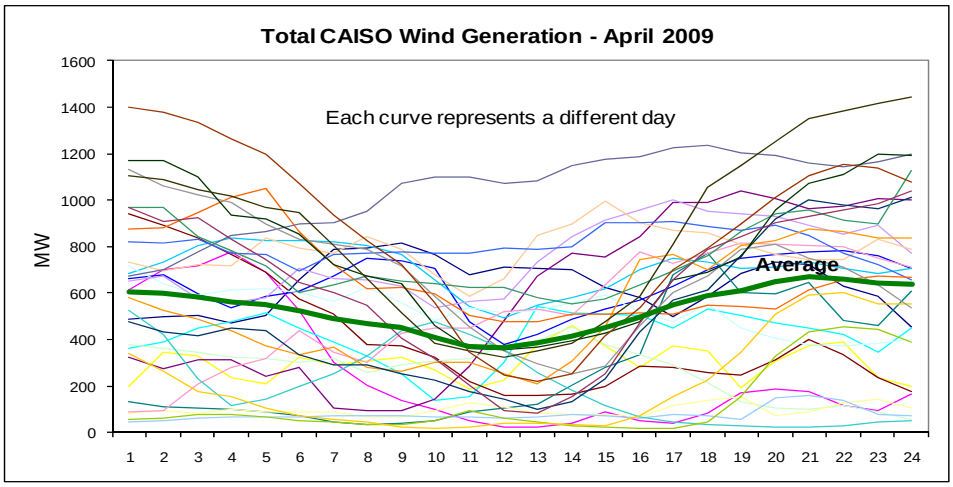
- A variable fuel source that is difficult to accurately forecast.
- A typical generation pattern that does not match system load and, in the case of solar, may be ramping down in the late afternoon as load is picking up.
- A generation pattern that does not inherently smooth out the variations to flow a predictable product onto the grid.
- An inability to dispatch on command, and an inability of solar photovoltaic (PV) resources and wind resources to significantly contribute to system inertia or frequency control.

Solar and wind generation patterns, on average, complement each other. Solar energy is highest in the early afternoon compared to system peaks in the later afternoon or early evening. Wind patterns vary considerably over seasons and locations, but commonly during the summer its highest production is at night. While each technology has a basic daily pattern, that pattern can

213 The 2020 share is from the California ISO study of 33 percent renewables for the CPUC Long-Term Procurement Proceeding.

also change from moment to moment and day to day. In these cases, each resource's variability may either cancel out or compound the total system variability. For example, the California ISO experienced an upward swing in one hour of 845 MW and a downward drop in another hour of -349 MW on July 6, 2011.[214] Figure 13 shows day-to-day wind variability.

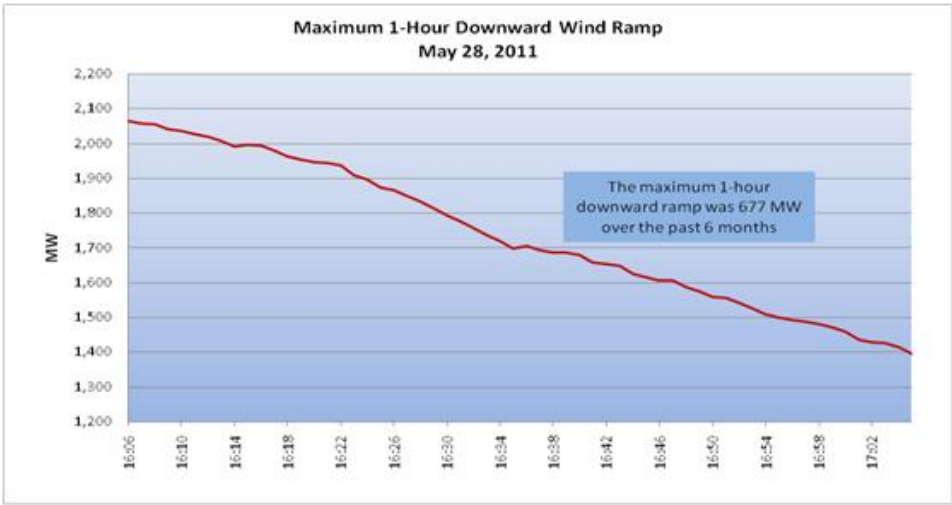
Figure 13: Daily Wind Variation Over One Month



Source: California Independent System Operator

Figure 14 shows that 677 MW of wind generation was lost within one hour on May 28, 2011. While these large swings may not be typical or frequent, system operators must prepare for smaller, ongoing changes as well as significant sudden losses of wind and solar resources.

Figure 14: Sudden Loss of Wind Production

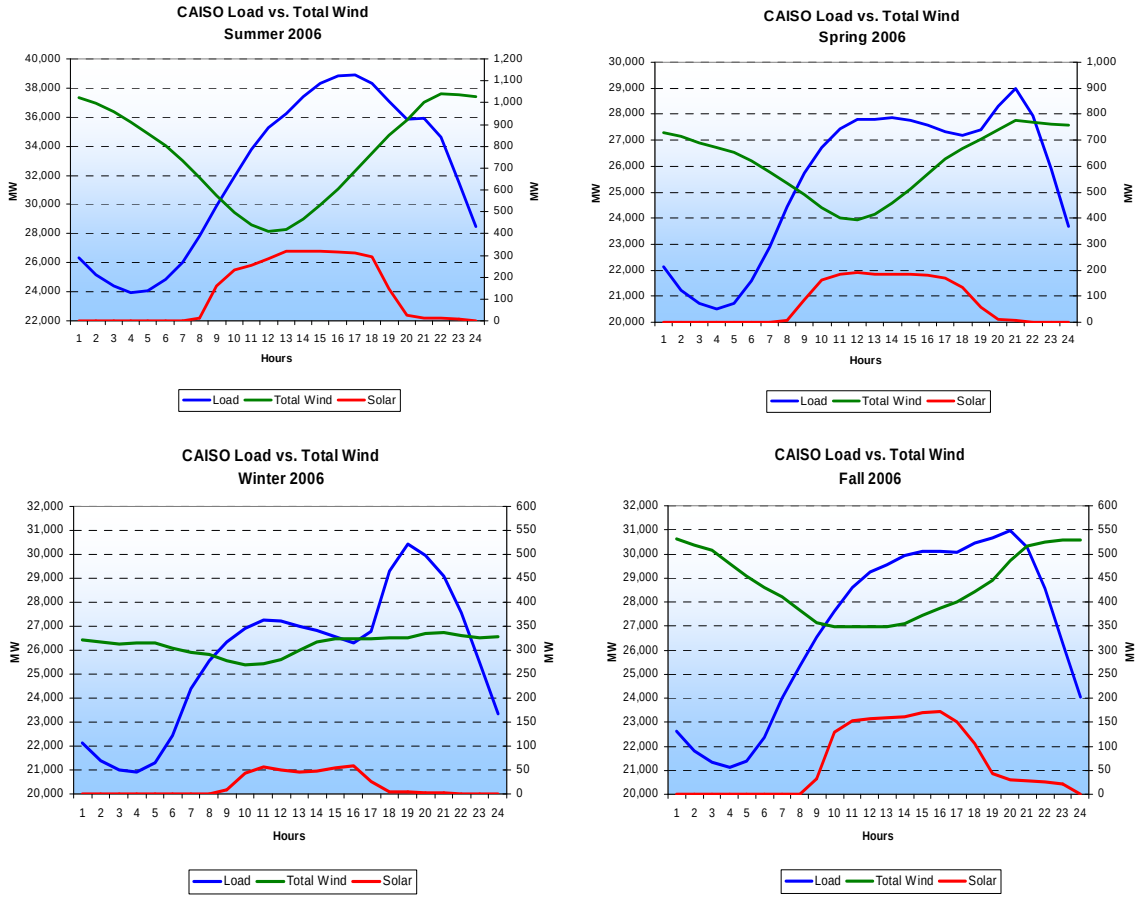


Source: California ISO

214 Dennis Peters, California ISO, e-mail communication, August 8, 2011.

Within these big swings are smaller variations such as when PV generation drops suddenly when a cloud passes over or wind currents gust or drop off. Figure 15 illustrates the daily load profiles for wind and solar over a 24-hour period in the California ISO. These large, fast changes pose operational challenges for example, if wind ramps down during the same period solar production begins, thermal units must be dispatched to fill the gap.

Figure 15: Daily Load Profiles for Wind and Solar



Source: California ISO 2007 Intermittent Renewables Integration Report

The following discusses operational challenges for integrating renewables including regulation, ramping, and inertia and frequency control, and the associated ancillary services to support them.

Regulation

Regulation is the automatic control of second-to-second variations in system frequency caused by changes in generation or load.[215] These services include generation or automated demand

215 Frequency is measured in cycles per second or in Hertz. In North America, frequency must remain near 60 Hertz. Maintaining a steady and safe frequency range is essential to the instantaneous balance between generation and load

response that are on-line and ready to respond immediately to automatic generation control signals sent by the system operator, and spinning reserves synchronous to the grid.[216] Gas-fired units, storage, demand response, or large hydropower that uses variable speed pumps currently incorporate regulation up and down products. However, the need for regulation, balancing, and intra-hour regulation capacity is expected to increase as more variable energy resources are added to the generation fleet.

Ramping (Load Following)

Ramping capability balances the less predictable energy production patterns of renewable resources such as wind and solar. These resources do not have the ability to firm and shape their production output. Ramping changes the operating level of a generating unit to ensure that the system remains in balance to meet the average demand moving from one 5-minute dispatch interval to the next. The California ISO needs flexible resources committed to sufficient ramping capability (both quick start-ups and slow-downs) to balance the system within the operating hour, including second-to-second real-time imbalances.

Ramping up (increasing output) and ramping down (decreasing output) are separate products; a unit might be able to ramp down from its current operating level but not be able to ramp up. The role of ramping is expected to grow because both wind and solar add or subtract power from the grid irrespective of the load and operations of other generation. Currently, the California ISO does not explicitly procure load-following in its day-ahead and real-time markets, but developing such a market is the subject of discussion.[217] One way the California ISO could accommodate the scheduling of intermittent resources would be to implement a 15-minute market that would increase bidding opportunities for all resources closer to real time.

Inertia and Frequency Response

Integration also has to consider the reliability concern of whether the system has sufficient system inertia. Inertia is the ability of the system to use the properties of synchronous generators to slow frequency deviation. For example, if a frequency excursion starts to develop, it can be reduced if large rotating masses or their equivalent are on-line that will slow down the excursion of the frequency from its desired levels. Keeping the lights on requires that power generators respond automatically within seconds to halt a swing in frequency and restore levels to the 60-cycle per-second standard. Demand and generation are constantly changing, meaning some unintentional outflow or inflow of energy occurs at any given moment. This mismatch,

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on an interconnected electric power system. See Joseph H. Eto, et al, December 2010, *Use of Frequency Response Metrics to Assess the Planning and Operating Requirements for Reliable Integration of Variable Renewable Generation*, Lawrence Berkeley National Laboratory, LBNL-4142E, http://www.ferc.gov/industries/electric/indus-act/reliability/frequencyresponsemetrics-report.pdf.

216 Spinning reserves are immediately responsive to system frequency and are capable of being loaded in 10 minutes and running for 30 minutes from the time it reaches desired capacity. See California Independent System Operator Corporation Fifth Replacement Tariff April 1, 2011, Appendix A Master Definition Supplement. http://www.caiso.com/Documents/AppendixA-FifthReplacementCAISOTariff.pdf.

217 California ISO, Integration of Renewable Resources: Operational Requirements and Generation Fleet Capability at 20% RPS, August 31, 2010, http://www.caiso.com/2804/2804d036401f0.pdf.

along with the obligation to maintain stable system frequency, is measured by Area Control Error (ACE). Balancing authorities must maintain sufficient regulating reserves to meet regional and national reliability standards for keeping ACE within limits.

A 2010 study released by Lawrence Berkeley National Laboratory (LBNL) reports that frequency levels are dropping further than realized on the nation's two largest grid systems, particularly at the start of the day when electricity demand ramps up and when it ramps down in the evening.[218] This situation is largely the result of operating choices by conventional generation and the lack of a unified method of paying generators to provide instantaneous frequency support. Intermittent resources are currently too small a factor to contribute to the decline, but as wind and solar increase, they could both add to the frequency deviation problem and help prevent such frequency swings if the operations are managed to that purpose.

The LBNL study points out that frequency control reserves play an essential role in ensuring reliability. If there is suddenly too much demand for generation on-line, control systems send an automatic signal to speed-regulating governors at power plants to get them to ramp up power within seconds. This "primary" frequency response is designed to halt a drop in frequency until other automatic but slower-responding "secondary" controls come into play. Finally, control room personnel acting within the hour can issue orders to bring other generators on-line to restore frequency to the proper level. Baseload coal-fired and natural gas-fired generating plants, equipped with governors, whose spinning generators have sizable inertial power, were ideal for primary response. This reserve capability, called "head room," is shrinking as plants operate at peak efficiency or produce a set output. To compound the situation, generators may be paid for slower-responding frequency support, but not for the instantaneous response to stop a sudden frequency deviation.

The California ISO is concerned that as intermittent resources displace conventional generation, the system may have insufficient inertia to maintain system frequency or enough governor response to stabilize system frequency following a grid disturbance. The ability to automatically reduce energy output in response to frequency deviations may become an increasingly important attribute as the percentage of variable resources in the supply portfolio increases over time.[219] The Electric Reliability Council of Texas (ERCOT) has already confronted inertia issues and found that "inertia of the grid helps limit the rate of change of frequency to allow conventional synchronous generators time to deliver Primary Frequency Response and stabilize grid frequency."[220]

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218 See Joseph H. Eto, et al, *Use of Frequency Response Metrics to Assess the Planning and Operating Requirements for Reliable Integration of Variable Renewable Generation*, Lawrence Berkeley National Laboratory, LBNL-4142E, December 2010, http://www.ferc.gov/industries/electric/indus-act/reliability/frequencyresponsemetrics-report.pdf.

219 California ISO. Renewables Integration Market Vision & Roadmap, Day-of-Market. Initial Straw Proposal. July 6, 2011.

220 ERCOT, *Emerging Technologies Integration Plan*, draft October 22, 2010, p. 43.

Wind turbines and solar PV provide little to no inertia, so when the frequency rises or falls, they do not smooth out their departures from the frequency balance, which needs to be maintained at all times. Wind offers a quick capability of dropping its energy output down and can respond quickly to add energy if there is head-room, which could be very influential in the one- to two-second period.[221] For example, wind turbines with pitch control, which allows their output to be curtailed in real time by adjusting the turbine blade pitch, can contribute to primary frequency regulation. The majority of wind turbines in use since 2006 has a wider speed range and finer control of active power production, more closely resembling conventional synchronous generators able to provide fast voltage control[222] Other energy storage technologies, such as flywheels and battery storage, can also add to the mix of stabilizing technologies to address inertia.

Forecasting Challenges With Increasing Intermittency

Grid operators need real-time data and improved forecasting methods to reduce uncertainty associated with intermittent renewable resources. As previously discussed, greater amounts of variable energy interconnected to the grid can increase the magnitude of forecasting errors, and this variability must be covered by other generation, which is ramped up and down to keep the system in balance. Inaccurate forecasts make it harder for grid operators to ensure that committed resources have the necessary capabilities (ramp rate) to meet expected variability.

Accurate forecasting of variable energy in the day-ahead and real-time operational time frame is important because resources must be procured ahead of time so that transmission and generation dispatchers will have sufficient and appropriate complementary resources available to meet demand. The larger the disparity between when resources need to be procured and actual conditions, the higher the probability that more resources will be dispatched at higher prices and the system will rely on more expensive regulating reserves.

Accurate weather forecasts are a critical element of reducing forecast error to allow cost-effective balancing of supply and demand. For example, in the California ISO system, for temperatures over 100 degrees F, a forecast error of one degree can result in a 980 MW over- or underestimation of load.[223] As discussed earlier, wind and solar generation variability can be significant. Forecast error of hour-ahead demand increases as loads are higher, typically being more pronounced in summer when they can deviate up or down by as much as 2,000 MW.[224] Concerns have been raised that the introduction of forecast error from intermittent renewables on the generation side, coupled with existing forecast error on the demand side, may result in larger discrepancies between forecasts and what would be needed in real time.

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221 North American Electric Reliability Council, *Accommodating High Levels of Variable Generation*, April 2009, http://www.aeso.ca/downloads/IVGTF_Report_041609(1).pdf , pp.16-23.

222 California Independent System Operator, *Integration of Renewable Resources*. November 2007, http://www.caiso.com/1ca5/1ca5a7a026270.pdf, p. 29.

223 Ibid.

224 Ibid, pp. 49-56.

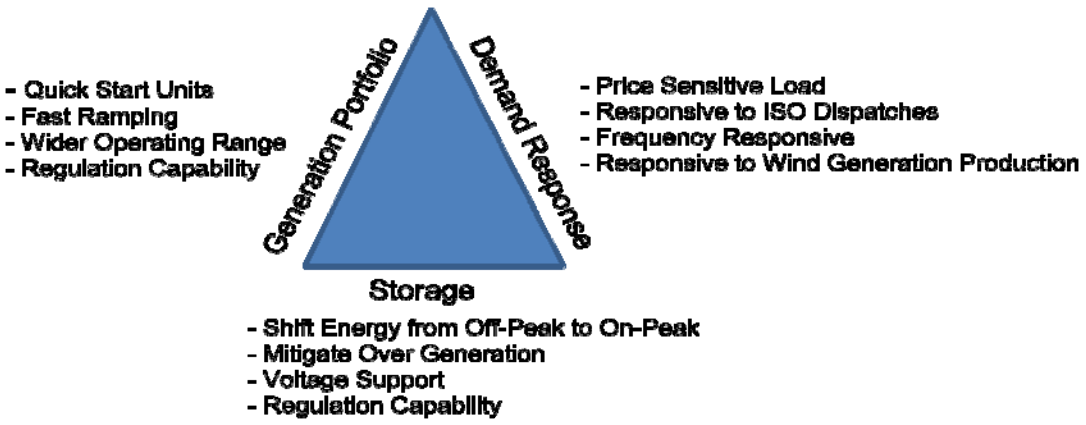
The California ISO has taken steps to improve its forecasting techniques and is evaluating promising new forecasting tools. For details, see the section "Forecasting Improvements" later in this chapter. In addition, the Energy Commission's Public Interest Energy Research (PIER) Program is providing funding to support grid-level activities that will reduce the uncertainty created by variable energy resources for control and balancing requirements. For details on R&D to address wind forecasting and operational issues, new forecasting tools for wind and solar generation, and future opportunities for research in this area, see Chapter 9 and Appendix H.

Complementary Integration Technologies: Storage, Demand Response, and Gas-Fired Units

Three types of infrastructure are being studied to support high levels of renewable integration – energy storage, demand response, and gas-fired units. Each has integration values and challenges in terms of effectiveness, commercial availability, relative cost, locational attributes, and environmental consequences. Smart grid advanced discussed in Chapter 6 will enhance their ability to address variable energy challenges. Some resources, like demand response, can provide bill-reducing benefits to individual customers, while others, like gas-fired turbines, are a source of energy and capacity. The California ISO calls these three resources "Partners for Success" in renewable integration.

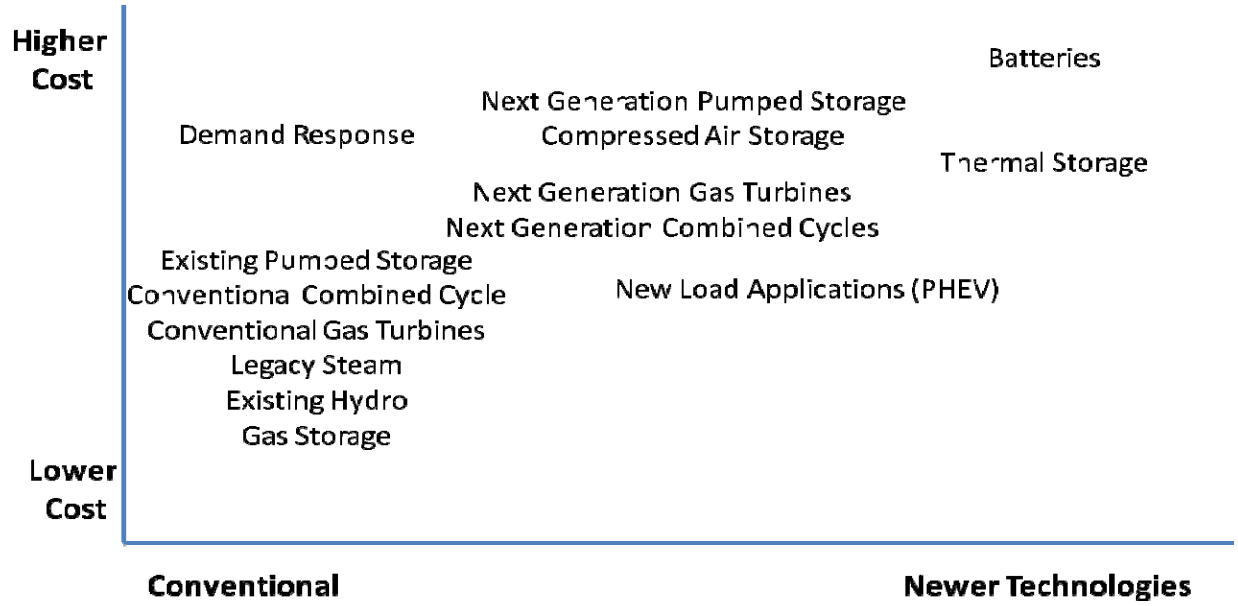
Figure 16 shows the different roles these complementary resources can play in integrating renewable resources. The three complementary services offer various choices for flexible and rapid response for renewable integration. Figure 17 depicts two key dimensions, costs and deployment status, for the various technologies.

Figure 16: Complementary Strategies for Integrating Renewable Generation



Source: California Energy Commission, modified from a California ISO depiction

Figure 17: Cost and Technology Deployment for Energy Storage, Demand Response, and Fossil Generation



Source: Presentation by Roy Kuga, Independent Energy Producers Annual Meeting, September 24, 2010, iepa.com/2010AnnualMeeting/RoyKugaIEP092410.ppt .

The following discusses the challenges and efforts to address renewable integration associated with energy storage, demand response, and natural gas-fired resources.

Energy Storage

Energy storage for renewable integration could provide flexible and controllable ancillary services and neutralize the impact of intermittent and unpredictable renewable generators in a variety of ways. Through voltage support, energy storage could help regulate voltage and reduce flicker;[225] automatically inject energy to provide frequency response; provide grid stability by supplying immediate energy to stop grid oscillations and improve grid damping; and potentially provide a service similar to inertia through smart inverters.[226] To the extent energy storage options are available and can competitively participate in providing ancillary services, they can also provide additional benefits not commonly available through conventional, fossil fuel-generated ancillary services. These include supplying ancillary services without greenhouse gas (GHG) or other air emissions and offering a place for excess energy to go when on-line generation exceeds load (overgeneration).

To manage frequent and wide variations in solar and wind energy output, storage must offer rapid response and operational flexibility to provide regulation and load-following capabilities.

225 Power-line flicker is a visible change in brightness of a lamp due to rapid fluctuations in the voltage of the power supply. Flicker is generated by load changes and can be reduced by less frequent or smaller load changes.

226 A "smart inverter" has increased communications and control capabilities. Hawkins, David, KEMA, Energy Storage Applications and Economics, presentation at the IEPR Committee Workshop, April 28, 2011, p. 7.

For better integration, different ramp rates (MW power delivered per minute) become an important consideration. Table 14 compares the ramp rates of various storage technologies with gas generation technologies, showing that some storage technologies have higher ramp rates than conventional gas generation.

Table 14: Ramp Rates of Different Generation and Storage Technologies

Types of Technology	Ramp Rates (MW/Minute)
Conventional Steam Generation	3 - 10
Conventional Peaker	10
Conventional Combined Cycle	12 - 15
Next Generation Fast Ramp Combined Cycle[227]	30
Next Generation Fast Ramp Peaker	30
Pumped Storage	40
Compressed Air Energy Storage (CAES)	90
Battery Technology	Depends on size and technology

Source: Roy Kuga presentation at Integrated Energy Planning Annual Meeting, September 24, 2010

While installed energy storage takes many forms, pumped hydro systems are by far the most widely used, with more than 127,000 MW installed worldwide. Compressed air energy storage (CAES) installations are the next largest (444 MW), followed by sodium-sulfur batteries (316 MW). All remaining energy storage resources worldwide total less than 85 MW combined and consist mostly of a few single installations. Underground CAES and pumped hydro are the lowest cost in $/kWh (total cost divided by hours of storage duration) but face constraints of identifying developable sites, environmental permitting, and availability near transmission assets.[228] Table 15summarizes various storage technologies and their attributes for grid stability.

Assembly Bill 2514 (Skinner, Chapter 469, Statutes of 2010) has set in motion formal planning for adding cost-effective storage to California's electricity system. It directed the CPUC and the publicly owned utilities to evaluate the need for and benefits of cost-effective and viable energy storage systems and determine appropriate targets by October 2013. The first target is to be achieved by December 2015 and a second target, if appropriate, by December 2020. The CPUC opened its proceeding in December 2010.[229] During the first phase, the proceeding will develop overall policies and guidelines for energy storage systems, including where and how storage could be deployed to provide maximum benefits to the electric system. During the second

227 General Electric's press release on its website on May 25, 2011, on new Flex-Efficiency Combined Cycle claims a ramp rate of 50 MW/minute.

228 For more details on costs of different storage technologies, see EPRI, *Electricity Energy Storage Technology Options, A White Paper on Applications, Costs, and Benefits*. Technical Update, December 2010, http://www.smartgridlegalnews.com/epri_report.pdf.

229 California Public Utilities Commission, R.10-12-007, *Order Instituting Rulemaking Pursuant to Assembly Bill 2514 to Consider the Adoption of Procurement Targets for Viable and Cost-Effective Energy Storage Systems*, December 16, 2010, http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/128658.htm.

phase, the proceeding will develop costs and benefits for energy storage systems and cost allocation.[230]

Table 15: Electricity Energy Storage Technology Options

Technology Option	Maturity	Capacity (MWh)	Power (MW)	Duration (hrs)	% Efficiency (total cycles)	Total Cost ($/kW)	Cost ($/kWh)
Bulk Energy Storage to Support System and Renewable Integration							
Pumped Hydro	Mature	1680-5300	280-530	6-10	80-82 (>13,000)	2500-4300	420-430
		5400-14,000	900-1400	6-10		1500-2700	250-270
CT-CAES (underground)	Demo	1440-3600	180	8	(>13,000)	960	120
				20		1150	60
CAES (underground)	Commercial	1080	135	8	(>13,000)	1000	125
		2700		20		1250	60
Sodium-Sulfur	Commercial	300	50	6	75 (4500)	3100-3300	520-550
Advanced Lead-Acid	Commercial	200	50	4	85-90 (2200)	1700-1900	425-475
	Commercial	250	20-50	5	85-90 (4500)	4600-4900	920-980
	Demo	400	100	4	85-90 (4500)	2700	675
Vanadium Redox	Demo	250	50	5	65-75 (>10,000)	3100-3700	620-740
Zn/Br Redox	Demo	250	50	5	60 (>10,000)	1450-1750	290-350
Fe/Cr Redox	R&D	250	50	5	75 (>10,000)	1800-1900	360-380
Zn/air Redox	R&D	250	50	5	75 (>10,000)	1440-1700	290-340
Energy Storage for ISO Fast Frequency Regulation and Renewable Integration							
Flywheel	Demo	5	20	0.25	85-87 (>100,000)	1950-2200	7800-8800
Li-ion	Demo	0.25-25	1-100	0.25-1	87-92 (>100,000)	1085-1550	4340-6200
Advanced Lead-Acid	Demo	0.25-50	1-100	0.25-1	75-90 (>100,000)	950-1590	2770-3800
Energy Storage for Utility Transmission & Distribution Grid Support Applications							
CAES (underground)	Demo	250	50	5	(>10,000)	1950-2150	390-430
Advanced Lead-Acid	Demo	3.2-48	1-12	3.2-4	75-90 (4500)	2000-4600	625-1150

Source: Electric Power Research Institute

230 California Public Utilities Commission. R.10-12-007. Scoping Memo and ruling of Assigned Commissioner and Administrative Law Judge. May 31, 2011. http://docs.cpuc.ca.gov/efile/RULC/136248.pdf.

The findings of the proceedings will also provide insights about the size and scope of energy storage on the California grid that would directly or indirectly help renewable integration. Assessments by the CPUC and the publicly owned utilities will draw heavily on the results of various storage pilot projects being constructed in California. To support this AB 2514 process, PIER is sponsoring a multiagency Energy Storage Vision Project to review the technical status of various technologies and produce 10-year scenarios highlighting the value of energy storage to meet state goals.[231] A white paper is expected later this year.

For details on the status of storage technologies and PIER-funded demonstrations, see Chapter 9 and Appendix H.

Demand Response

Demand response (DR) refers to "changes in electric usage by demand-side resources from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized."[232] The most basic DR programs maintain system reliability and prevent blackouts, but in recent years DR has evolved into a more dynamic resource that also provides price mitigation and ancillary services to utilities and grid operators.

The Energy Commission developed load management standards in 1976 in three suggested areas: rate structure adjustments (with final authorization by the CPUC), end-use storage systems (thermal, pumped), and mechanical or automatic control devices.[233] California utilities have used reliability-based DR programs like air conditioning cycling and industrial process curtailments since the 1980s. The 2001 energy crisis and the 2006 heat storm created new interest in demand-side reliability services. While research will enhance understanding of DR's role in renewable integration, much of the infrastructure and many market products exist to provide demand-side ancillary services in the current market.

DR must respond in different time frames: slow (day ahead), fast (10 minutes), and instantaneous (less than 5 minutes).[234] DR's potential role in integrating renewables comes from its ability to aggregate smaller loads to provide regulation or ramping through automatic controls that turn individual loads up or down as needed.[235] In certain markets, DR is already

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231 2020 Energy Storage Vision for California. Slide presentation by Ethan Elkind and Byron Washom, 2011 IEPR Committee Workshop on Energy Storage for Renewable Integration, April 28, 2011. http://www.energy.ca.gov/2011_energypolicy/documents/2011-04-28_workshop/presentations/02_UCB_UCSD_2020_Energy_Storage_Vision_for_CA.pdf.

232 http://www.ferc.gov/industries/electric/indus-act/demand-response/dem-res-adv-metering.asp.

233 California Energy Commission, *2007 Integrated Energy Policy Report*, December 2007, http://www.energy.ca.gov/2007_energypolicy/index.html, p. 97.

234 Kiliccote, Sila et al. *Integrating Renewable Resources in California and the Role of Automated Demand Response*. Lawrence Berkeley National Laboratory, LBNL-4189E,.November 2010, pp. 20-26.

235 ENERNOC White Paper, *Demand Response: A Multi-Purpose Resource for Utilities and Grid Operators*, 2009, http://www.enernoc.com/resources/files/whitepaper-dr-a-multi-purpose-resource.pdf.

eligible to provide ancillary services, including spinning reserves and regulation services. Customers who can immediately reduce power demand (typically for a 10- to 60-minute period) in response to dispatch signals without significant impact on business operations are effective ancillary resources. A portfolio of DR approaches is best to mitigate the combined variability of wind and solar generation.

Economic or price-response DR programs involve a voluntary response to a price signal. In these programs, a utility or system operator can schedule and dispatch DR when a price reaches a level at which a DR resource is willing to respond. Emergency or reliability programs differ in that the response is not voluntary (capacity obligations are guaranteed) and a capacity payment for being available is generally involved. Peaking alternative programs, another type of DR program, share many of the characteristics of emergency programs but are dispatched more frequently. Many of these programs are sufficiently dispatchable to be called upon as needed with 10 minutes or day-ahead notification.

It may even be possible that real-time interface of building automation systems and home area networks with prices and grid conditions could mean devices that respond to grid stress are able to shift or curtail use even before a system event, such as tight power supply or equipment approaching capacity limits, actually occurs. Pilots and research efforts for devices to directly react to grid condition indicators are expected to begin later this year as discussed in Chapter 9 and Appendix H.

In November 2006, the CPUC called for the expansion and augmentation of the investor-owned utilities' DR programs.[236] Since that decision, utilities have increased their reliability and price-responsive DR programs and created a utility portfolio projected to reach 3,000 MW in 2011.[237] Many of these utility programs could provide supporting energy and capacity services in markets with increasing penetration of intermittent renewable generation. To effectively integrate renewables, reliability-based DR needs to be available more hours throughout the year and provide a wider range of load response. The Demand Response Measurement and Evaluation Committee, composed of members from the CPUC, the Energy Commission, and California IOUs, is developing a request for proposals to assess utility DR programs and their potential to provide renewable integration services.

Integrating DR into open markets requires overcoming barriers. While DR services can come on-line quickly and last for minutes up to a few hours, longer-term responses of four to six hours are more difficult to provide. Similarly, DR products may not fulfill the current continuous energy requirement for spinning reserves, nonspinning reserves, and regulation products. The following describes examples of DR products and programs currently used for integration.

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236 California Public Utilities Commission, *Order Adopting Changes to 2007 Utility Demand Response Programs*, D.06-11-049, November 30, 2006, http://docs.cpuc.ca.gov/published/FINAL_DECISION/62281.htm.

237 http://www.narucmeetings.org/Presentations/Demand_CPUC.pdf.

The California ISO offers two DR products – the Participating Load Product and the Proxy Demand Resource. The Participating Load Product is dispatched directly by the California ISO and can provide nonspinning reserve or curtailable load in the real-time market, and the Proxy Demand Resource submits bids into the day-ahead or real-time markets at the customer's or the aggregator's discretion.[238] Both products are laying the foundation for the role of DR in renewable integration efforts.

Other ISOs in the United States have modified their tariff structures to allow load resources such as DR to participate in their markets.

- PJM, a regional transmission organization located in Pennsylvania that coordinates the movement of wholesale electricity in 13 Eastern states and the District of Columbia, allows load resources to provide forward capacity, synchronized reserve, and regulation and uses DR products for regulation and spinning reserve. DR can be used in the Synchronized Reserve Market – where customers curtail their energy use within 10 minutes for about 15 minutes – alongside generation to provide operating reserves resources.
- The increasing penetration of wind resources in Texas helped spur innovation in ERCOT's energy management processes. In December 2010, ERCOT moved from a zonal to nodal market structure.[239] The design of ERCOT's new nodal market includes provisions for load participation in ancillary service markets as regulation, responsive reserve, nonspinning reserve, and curtailment resources. DR must reduce automatically through an underfrequency relay when grid frequency falls below a certain level and within 10 minutes to provide Responsive Reserve Service.
- The ISO/RTO (Regional Transmission Organization) Council published a comparison table of more than 50 North American DR programs.[240] The document contains summary information on programs, products, and services with an overview of more in-depth DR rules and procedures.

Using DR to address renewable integration issues has a number of challenges, including the need for additional R&D. For details on R&D related to demand response programs, see Chapter 9 and Appendix H.

Gas-Fired Generation – Existing, Retiring, and New

California's fleet of natural gas generators includes gas-fired combined cycles, steam boilers, peaking plants, and turbines. These generators provide some operational characteristics that can be used to integrate variable renewable resources. With the construction of new, more

238 http://www.caiso.com/271e/271ee8df2c760.pdf.

239 ERCOT, Texas Nodal Market Implementation, http://nodal.ercot.com/.

240 *North American Wholesale Electricity Demand Response Program Comparison*. 2010 Edition. http://www.isorto.org/atf/cf/%7B5b4e85c6-7eac-40a0-8dc3-003829518ebd%7D/IRC%20DR%20M&V%20STANDARDS%20IMPLEMENTATION%20COMPARISON%20(2009-05-18).PDF.

efficient gas-fired units and the retirement of older ones over the last several years, natural gas generation now comprises more than half of the in-state energy production and produces the same level of energy while using 17 to 23 percent less natural gas than it did just a decade ago.[241]

Gas-fired resources under AGC, primarily newer combined cycles, expected to be on-line a significant number of hours during the year, can provide regulation services. Aging steam turbines, such as those expected to retire or be retrofit or repowered under the State Water Resources Control Board (SWRCB) policy on once-through cooling (OTC), also provide regulation services while on-line if they are equipped with AGC. Peaking facilities do not typically provide regulation as it is not economic to fit them for AGC given their limited hours of operation.

This same set of gas-fired resources can provide spinning reserve while on-line and operating at less than full load. Aging steam turbines provide substantial amounts of spinning reserve and are able to ramp down to very low operating levels but must remain on-line if they are to be made available later in the day or for the next day given their slow start up. The unloaded upper blocks, or the "idle share" of these turbine units, can be a substantial source of potential output at a few minutes' notice. Peaking facilities also provide spinning reserve to the extent that they can meet California ISO requirements for providing energy on short notice.

Newer combined cycles and peakers provide nonspinning reserves, although the former generally provide nonspin only under warm-start conditions, meaning the generation had stopped running within a matter of hours earlier. Due to their slow-start nature, aging steam turbines are not relied upon for nonspinning services. If on-line at less than full load, these resources provide spinning reserves but if off-line cannot ramp up quickly enough to meet the requirements for nonspinning reserve delivery.

New gas-fired resources are expected to provide different types and amounts of ancillary services depending on the speed at which they ramp up and operate over wide output ranges. Faster-starting combined cycles capable of operating at well below full load will be increasingly able to participate in the nonspinning reserve market since they can come on-line and meet their nonspinning reserve obligation within 10 minutes, more quickly provide larger amounts of spinning reserves within 10 minutes, or provide load-following due to their ability to operate at a lower load levels.

A key challenge going forward is the need to modify revenue streams for natural gas units that provide integration services; the revenue streams need to cover the incremental costs of shifting use from maximizing efficient energy production to providing flexible products more for operating reserves or regulation. The California ISO's market tariffs will be a major avenue for

241 California Energy Commission, *Thermal Efficiency of Gas-Fired Generation in California,* staff paper, August 2011, http://www.energy.ca.gov/2011publications/CEC-200-2011-008/CEC-200-2011-008.pdf.

these changes, as will the contracts offered by utilities and energy service providers.[242] Market activities are discussed later in this chapter.

To properly support the modern grid and to fully address the need for system inertia, additional research is needed on the roles that these and other technologies can provide. PIER research continues to investigate inertia and ways to increase flexibility of the current generation fleet.[243]Another challenge may be the potential for environmental impacts from integrating renewable with natural gas resources, depending on the supply and market strategies selected. Integration may be obtained with minor incremental environmental impacts if services can be provided by better use of existing natural gas infrastructure. If a new gas-fired power plant provides renewable integration services more efficiently than the existing fleet, then the new plant could provide a net reduction of greenhouse gases directly emitted in electricity generation.[244] However, recent California ISO studies indicate that integration issues could limit the air quality and environmental benefits of renewable resources. In addition, if existing units cycle more frequently, there may be tradeoffs between decreased energy production and increased production of ancillary services, which may increase or decrease local air pollution.

The process is complicated because integration services are not added in a vacuum; electricity systems may also need units for local reliability or system support. Additional study in this area, such as the Joint Energy Agencies studies being conducted as part of the SWRCB's implementation of OTC rules related to gas-fired generation, will help clarify the role of new, replaced, or repowered OTC gas-fired generation, which in turn will help with assessing their potential environmental impacts. An additional issue not well understood is the environmental impacts of different placement of integration services, whether close to generation or load or in an intermediate location.

Overgeneration could also reduce the environmental benefits of renewable resources. This typically occurs when the combined levels of imports, hydro, wind, and solar generation exceed load – primarily nights or weekends – and generation is sold at a loss, backed out, or shut down to balance the system. If fossil generation is not backed out, fuel use is not reduced, and

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242 Much of this section is summarized from *Framework for Evaluating Greenhouse Gas Implications of Natural Gas-Fired Power Plants in California*, CEC-700-2009-009-F, December, 2009, pp. 91-96.

243 See for example, California Energy Commission. *Renewable Resource Integration Project – Scoping Study of Strategic Transmission Operations, and Reliability Issues.* PIER Final Project Report. December 2008. CEC 500-2008-081. http://www.energy.ca.gov/2008publications/CEC-500-2008-081/CEC-500-2008-081.PDF.

244 "Although a single natural gas-fired power plant produces GHG emissions, under certain circumstances the addition of a gas-fired plant may yield a GHG emission benefit. The authors conclude that this would be the case if the plant provided support to integrate renewable energy under a 33 percent RPS, if the addition raised the overall efficiency of the electric system, or if the new plant served load growth more efficiently than the existing fleet." McClary, Steven C., Heather L. Mehta, Robert B. Weisenmiller, Mark E. Fulmer and Briana S. Kobor (MRW & Associates). 2009. *Framework for Evaluating Greenhouse Gas Implications of Natural Gas-Fired Power Plants in California*. California Energy Commission. CEC-700- 2009-009. http://www.energy.ca.gov/2009publications/CEC-700-2009-009/CEC-700-2009-009-F.PDF, p. 8.

environmental benefits of the renewable generation are decreased. Devices such as storage that can consume more and receive compensation for storing that energy may be one way to manage overgeneration situations.[245] The California ISO is also considering market changes that would eliminate some of the existing incentives that renewable resources have for continuing to produce in overgeneration situations.

Adding nonfossil fuel resources, such as DR or storage, to help support intermittent renewable generation could reduce emissions. The production and disposal of new equipment types such as flywheels and lithium or other substances in batteries may also cause direct and indirect environmental impacts. Pumped hydropower storage facilities can have mixed environmental impact depending on the location, size, and design of the reservoirs.[246]

Efforts to Address Integration Challenges

California Independent System Operator

Forecasting Improvements

The California ISO is taking steps to improve forecasting techniques to reduce uncertainty in its integration-related forecasting by:

- Shortening the length of load and generation forecast times from two hours ahead to 75 minutes ahead to allow operators to deal more effectively with potential under- or overgeneration issues.
- Basing solar profiles on new National Oceanic and Atmospheric Administration (NOAA) satellite irradiation data rather than less accurate NREL land-based solar measurements. Solar profiles will become increasingly important as large solar PV interconnects to the bulk power grid. Currently California ISO operators deal with about 100 MW of solar PV and 400 MW of solar thermal, but future levels will increase significantly.
- Evaluating a regulation prediction tool developed by the Pacific Northwest National Laboratory with PIER support to estimate upward and downward regulation requirements for capacity, ramp rate, and ramp duration for each operating hour of the day.
- Evaluating a ramp and load-following prediction tool developed by the Pacific Northwest National Laboratory with PIER support to predict, in the three- to five-hour-ahead period,

245 Comments by Mark Rothleder and Chairman Robert Weisenmiller, Transcript of IEPR Committee Workshop on Energy Storage for Renewable Integration, April 28, 2011, pp. 56-58, http://www.energy.ca.gov/2011_energypolicy/documents/2011-04-28_workshop/2011-04-28_Transcript.pdf.

246 For example, the Lake Elsinore Advanced Pumped Storage project encountered significant public opposition due to expected environmental impacts and related concerns. FERC dismissed its application on July 12k 2011. See http://lakeelsinore-wildomar.patch.com/articles/feds-question-viability-of-leaps-project. See also, http://www.evmwd.com/depts/admin/public_affairs/leaps/about_leaps.asp.

load-following capacity and ramping requirements affected by forecast uncertainties regarding loads and renewable generation.[247]

Addressing the geographic diversity of renewable resources in operational forecasting is receiving increased attention. In 1978, Edward Kahn of Lawrence Berkeley National Laboratory, with Energy Commission support, conducted one of the first comprehensive studies to address the issue of geographical diversity of wind plants.[248] Using California wind and utility data, Kahn found that reliability does increase as a function of geographic dispersal, but this increase is limited by the geographic wind diversity and the barrier of large wind plant penetrations relative to the conventional generator mix. In recent studies of wind, Andrew Mills and Ryan Wiser from LBNL demonstrated and documented the significant smoothing effect of geographic diversity. Working with the California ISO, the authors also studied forecasting improvements through geographic modeling of solar PV plants.[249]

Solar has been less studied than wind, but Mills and Wiser found indications in previous research that with "enough" geographic diversity, the subhourly variability due to passing clouds is smoothed. Available land or rooftops or transmission capacity could lead to sufficient geographic dispersion. On the other hand, getting sufficient geographic dispersion could lead to more transmission losses from distant sites or plants sited in lower quality areas. These complex trade-offs deserve further study by the Energy Commission and others. Benefits of increasing the distance within individual plants, between plants in one area, and between plants in the same balancing authority – and cost comparisons – also need to be studied.

Additional study results show that, at individual sites, PV production is more variable than wind for subhourly time scales, but that the distances between sites required to obtain diversity and therefore smooth the output for sub-hourly variability are slightly less than for wind. While study results indicate geographic diversity has some beneficial potential for smoothing variable output, questions remain for productive research.[250] For details on PIER research dealing with forecasting under increasing variability, see Chapter 9 and Appendix H. For information on potential environmental justice concerns regarding geographic diversity for renewable generation buildout, see Chapter 10.

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247 *Incorporating Wind Generation and Load Forecast Uncertainties into Power Grid Operations*. Wind Energy Management System EMS Integration Project. Pacific Northwest National Laboratory. PNNL-19189. January 2010. Also John W. Zack, "Wind Forecasting Efforts to Improve Renewable Penetration," Presentation at IEPR Workshop, July 31, 2008.

248 Kahn, Edward. *Reliability Planning in Distributed Electric Energy Systems.* Lawrence Berkeley Laboratory, University of California. Prepared for the Systems Integration Office, California Energy Resources Conservation and Development Commission. LBL-7787. October 1978.

249 Mills, Andrew and Ryan Wiser. *Implications of Wide-Area Geographic Diversity for Short-Term Variability of Solar Power. Lawrence Berkeley National Laboratory*. LBNL-3884E. September 2010.

250 Thomas Hoff and Richard Perez of Clean Power Research are conducting similar geographic diversity analysis for solar PV as part of the CPUC's Long-Term Procurement Proceedings. Their results validate the LBNL study.

Market and Product Changes

In concert with FERC's leadership, the California ISO has embarked on a several-year market and product review for renewable integration. Sound market design can address operational issues by aligning technical requirements and market incentives. This is important in systems such as the California ISO in which market rules coordinate efficient performance of the electricity system.

In 2010, the California ISO began a stakeholder process[251] to restructure its wholesale market design, including new market products and market rules. Rules such as the Participating Intermittent Resource Program (PIRP), originally designed in 2002, did not recognize the California ISO's need to economically dispatch variable resources in a real-time market. Changes are needed to improve nondiscriminatory access; allow more nontraditional resources to compete in the energy, capacity and ancillary services markets; and assign costs fairly among market participants. The stakeholder process is also addressing how revenues for conventional generators will change as they switch roles from providing primary sources of energy to providing more load-following and grid supportive functions for integrating renewables.

In the energy market, California ISO has indicated that the following market reforms may help with renewable integration:

- Increase operational flexibility by reducing generation self-scheduling.
- Economic dispatch of variable energy resources.
- Changes to the energy bid floor to encourage ramping down.
- Day-ahead scheduling of renewables and exploration of allowing intrahour scheduling.
- Dynamic transfers with neighboring balancing authorities.

In spring 2012, the California ISO is scheduled to implement a regulation energy market that will allow DR and energy storage to submit bids to provide ancillary services. California ISO is working on allocating renewable integration costs and has developed a starter list of issues for the next phase of design reform, such as dealing with the impact of adding renewables to the wholesale energy market.[252] Operational conditions that could require curtailment of renewable energy are expected to increase in magnitude and frequency, particularly overgeneration in spring high hydro, light load conditions, but possibly during other times as well. The current self-scheduling rules of the PIRP do not determine the most efficient amount of each resource to

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251 Renewable Integration — Market and Product Review. http://www.caiso.com/27be/27beb7931d800.html. Phase 1 identifies short-term solutions and Phase 2 considers mid- and longer-term solutions.

252 California Independent System Operator, *Issue Paper: Renewable Integration Market and Product Review Phase 1*, September 30, 2010 , and Mark Rothleder, Energy Storage for Renewable Integration, presentation for IEPR Committee Workshop on April 28, 2011, slide 9.

resolve overgeneration conditions. The overarching goal is to reduce reliance on administrative measures and to provide the correct incentives for economic bids.[253]

Moving toward more intrahour scheduling on interties among the various balancing authorities could significantly aid in integrating variable renewables. Extending dynamic transfer of renewable resources on the interties (across balancing area authorities) raises issues not encountered with conventional resources. Significant growth in renewables could mean bringing intermittent power into the control and responsibility of the California ISO through dynamic transfer agreements. The California ISO is engaged in a pilot project with Bonneville Power Authority (BPA) to increase scheduling frequency and is continuing discussions with other balancing authorities to develop a dynamic transfer policy. Lessons from various pilots will feed into rules on how to import and export variable resources without losing grid efficiency and reliability.

In July 2011, the California ISO released a vision to accommodate more variable energy resources and other emerging technologies into the grid using a "day-of market" concept. Large, fast ramps that are difficult to forecast are a particular concern. The goal is to develop a roadmap to translate the operational challenges into market changes. The California ISO expects to need increased load following capacity to cover for forecast uncertainty related to wind and solar output variability, and increased ramping capacity fast enough and often enough to match variable energy resources' production patterns. Market changes will also need to consider increased starting and stopping of flexible, gas-fired generators, causing more wear and decreasing market revenues. A preferred grid protection strategy is one that automatically reduces energy output to maintain system frequency levels and provides active power control over variable energy resources.

The California ISO vision presents two options for modifying real-time dispatch. Option A changes the Real-Time Economic Dispatch (RTED) and pricing interval from today's 5 minutes to 15 minutes; Option B keeps the 5-minute dispatch and pricing interval the same. Both options add a new ancillary service, Real-Time Imbalance Service, which would provide resources that can be dispatched on a minute-by-minute basis (between the full economic dispatch runs), allowing focus on ramping capabilities within the minute.[254] This service also incentivizes resources that can ramp most quickly.

On November 1, 2011, the California ISO released a straw proposal to define upward and downward flexible ramping products.[255] The flexible ramping products are targeted to handle uncertainties or deviations of supply and demand between the California ISO's real-time

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253 California Independent System Operator, Third Revised Straw Proposal, Renewable Integration: Market and Product Review, Phase I, July 12, 2011, http://www.caiso.com/27be/27beb7931d800.html.

254 California Independent System Operator, *Renewables Integration Market Vision & Roadmap, Day-of Market, Initial Straw Proposal*. July 6, 2011. http://www.caiso.com/2bb3/2bb3e594394f0.pdf.

[255] California Independent System Operator, http://www.caiso.com/informed/Pages/StakeholderProcesses/FlexibleRampingProduct.aspx.

predispatch process and the real-time dispatch process.[256] Uncertainties between the real-time predispatch and real-time dispatch include load forecast changes, variable energy resources production changes, and other changes. Because these uncertainties occur before real-time dispatch, there is sufficient time to make unit commitment and flexible ramping procurement decisions to handle uncertainties. The California ISO is proposing to define the flexible ramping products that provide a market mechanism for procuring sufficient ramping capability. The straw proposal lays out high-level descriptions of core flexible ramping product design. The California ISO anticipates that as the stakeholder process moves forward, more details about resource qualifications, bidding rules, settlements, multi-stage generator modeling and other relevant matters will be developed.

Market rules will also help to ensure that storage technologies can provide integration services effectively. The ability of a storage technology to provide ancillary services, such as frequency regulation and load balancing, is not enough to support deployment of such technologies. The market rules, under which the balancing authorities procure such services, must change to recognize the additional system benefits newer energy storage technologies provide compared to the traditional generating sources.

New market rules and standards will also help DR and distributed energy resources to provide integration services in the California ISO market. As previously discussed, other ISOs have considered the time limitation of energy storage and DR and recognized that such assets have other benefits (for example, high ramping capabilities) that might compensate for the relatively shorter duration of their availability. The California ISO outlines a vision for including roles for these new and emerging technologies in its *Smart Grid Roadmap and Architecture* document.[257] The California ISO also actively participates in wholesale standards development at the national level and DR policies being considered at the Energy Commission and smart grid proceedings at the CPUC.

Federal Energy Regulatory Commission

FERC approves the standards for regulation services and the rules by which the California ISO procures integration services. Several efforts are underway to promote new renewables and emerging technologies through FERC's regulatory authority. In November 2010, FERC issued a notice of proposed rulemaking on variable energy resources.[258] According to FERC, among other changes the proposed rule would:

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[256] Real-time predispatch process is the period from 5 hours to 15 minutes ahead of actual time wherein unit commitments are made every 15 minutes on a 15 minute interval basis and ancillary services (on top of day-ahead and hour-ahead procurements) for the coming 15 minutes are procured. Real-time dispatch is the period 5 minutes in a 5 minute interval basis ahead of actual delivery wherein economic dispatch is performed.

257 California Independent System Operator, *Smart Grid Roadmap and Architecture*, December 2010. http://www.caiso.com/Documents/SmartGridRoadmapandArchitecture.pdf, pp.11-13.

258 FERC, November 18, 2010, *Notice of Proposed Rulemaking, Integration of Variable Energy Resources*, http://www.ferc.gov/whats-new/comm-meet/2010/111810/E-1.pdf.

- Provide generators with the option of using 15-minute transmission scheduling intervals so they may adjust schedules to more accurately reflect power production forecasts.
- Require variable energy resources to submit meteorological and operational data to the transmission providers so the providers can implement power production forecasting tools that will reduce the amount of regulation reserves needed to maintain reliability.

On March 14, 2011, FERC issued an order that conditionally accepts proposed revisions to the New York System Operator's market rules and tariffs to permit more frequent, intrahour transaction scheduling at its borders, consistent with other balancing authorities in the region.

Other FERC initiatives related to integration of renewable energy include a February 2011 Notice of Proposed Rulemaking on frequency regulation compensation in organized wholesale power markets. This rule would compensate electric storage systems and other new technologies that can provide faster ramping up and down of generation than previously available.[259]

FERC is also working to allow DR to participate in wholesale markets. To address the shorter time-frame that DR products can provide, the California ISO has submitted language to FERC as part of its Non-Generator Resources in Ancillary Services Market Initiative. This language reduces some limiting duration and capacity requirements. The revised tariff is complete, and implementation is pending.[260] These changes will also benefit storage and other demand-side resources wanting to participate in California ISO markets.

The inclusion of DR as capacity products and ancillary services provides an additional resource that will increase the competitiveness of wholesale energy markets. With this goal in mind, the FERC has issued a Notice of Proposed Rulemaking calling for the compensation of load reductions at the current market price.[261] The rulemaking will standardize compensation mechanisms and attract additional load participation in ISO markets.

Western Regional Market and Integration Initiatives

Although California intends to meet its 33 percent RPS primarily with in-state renewable resources, there are opportunities in the Western Region to better integrate renewable resources. The Governor's Office recently expressed its support for the Western Electricity Coordinating Council's (WECC) efforts underway to develop a dynamic grid that allows for the flexible importing and exporting of power and ancillary services in real time among balancing authorities.[262] These efforts include movement toward subhourly scheduling and the study of

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259 FERC, February 17, 2011, Notice of Proposed Rulemaking, http://www.ferc.gov/whats-new/comm-meet/2011/021711/E-4.pdf.

260 http://www.caiso.com/2415/24157662689a0.html.

261 http://www.ferc.gov/whats-new/comm-meet/2010/031810/E-1.pdf.

262 Letter from Michael Picker, Senior Advisor to the Governor for Renewable Energy Facilities, to Brad Nickell, Director, WECC Transmission Expansion Planning, August 3, 2011, "Reflecting Current California Trends and Policies in Regional Transmission Planning."

energy imbalance markets that enable additional renewable generation output while helping to reduce reserve requirements and load-following requirements.[263] A wide range of market and associated integration initiatives and studies are in varying stages of implementation throughout the West. Of particular interest to California are the innovative efforts shown in Table 16.[264]

Table 16: Western Variable Generation Initiatives

Initiative	Description/Status
Energy Imbalance Market	A real-time centralized energy dispatch market addressing energy and balancing needs, resource and transmission characteristics, and energy offers to create an optimal 5-minute dispatch operation. WECC is evaluating the benefits and costs of establishing a market and considering critical questions. A "go-no go" decision may occur in late 2011.
Intrahour Transmission Purchasing & Scheduling	Project designed to facilitate intrahour schedule changes to address unanticipated changes in generation and to allow better use of capacity within and from outside BAAs by developing common business practices that allow shorter time frames for scheduling. Intrahour scheduling with partial implementation of 30-minute scheduling in July 2011, or as soon as automated scheduling tools are available.[265]
Dynamic Scheduling System	Project to provide a more agile delivery mechanism for dynamic energy products, including dynamic schedules and pseudo-tie resources. Implemented in March 2011
Intrahour Transaction Accelerator Platform (I-TAP)	Project to facilitate bilateral transactions from both within and outside a BAA. Web-based trading exchange is in the software development state and could be available late 2011.
Dynamic Scheduling Assessment	Western Interconnection experts are evaluating the potential limits to dynamic transfers and options for enhancing transfer capability. Phase 1 conclusions: increases in dynamic transfer require system enhancements; need improved ability of transmission system to respond automatically.[266] Phase 2 (2011) is simulating system power flows and will identify system enhancements and potential limits if needed (2012).
Customer Self-Supply of Generational Imbalance	Effort is to provide customers a choice of balancing reserve suppliers and to reduce the overall dependence on the federal Columbia River Power System for balancing capacity and energy. Initiated Sept. 2010
DSO 216	Operating Procedure to delimit BPA's reserve obligations and ensure the reliability of the BPA BAA. It has also been deployed as a way to reduce wind integration costs by substituting infrequent wind curtailments for additional reserves. Initiated Oct. 2009.
Third Party Supply of Regulation Reserves	As a pilot effort, BPA purchased 75 MW of decremental imbalance reserves from a Calpine natural gas-fired plant from Sept. to Nov. 2010. BPA is implementing a pilot in 2012-2013.

Source: Adapted from WECC Variable Generation Subcommittee, Draft for Comment July 7, 2011

263 Ibid.

264 A complete list of initiatives and integration studies is available at http://www.wecc.biz/committees/StandingCommittees/JGC/VGS/Shared%20Documents/Forms/AllItems.aspx.

265 IID and SMUD are working toward this goal, and the California ISO is coordinating through dynamic scheduling.

266 Includes enhanced state awareness (measure of the system operator's nearly instantaneous ability to know the frequency and stability of westwide transmission/generator system, using visual, electronic, mechanical data/tool); automation of controls; additional reactive equipment; and increased staffing at control centers.

The concept for a voluntary energy imbalance market being examined in the West would be a real-time, centralized, energy dispatch market. It would use a security-constrained economic dispatch that addresses energy and balancing needs, resource characteristics, transmission characteristics, and energy offers. The result would seek to create an optimal 5-minute dispatch operation for those balancing authorities who opt in to rely on the market. WECC is evaluating the benefits and costs of establishing a market and considering critical questions such as who would administer the market, how many BAAs might participate, and many other foundational issues. Initial cost analyses indicate a market would be beneficial if startup and operation costs were moderate and benefits were above mid-range estimates. A "go-no go" decision may be reached in fall 2011.

If Western utilities and policy makers choose to pursue a voluntary energy imbalance market framework, many new opportunities for flexible scheduling and pricing of resources and ancillary services could become available in 2013.

CPUC Long-Term Procurement Plan

The CPUC has consolidated its resource planning process into Long-Term Procurement Plans (LTPP) that integrate policy direction on energy efficiency, combined heat and power, renewables, distributed generation, customer costs, system stability, and utility performance. The 2011 *33 Percent RPS Integration Study*, led by the California ISO and filed at the CPUC on July 1, identifies operational requirements to operate the California grid reliably in 2020 with a 33 percent RPS mandate.[267] The results of this integration study are preliminary at this point, and the scenarios are summarized in Table 17.

Table 17: Scenarios Studied in CPUC LTPP

	Scenario	Description
1	33% Trajectory Base Load	Intended to model future similar to current IOU contracting and procurement actions
2	33% Environmentally Constrained	High solar and distributed generation
3	33% Cost Constrained	Resources that are lowest cost
4	33% Time Constrained	Resources that can come on-line quickly
5	20% Trajectory	Intended as comparison
6	33% Trajectory High Load[268]	Reflective of future uncertainties in load growth and/or program performance
7	33% Trajectory Low Load	Reflective of future load uncertainties

Source: CPUC Long-Term Procurement Plan

267 See Memorandum from Keith Casey to ISO Board of Governors, August 18, 2011, for a summary. http://www.caiso.com/Documents/110825BriefingonRenewableIntegration-Memo.pdf.

268 The 4,600 MW of incremental upward balancing need (including 2,000 MW of OTC replacement capacity) as well as 800 MW of downward balancing shortage. Memorandum from Keith Casey to ISO Board of Governors, August 18, 2011, http://www.caiso.com/Documents/110825BriefingonRenewableIntegration-Memo.pdf.

The California ISO analyzed the first four scenarios and Scenario 6 – the 33 percent trajectory high load that serves as a bookend. The trajectory high load case assumes 10 percent higher peak load. After running production cost simulation modeling, no system capacity shortfalls were identified in the four CPUC cases with lower load assumptions based on energy efficiency. However, shortfalls were observed with Scenario 6 with some upward violations occurring if enough units could not increase output quickly because they were already at maximum operating points or they could not change output fast enough. There are a few hours of load following downward constraint, with a maximum violation of about 1,200 MW during December. Availability of flexible generation is limited in the late winter and early spring as units are often out or in maintenance mode while loads are light.

In general, this means that the modeled fleet of resources can provide the integration needed in most cases by changing the way it is dispatched. All parties believe that the few hours of downward constraint could be met by a mix of curtailment, increased use of out-of-state ancillary services, DR, and energy storage.[269]

These preliminary findings depend heavily on the input assumptions such as the load forecast and the incremental renewables target used in the study to achieve 33 percent by 2020.[270] The study assumed that gas-fired units that use once-through cooling will be retired by December 2019 and that no new generation in addition to what is identified in the CPUC's technical assumptions would need to be added to meet minimum planning reserve margins. A more complete 10-year view of local area capacity requirements that incorporates once-through cooling regulations is expected in December 2011. In addition, CPUC consultants will develop the additional capital cost component needed by the CPUC in its LTPP proceeding to evaluate the total cost, including integration costs, for each CPUC-defined scenario.

Publicly Owned Utility Integration Efforts

California's publicly owned utilities are developing integration strategies that allow procurement of renewable generation while maintaining a stable electricity supply. Unlike IOUs, electric service providers, and community choice aggregators, most publicly owned utilities are full service, vertically integrated utilities. However, they still have a combination of utility-owned and contracted resources to meet load. Most participate in the California ISO markets as well as other commercial markets.

Sacramento Municipal Utility District (SMUD) has engaged in a diverse set of strategies to integrate renewable generation. In addition, SMUD contracts for baseload geothermal generation, including a recent contract with Vulcan Power for 500 GWh of generation per year that may eventually ramp up to 1,000 GWh per year,[271] which could allow SMUD to increase its

269 Slides 26 and 27, California Independent System Operator Summary of Preliminary Results, May 10, 2011.

270 The California Independent System Operator estimate does not include additional incremental energy efficiency for 2013-2020.

271 Originally based in Bend, Oregon, Vulcan Power has now relocated to Reno, Nevada, as Gradient Resources. No California projects are listed on the company's website. http://www.gradient.com/2010/08/geothermal-energy-developer-moves-corporate-headquarters-in-reno-bringing-jobs-and-clean-energy-to-the-state/.

renewable portfolio while avoiding many of the challenges involved with integrating intermittent generation.

With an RPS target of 35 percent by 2020, the Los Angeles Department of Water and Power (LADWP) proposes in its annual resource plan to complete a comprehensive study of issues associated with integrating increasing amounts of variable energy resources to "reflect possible megawatt limits for the LADWP electric power system."[272] Recognizing the scarcity of transmission lines available to develop renewable generation facilities in resource rich areas, LADWP will develop strategies to locate facilities as close as practical to load centers.[273] LADWP primarily uses its Castaic pumped-storage hydroelectric plant in conjunction with its gas-fired generation fleet to integrate its variable renewable resources. LADWP is implementing new integration strategies that include increasing directed biogas[274] use in conventional generators that they believe will respond well to integration needs, and exploring the possibility of using municipal solid waste conversion technologies. Also in the next two to four years, LADWP plans to assess whether new transmission will be necessary to deliver electricity generated from new facilities.

Deployment of Existing and New Technologies

As California moves toward modernizing its electric grid into a smart grid, several technological advances will enable system operators to monitor every important element of the grid and transmission network with much more accuracy. Existing technologies like synchrophasors measure power flows, voltage, and other electrical characteristics in real time at subsecond intervals, providing important information to grid operators about grid conditions. Deployment of this technology is accelerating under Department of Energy initiatives and a project conducted by the WECC. Expected benefits from smart grid technology to integration of variable resources include recognizing grid problems sooner, making customers more active participants in reacting to grid conditions, and leveraging demand response, storage, and distributed energy resources to address variable energy challenges.[275] For details on smart grid potential, see Chapter 6.

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272 City of Los Angeles Department of Water and Power, *2010 Power Integrated Resource Plan, Final,* December 15, 2010, pp.5-27. http://www.ladwp.com/ladwp/cms/ladwp014239.pdf.

273 Ibid.

274 Directed biogas renewable fuel is obtained under to a contract where biogas is nominated and delivered via a natural gas pipeline.

275 California Independent System Operator, *Smart Grid Roadmap and Architecture,* December 2010, http://www.caiso.com/2860/2860b3d3db00.pdf.

CHAPTER 6: Distribution-Level Integration Issues

The electricity distribution system is the largest element of the overall electric system with more than 244,000 miles of distribution circuits.[276] Over the next five to ten years, California utilities will invest billions of dollars to expand, replace, and modernize aging distribution infrastructure. This creates an important opportunity to upgrade the system to ease renewable energy integration at the distribution level to meet the state's renewable energy goals while continuing to provide reliable, safe, and reasonably priced power to customers.

Just as integrating large-scale renewable generating facilities into the transmission grid faces many challenges (Chapter 5), there are also significant difficulties integrating large amounts of renewable distributed generation (DG) into the distribution system that delivers power from substations to consumers.

About This Chapter

This chapter discusses the major challenges to integrating high levels of DG into the state's distribution system, including:

- Current system design allows electricity to flow in only one direction from central-station generation to substation to customer. As more DG is added to the system, the amount of power generated by these resources may exceed demand and flow backward into circuits or substations, requiring new protection and control strategies to avoid damage to the electric system.
- Increased amounts of renewable DG may cause voltage variations that exceed current standards. Much of the distribution system is based on mid-20th century technology designed to provide power to simple analog devices like incandescent light bulbs, motors, and clocks, while electronic equipment used in today's homes and businesses is much more sensitive to voltage variations and frequency deviations.
- Better coordination between distribution and transmission planning is needed to maintain system operations and reliability, as well as uniform and open standards necessary to integrate intelligent technologies, renewable generation, and communication devices into a "smart grid."
- Given the large number of facilities needed to meet the Governor's goal of 12,000 megawatts (MW) of DG, the complexity, expense, and time associated with interconnection processes must all be reduced.

276 Totals for investor-owned utilities' distribution circuits.

The chapter also outlines the efforts underway in California to address these integration challenges:

- Energy agencies are working with utilities and stakeholders to reduce the time and costs associated with processing interconnection requests, revise existing standards, and develop new standards for DG equipment such as inverters.
- Utility engineers, regulators, and DG developers are working to identify new standards, technologies, and tools to address operational and planning challenges, and utilities are providing detailed maps on their websites to help DG developers identify grid locations unlikely to trigger expensive studies and upgrades to the distribution system.
- The Energy Commission and the California Independent System Operator (California ISO) are studying past and current European strategies for integrating large amounts of renewable DG.

Description of Challenges

This section discusses difficulties in interconnecting large amounts of renewable DG projects to the distribution system and identifies the challenges that distribution operators and planners face as DG penetration increases.

Interconnection Challenges

Three categories of DG resources require interconnection to the grid. The first type, located on the customer-side of the meter, is typically small (10 kW up to 1 MW) and produces energy to offset some of the customer's own electric load. The second type of DG is slightly larger (1 MW to 5 MW), is usually within or close to load centers, [277] and may export all of the power generated or use some and export the excess to the utility. The third type of DG system, located on the utility side of the meter, is larger (5 MW to 20 MW) and exports all of its generation.

Over the past decade, California utilities have successfully interconnected more than 95,000 small self-generation PV projects at customers' homes and businesses[278] due to a confluence of state rebates, federal tax incentives, net metering incentives, and an efficient and quick interconnection process (CPUC Rule 21).[279] These small projects (generally less than 10 kW) have little impact on the local grid and qualify for a fast-track interconnection; however, as more small projects accumulate on a circuit, they may trigger the need for a more in-depth review process and distribution grid upgrades.

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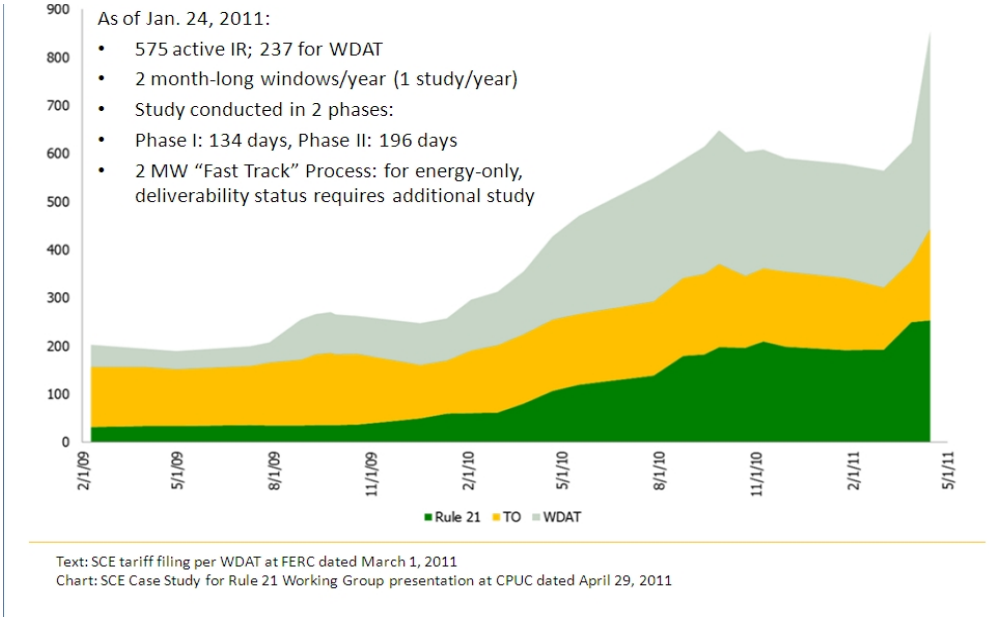
277 Southern California Edison noted in its comments on the draft version of this report that "…experience with SCE's California Renewable Energy Small Tariff program has been that the vast majority of 1.5 MW project applicants have attempted to locate in remote, transmission constrained areas-making it difficult for SCE to study/interconnect them." Written Comments on Committee Workshop on Renewable Power in California: Status and Issues, Attachment I, p.10, Docket No.11-IEP-1G. October 5. 2011.

278 Go Solar California, http://www.gosolarcalifornia.org/.

279 Rule 21 describes the interconnection, operating and metering requirements for generation facilities to be connected to a utility's distribution system, over which the CPUC has jurisdiction. California Public Utilities Commission, http://www.cpuc.ca.gov/PUC/energy/DistGen/rule21.htm.

Interconnection is a major challenge that affects both project developers and grid operators. Figure 18 shows the large increase in interconnection requests at the distribution level beginning in early 2010 through Southern California Edison's (SCE) Wholesale Distribution Access Tariff (WDAT).[280] Similar trends for Pacific Gas and Electric Company (PG&E) and San Diego Gas & Electric (SDG&E) indicate this dramatic increase is possibly driven by both increased interest in programs dedicated to systems 20 MW and smaller – such as an expanded feed-in tariff, the Renewable Auction Mechanism (RAM), and utility PV programs – and by the interconnection process itself. Many of these programs require commercial on-line dates within 18 months of when the contracts are signed, while the interconnection process may take up to a year. Because developers have a limited window of time (two months) to enter an interconnection study, done only once a year, they may not receive the interconnection results, let alone start construction, in time to meet an 18-month commercial on-line date. In response, many developers have placed multiple speculative projects into the interconnection queues.

Figure 18: Southern California Edison's Active Interconnection Requests (excluding net energy metering)



Source: SCE Case Study for Rule 21 Working Group presentation at CPUC, April 29, 2011. Represents interconnection requests through Rule 21, Transmission Operators (TO), and Wholesale Distribution Access Tariff (WDAT).

The CPUC acknowledges that Rule 21 must be reformed to meet the technical needs and policy goals of interconnecting DG; for example, one area of consensus is to review and reconsider the appropriateness of technical screens used to determine interconnection effects on local circuits or substations.[281] Both the CPUC and the Federal Energy Regulatory Commission (FERC) use

280 The WDAT Interconnection Process is FERC jurisdictional and applies to 20 MW or smaller projects that want to interconnect to SCE's distribution system (all lines below 200 kV) and sell all their power at wholesale.

281 http://www.cpuc.ca.gov/PUC/energy/DistGen/rule21.htm.

these screens to determine which projects are subject to additional and often costly studies. On August 19, 2011, CPUC staff announced that the next step in the "Rule 21 Work Group" process is to reach a global settlement on issues regarding DG interconnection to the investor-owned utility (IOU) distribution system in California. Parties are anticipated to reach agreement on terms of a comprehensive, multijurisdictional interconnection tariff (and associated forms of agreement) by December 31, 2011, for presentation to the CPUC for approval and possible subsequent approval by FERC.[282]

On September 22, 2011, the CPUC also opened an Order Instituting Rulemaking (R.11-09-011)[283] on interconnection-related issues and will review and, if necessary, revise the rules and regulations governing interconnecting generation and storage resources to the electric distribution systems of the IOUs. The CPUC may use the rulemaking as the procedural forum for settlement discussions focused on DG interconnection and addressing matters related to Rule 21.

System Planning and Operation Challenges

Maintaining system reliability and dealing with aging distribution infrastructure are challenges to the increased penetration of DG. The current use of "blind"[284] and manual operations and electromechanical components in the distribution system must evolve over time into a modern and flexible system – a smart grid – that manages complex operations in real time. Radial circuits are designed and operated based on the principle of centralized generation, in which electricity flows in one direction to the distribution substation and the end-use customer rather than in both directions as might be realized with a smart grid (Figure 19). These substations provide power through circuits to customers based on demand, and simultaneously ensure adequate power quality and reliability using circuit breakers and fuses to detect a fault on the line.

As increasing amounts of customer-generated power, usually solar PV, are installed at customers' homes and businesses, generation may exceed load at different times of the day and flow backward into the circuit or substation. Currently, load levels are controlled by adjusting transformer taps or by voltage regulators installed on the lines. These are near-term solutions, but continued use of voltage regulators to manage constant voltage fluctuations can reduce the useful life of this equipment. New and emerging smart grid technologies will be needed to provide protection and control strategies, enhanced distribution automation,[285] voltage and volt-ampere reactive (VAR) management, and new devices.

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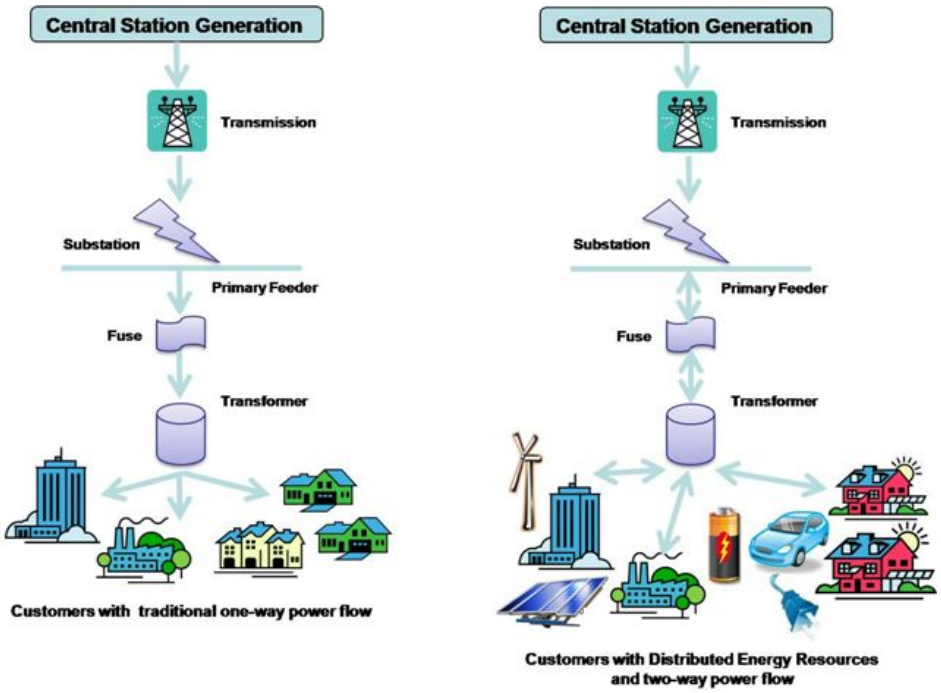
282 E-mail from Rachel A. Peterson to Rule 21 Working Group [list serve] on the following subject: Notification: Distribution System Interconnection Summit – Settlement Process, August 23, 2011.

283 http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/144161.htm#P60_1197.

284 Those locations on the distribution grid where the system operator has no visibility and/or control. There are still locations on the distribution systems throughout the state where the first notification of a problem comes from a customer calling in and indicating they do not have power.

285 Distribution automation includes a suite of technologies that allow real-time adjustment to changing loads, generation, and failure conditions of the distribution system, usually without operator intervention.

Figure 19: Traditional Power Flow Versus Smart Grid



Source: California Energy Commission

The following describes some of the significant challenges that distribution operators and planners must deal with as DG levels increase.

Voltage Regulation Challenges

The CPUC's Rule 2 sets the standard for voltage and the limits of variations and allowable exceptions.[286] Voltage variability is important because it can affect operation and longevity of sophisticated electronic equipment in homes and businesses. Voltage problems can originate with a utility if a line short circuits or with a customer starting a large motor. These types of momentary voltage sags, swells, and interruptions usually last only a few seconds and do not usually cause problems like brownouts or flickering lights. However, voltage problems may become more difficult to manage with increased DG interconnections that increase two-directional power flow.

Voltage problems associated with PV systems are generally avoided by simply having inverters inject the power into the system, following whatever voltage appears at its terminals, rather than attempting to directly regulate the voltage. Regulating voltage for PV is manageable with low amounts of distribution level PV, low concentrations of PV near the end of the circuit, or not having a single large PV facility near the end of a regulation zone, but will become more challenging with increasing PV penetration.

286 Rule 2 is a tariff addressing voltage class for electricity delivery points of service for investor-owned utilities. See PG&E's Rule 2 tariff at http://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_2.pdf.

During a June 22, 2011, Integrated Energy Policy Report (IEPR) Committee Workshop on distribution infrastructure challenges, utilities indicated that [287] the biggest challenges they face when managing voltage are a lack of experience absorbing and managing increasing amounts of DG connected to the distribution system and a lack of historical data on operational profiles of circuit behavior with DG. SDG&E reported that it has 263 circuits with >30 percent PV and 667 circuits with >20 percent PV, and has observed changes and issues with system performance on those distribution circuits with high levels of conventional DG. SDG&E presented field measurements from its system showing the effect of 1 MW of PV over 10 minutes on a cloudy day that caused extreme voltage fluctuations on the SDG&E circuit.[288] Also, the Sacramento Municipal Utility District (SMUD) indicated that voltage regulation is a particular concern on bus-regulated substation transformer banks (one regulating device for multiple distribution feeders) and that local voltage regulation is likely to be more of an issue than protection, load, fault, harmonic, and stability as DG penetration increases.[289] These results underscore the need for increased monitoring of distribution circuit behavior due to increased penetrations of PV.

Protection Systems

Overcurrent, or fault protection, is essential to the safe operation of power systems.[290] Protection practices allow nonconsequential faults – for example, if a tree momentarily touches a conductor – to be quickly cleared from the system. Protection systems also isolate permanent faults caused by failed equipment to prevent further damage and reduce power interruptions. Equipment and protection practices that have evolved during the last 100 years of field experience with power systems did not take into account distribution-connected generation between the substation and load that can change flow direction and create new fault-current paths. This can cause unnecessary operation of network protection equipment, confusion for automatic switches, and increased damage to conductors or equipment.[291] To deal with these problems, utilities are modifying protection practices to accommodate current levels of DG interconnected to the system.

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287 June 22, 2011, IEPR Committee Workshop on Distribution Infrastructure Challenges and Smart Grid Solutions to Advance 12,000 Megawatts of Distributed Generation. http://www.energy.ca.gov/2011_energypolicy/documents/index.html#06222011.

288 Docket 11-IEP and 11 IEP-1H Distribution Infrastructure and Smart Grid, July 14, 2011, Presentation by Tom Bialek, SDG&E, Slide 6.

289 Dockets #11-IEP-1G, 11-IEP-1H "Distribution Infrastructure and Smart Grid," Comment of Sacramento Municipal Utility District, July 20, 2011, LEG 2011-0372, p.12.

290 Overcurrent is a condition in an electrical circuit when the current (amperage) in the circuit exceeds the rated amperage capacity of that circuit or of the connected equipment on that circuit.

291 *Renewable Systems Interconnection Study: Advanced Grid Planning and Operations*, Mark McGranaghan, Thomas Ortmeyer, David Crudele, Thomas Key, Jeff Smith, Phil Barker, Prepared by Sandia National Laboratories, SAND2008-0944P, Unlimited Release, Printed February 2008.

Islanding

"Islanding" occurs when DG continues to provide energy to a circuit even though power from the utility is no longer present. Islanding takes two forms – intentional and unintentional. An intentional island is specifically planned and designed to meet all safety requirements to provide critical customers like airports, military bases, and data centers with continuous high-grade power using local generation, especially during an outage or emergency. Intentional islanding can also apply to customers that meet all or most of their own energy needs by interconnecting load and DG resources, operating in parallel with the grid or independently. In contrast, an unintentional island is accidental, unplanned, and can be dangerous even if it lasts for just a few seconds. From an operational perspective, unintentional islanding is very important because it can cause safety concerns. For example, if a building has solar panels that can feed power back to the electrical grid during a blackout, the building becomes an "island" of power surrounded by unpowered buildings, which can pose a danger to utility repair workers.

To deal with this problem, distributed generators include anti-islanding devices designed to detect islanding and immediately stop producing power. Utilities are concerned that increasing penetrations of PV inverters and other DG installed on a single circuit may cause active anti-islanding algorithms to fail and result in increasing incidences of unintentional islanding. To manage this issue, additional logic and communications capabilities may need to be added to the distribution grid to initiate a remote tripping signal to any DG units that become isolated.

Another islanding issue, identified by SDG&E at the June 22 workshop, is that serious problems could result from possible tripping of large amounts of DG in response to a transmission level outage or fault. SMUD expressed a similar concern in its presentation, indicating that a loss of more than 50 percent of PV on their system in one minute would exceed their contingency requirements.[292] SCE also indicated that this was a system operational issue being studied in its PV Generation Studies.[293] Utility transmission and distribution operators agree that losing a large amount of DG at one time, no matter the reason, is something they need to understand and plan for.

As DG penetration increases, utilities and the California ISO will need to coordinate studies to assess transmission level fault events to determine the impacts if large amounts of DG are tripped and whether low-voltage ride-through (LVRT) requirements should be imposed on some sizes of DG units.[294]

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292 June 22, 2011, IEPR Committee Workshop, presentation by Jeff Berkheimer, SMUD, Research and Development Manager, "Can the Smart Grid Enable More DG and Does Storage Have a Role," http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

293 June 22, 2011, IEPR Workshop, presentation by Bob Yinger, SCE, Operational Challenges with High Inverter Penetration, http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

294 Low-voltage ride-through is a generating facility's ability to stay interconnected to and synchronized with the transmission system during disturbances.

System Analysis and Modeling

Increased DG penetration levels call for unprecedented changes in distribution system operations, planning, and design. Distribution system modeling and other tools help identify the effect of new additions or changes in basic operations. At the June 22 IEPR workshop, SDG&E discussed the impact large-scale DG penetration would have on voltage and power quality and suggested extensive data gathering and analytical modeling to gain insights into the new dynamics.[295] In follow-up workshop comments, SCE mentioned using models such as Cyme Cymdist and General Electric's PLSF[296] load-flow model to simulate key characteristics such as voltage and power quality, and changes to these characteristics under different conditions. SDG&E believes that distribution operators should develop capabilities to analyze dynamic conditions such as transient currents and wide voltage fluctuations.[297]

A Sandia National Laboratories report identifies improvements in current tools needed for the economical, efficient, and safe integration of DG:[298]

- Utilities' current analysis tools must evolve to address a new and more interactive distribution system.
- Distribution engineering tools must become better suited to handle distributed and renewable generation-related issues.
- Better analytics must be developed to determine the effects of high penetrations of DG on capacity limits.
- Modeling and specification requirements for DG interconnection equipment must be determined.
- Cost and benefit evaluation tools that better capture the value of distributed resources to power system operations and dispatching must be developed.

From an operations perspective, the Sandia report suggests that no matter what the existing system looks like, new and updated software (for example, load-flow programs) is needed so operational engineers can accurately determine basic capacity and voltage regulation issues associated with increasing DG interconnections. The complex time- and location-dependent

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295 SDG&E Presentation by Dr. Tom Bialek at the June 22, 2011, IERP Committee Workshop on Distribution Infrastructure Challenges and Smart Grid Solutions to Advance 12,000 Megawatts of Distributed Generation, http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

296 Southern California Edison Company Followup Comments Regarding the Committee Workshop on Distribution Infrastructure Challenges and Smart Grid Solutions, p. 6, Docket #11-IEP-1G and #11-IEP-1H.

297 SDG&E Presentation by Dr. Tom Bialek at the June 22, 2011, IERP Committee Workshop on Distribution Infrastructure Challenges and Smart Grid Solutions to Advance 12,000 Megawatts of Distributed Generation, http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

298 Ortmeyer, Tomas, Roger Dugan, David Crudele, Thomas Key, and Phil Barker, *Renewable Systems Interconnection Study: Utility Models, Analysis, and Simulations Tools*, prepared by Sandia National Laboratories, February 2008, p vii, http://www1.eere.energy.gov/solar/pdfs/utility_models_analysis_simulation.pdf.

relationships between feeder segment loads and PV output require many studies to understand myriad conditions the new system will experience. New tools will allow these studies to progress more quickly.

Modeling a higher penetration of solar and wind DG for system analysis and management must also include an accurate hour- or day-ahead forecast of solar and wind resources. Such forecasts can alert distribution operators of impending drops in solar output if clouds are expected in a given region. For more details on the need for forecast improvements, see Chapter 5.

Standards

Standards are especially important regarding investments in distribution infrastructure equipment and systems that enable installing greater quantities of renewable generation on the distribution system. Currently, neither California nor the federal government mandates the adoption of specific standards related to smart grid technologies and generation devices. While standards ensure that products function well, are compatible, and facilitate interoperability and communication between technologies, the intense effort, expertise, and financial commitment required to develop new standards are prohibitive for many stakeholders who – while acknowledging the urgent need for standards – often do not have the time or finances to participate in the development process. Utilities, manufacturers, and regulatory entities acknowledge the necessity of standards, yet development, consensus, and adoption are slow to occur. Progress toward a truly smart grid, where technologies communicate and are controllable, could be delayed due to a lack of consensus on critical standards.

Cyber Security and Inverter Standards

In the FERC standards process[299] and the CPUC's smart grid proceeding, cyber security tops the list of concerns. From securing customer data at the meter to communication and control of the transmission system, cyber security must ensure system integrity, consumer privacy, and maintenance of a safe and reliable system. To strengthen security, utilities and industry need technologies that work across varying geographic areas and with a mix of new and aging equipment. Inverter standards are another area of concern. In written comments submitted after the June 22 IEPR workshop, SCE stated that it tested PV inverters and modeled the effects of high penetrations of inverters on the transmission and distribution system. SCE's analysis identified potential challenges including overvoltage, harmonics, and visibility and control.

During the June 22 workshop, several utilities noted the importance of standards like IEEE's proposed 1547.8 standard.[300] This standard intends to make high penetrations of DG and similar technologies more user-friendly to utilities and includes solutions that incorporate advanced functionality inverters (discussed further in a later section).[301] However, regarding

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299 http://www.ferc.gov/industries/electric/indus-act/smart-grid.asp.

300 June 22, 2011, IEPR Workshop Presentations by Frances Cleveland of Xanthus Consulting, Tom Bialek of SDGE, Robert Yinger of SCE, Ben Kropowski of NREL, Tom Von Dollen of EPRI, http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

301 The goal of the IEEE 1547.8 standard is to ensure that DG units disconnect or "do nothing" when a problem occurs such as undervoltage or overvoltage.

managing, controlling, and communicating with DG resources, the utilities have indicated an interest in potential grid-supportive functions including voltage regulation and reactive power, overvoltage protection, limit fault current contribution, and potential for low-voltage ride-through that could be provided by inverter-based resources such as PV, storage, and plug-in electric vehicles.[302]

The June 22 workshop included a discussion of inverter functions and suggestions by the Electric Power Research Institute (EPRI) that making smart inverters does not necessarily require high bandwidth. EPRI presented functionalities that could be achieved on an interim basis, which is similar to Germany's approach of gradually requiring increased inverter functionality to integrate large amounts of DG. Options discussed include:

- Autonomous "smart" behaviors responding to local voltage and frequency, steady-state, and transients.
- Centralized control via infrequent configuration to achieve desired outcomes.
- Configurable "modes" that can enable fast management of many devices.
- Common Advanced Metering Infrastructure (AMI) and SCADA systems to be used for this kind of management.[303]

Based on experience in Germany, if inverters in the United States were required to include equipment that allows utilities to actively manage the inverter, then interconnection studies could potentially be completed quickly and at lower cost.[304]

Efforts to Address Challenges to Interconnecting and Integrating Distributed Generation

Interconnection Process Improvements

Table 18 lists interconnection processes available in California for projects 20 MW or smaller. Each process has an expedited procedure for small projects not expected to have any impact on the grid that can be demonstrated by passing various screens (Table 19). Generator qualifications for these fast track processes vary across utilities and the California ISO, ranging from up to 2 MW or 5 MW, so interconnection differs depending on the process and utility or transmission operator used to interconnect.

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302 Comments filed by SCE regarding June 22, 2011, IEPR Committee Workshop http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/comments/SCE_Follow-up_comments_TN-61394.pdf, pp. 113-14.

303 Presentation by Brian K. Seal and Don Von Dollen, EPRI Perspective on Distribution Infrastructure Challenges for DG, Slide 3, http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

304 This statement is based on discussions in the KEMA study on distribution interconnection in Europe. The Commission is using the study to better understand the lessons learned from experiences in Europe. Staff is not suggesting that California's distribution system is or should be designed like Germany's, and recognizes that issues remain with technology availability.

Table 18: State and Federal Interconnection Processes

Process	Project Size Limit	Jurisdiction	Grid	Status	Timing
Rule 21	None	CPUC or Publicly Owned Utility	Distribution or Transmission[A]	In use today; typically used with customer programs or qualifying facilities	90 -180 Business Days
Wholesale Distribution Access Tariff (WDAT)	None	FERC	Distribution	In use today. PG&E and SCE recently changed study process from serial process to cluster study process. FERC approved changes in May 2011	+/- 330 Calendar Days[B]
Small Generator Interconnection Procedure (SGIP)	20 MW	FERC	Transmission	No longer available. Reformed from serial to cluster study process in 2010.	n/a
Large Generator Interconnection Procedure (LGIP)	None	FERC	Transmission	No longer available, merged with SGIP into GIP. Reformed from serial to cluster study process in 2009.	n/a
Generator Interconnection Procedure (GIP)	None	FERC	Transmission	In use today. Combines SGIP and LGIP into one cluster study.	+/- 420 Calendar Days[B]

[A] Note: Rule 21 has not yet been used for interconnection to the transmission system.
[B] Estimates of Calendar days
Source: California's Path to 12,000 Megawatts of Local Renewables, Governor's Local Renewable Power Working Conference, Interconnection and Approval Processes Panel Discussion Paper, July 2011.

To increase the capacity of small-scale localized electricity generation, the CPUC developed new programs and solicitations such as the Renewable Auction Mechanism (RAM) that targets development of larger wholesale renewable DG projects.[305] As part of the program, the CPUC directed the IOUs to provide detailed maps that allow DG developers to identify where they could interconnect new solar DG projects on the grid without triggering expensive studies and upgrades to the distribution system (Table 19 and Figure 20). Each utility also posts and updates queues detailing the amount of DG that could be interconnected on a circuit with minimal studies (up to 15 percent of peak load of the circuit). This new information should result in many successful DG interconnections.

305 The RAM is a simplified, market-based procurement mechanism for renewable DG projects up to 20 MW on the system side of the meter and is capped at 1,000 MW for the three IOUs over the next two years, with the first auction expected later this year. California Public Utilities Commission, *Decision Adopting the Renewable Auction Mechanism*, D. 10-12-048, December 16, 2010, http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/128432.pdf.

Table 19: Expedited Interconnection Processes

Interconnection Process	Expedited Review	Project Size Limit	Screens	Timing
Rule 21	Initial Review, Simplified Interconnection	None	Must pass 8 Screens [A]	< 1 month
WDAT	Fast Track	2 MW (SCE and SDG&E) 5 MW (PG&E)	Must pass 10 screens, which were derived from Rule 21 [B]	≈ 1 month
GIP	Fast Track	5 MW	Must pass 9 screens [C]	≈ 1 month

[A] See http://www.energy.ca.gov/distgen/interconnection/application.html.
[B] See http://www.sce.com/NR/sc3/tm2/RPA/Reg_Info_Ctr/OpenAccess/WDAT/attachment_g.pdf, Section 2 on pages 6-8.
[C] The California ISO revised the Fast Track through the SGIP stakeholder process, raising the project limit from 2 MW to 5 MW and removing the 10th screen, which did not allow a project to proceed through the fast track if it triggered any grid connection upgrades.
Source: California's Path to 12,000 Megawatts of Local Renewables, Governor's Local Renewable Power Working Conference, Interconnection and Approval Processes Panel Discussion Paper, July 2011.

Table 20: Utility Website Information for Potential Available DG Capacity

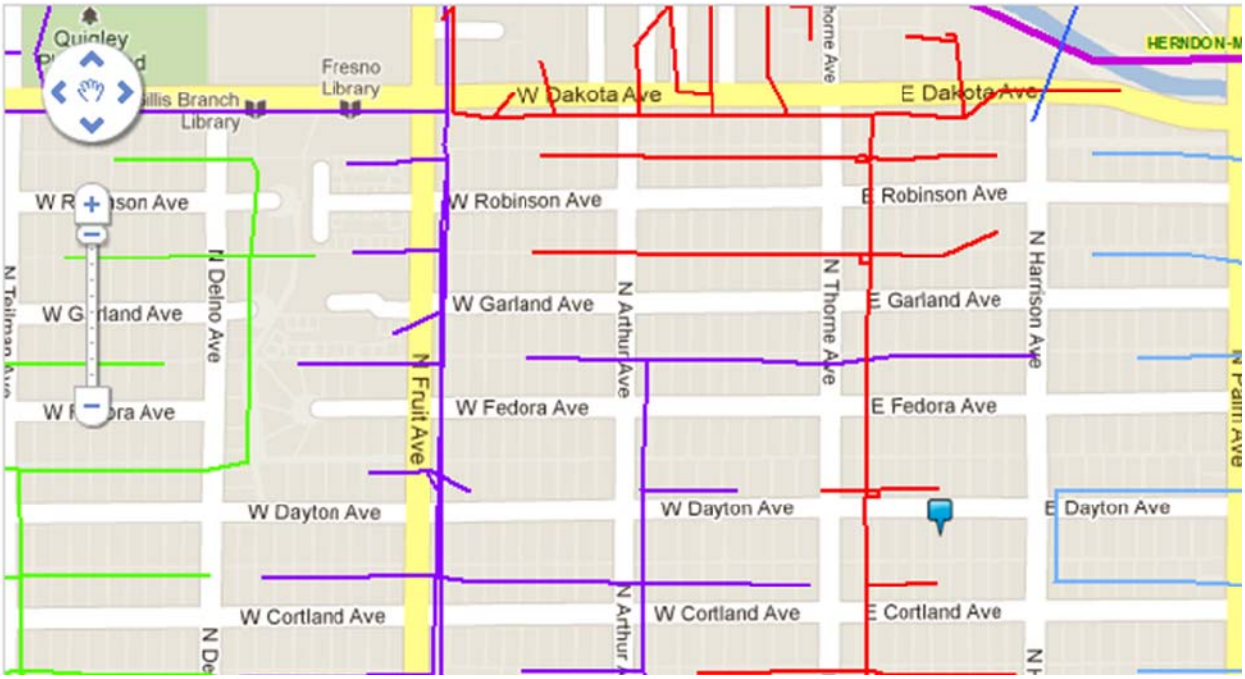
Utility	Program	Link
PG&E	Solar Photovoltaic and Renewable Auction Mechanism Program Map	http://www.pge.com/b2b/energysupply/wholesaleelectricsuppliersolicitation/PVRFO/pvmap/
SCE	Renewable and Alternative Power	http://www.sce.com/EnergyProcurement/renewables/renewable-auction-mechanism.htm
SDG&E	SDG&E Distribution System Available Capacity for Distributed Generation	http://sdge.com/builderservices/dgmap/
SMUD	Solar Interconnection Map	http://www.smud.org/en/community-environment/solar-renewables/Documents/InterconnectionMap.pdf

Source: California Energy Commission

In the near term, new system-side renewable projects will also benefit from FERC's approval of combining the SGIP and LGIP into a coordinated GIP for the California ISO that uses a single cluster approach for studying interconnection requests to ensure that interconnection of large and small projects on a transmission line are coordinated and reduce interconnection study times and costs for developers.[306]

306 133 FERC ¶ 61,223, United States of America, Federal Energy Regulatory Commission, California Independent System Operator Corporation, Docket No. ER11-1830-000, December 2010.

Figure 20: Example of PG&E's Interconnection Map Showing Circuit Detail



Source: California Energy Commission. Image generated using PG&E's PV RAM Program with residential address in Fresno, California. Colors indicate different line segments throughout the sample area.

An additional change to the WDAT is the new cluster study process for distribution-connected generators approved by FERC for SCE and PG&E.[307] The previous "one-at-a-time" serial approach required the generator that triggers an upgrade to pay 100 percent of the upgrade cost regardless of the size of the project or how many other generators had requested interconnection earlier on the same circuit. Now, if distribution upgrades are required, the costs are allocated pro-rata to all generating facilities in the cluster. This allocation is different from the California ISO process in which costs of transmission upgrades are socialized and developers are not required to absorb the costs.[308]

Improving Distribution System Planning and Operation

Many of the solutions to the planning and operational challenges to DG integration addressed earlier in this chapter are being addressed by a diverse set of efforts that generally fall under the heading of "smart grid." California utilities have been aware for at least a decade that their

307 SCE WDAT Revision at FERC, http://elibrary.ferc.gov/idmws/file_list.asp?accession_num=20110301-5198; PG&E WDT Revision at FERC, ¶ 61,094, United States of America, Federal Energy Regulatory Commission, Order Conditionally Accepting Tariff Revisions and Denying Motions in favor of PG&E's WDT amendment, April 29, 2011.

308 Docket 11-IEP-1G and 11-IEP-1H Distribution Infrastructure and Smart Grid, SCE Follow-up Comments Regarding the Committee Workshop on Distribution Infrastructure Challenges and Smart Grid Solutions to Advance 12,000 Megawatts of Distributed Generation, pp. 4-5.

distribution systems need to be modernized. This modernization is likely to accelerate because of Senate Bill 17 (Padilla, Chapter 327, Statutes of 2009), which requires utilities to develop smart grid deployment plans.[309] All utilities in the state are moving forward to modernize their distribution systems, with the investor-owned utilities subject to a CPUC smart grid rulemaking.[310] On July 1, 2011, the IOUs filed smart grid deployment plans at the CPUC that identify smart grid technologies to be evaluated for inclusion in their General Rate Cases.[311] Publicly owned utilities are developing similar plans.

At the June 22 IEPR workshop, investor-owned and publicly owned utilities reported that they are making significant investments in upgrading aging distribution infrastructure to increase visibility, flexibility, safety, and reliability. SCE indicated that its spending for distribution infrastructure replacement in 2009 totaled $66.6 million, with an additional $212.3 million for capital distribution inspection and preventive maintenance programs.[312] PG&E proposed about $66 million in its 2011-2013 capital expenditure forecast for technology infrastructure upgrades (information exchange, data management, and data storage).[313] SDG&E reports that it is expanding use of supervisory control and data acquisition (SCADA) systems and synchrophasors[314] to provide data to assess grid conditions better and respond early to problems.[315]

SMUD indicates that while it supports state goals and clean local generation, it is concerned that DG implementation should not get too far ahead of the necessary research to understand the cumulative impacts on the grid and the best solutions to smooth and reliable integration. SMUD

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309 See California Public Utilities Commission, *Decision Adopting Requirements for Smart Grid Deployment Plans Pursuant to Senate Bill 17 (Padilla), Chapter 327, Statutes of 2009*, June 28, 2010, http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/119902.htm.

310 California Public Utilities Commission Rulemaking R.08-12-009 will consider policies for California investor-owned electric utilities to develop a smarter electric grid. The proceeding will consider setting policies, standards, and protocols to guide the development of a smart grid system and facilitate integration of new technologies such as DG, storage, demand-side technologies, and electric vehicles. http://docs.cpuc.ca.gov/published/proceedings/R0812009.htm.

311 For more information about what was required in smart grid deployment plans, see Chapter 9.

312 Docket 11-IEP-1G and 11-IEP-1H Distribution Infrastructure and Smart Grid, Southern California Edison Company Follow-up Comments Regarding the Committee Workshop on Distribution Infrastructure Challenges and Smart Grid Solutions to Advance 12,000 Megawatts of Distributed Generation, p. 2.

313 Docket No. 11-IEP-1G, 11-IEP-1H, Distribution, Infrastructure and Smart Grid, July 14, 2011, Pacific Gas & Electric Comments in Response to the June 22, 2011, IEPR Workshop on Distributed Infrastructure Challenges and Smart Grid Solutions to Advance 12, 000 Megawatts of Distributed Generation, pp. 4-5.

314 SCADA systems are software applications used for process control and gathering real-time data from remote locations to exercise control on equipment and conditions. Similarly, synchrophasors allow real-time measurement of grid conditions by collecting and reporting information to grid operators 30 times per second.

315 Docket 11-IEP and IEP-1H presentation of SDG&E at the IEPR Committee Workshop, June 22, 2011, Tom Bialek, slides 5-12, http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

notes that further research will help determine the amount of and timing of new DG that will be best for California.[316]

Utilities are pursuing other promising technologies like distribution management systems with advanced load control systems, increased automation, and energy storage combined with solar PV. Investments in distribution infrastructure are substantial and depreciated over 20- to 30-year time frames. The value of traditional infrastructure investments compared with investments in new emerging smart grid technologies is the first challenge regulatory agencies and boards must consider. The long-term performance and value of new and emerging technologies may still be uncertain and difficult to justify economically.[317] Optimal timing of smart grid upgrades is a consideration.

Smart transformers are another example of a new emerging technology that will make today's distribution grid smarter. In response to signals from a utility or a home, smart transformers will be able to change the voltage and other characteristics of the power they produce. They will feature built-in processors and communications hardware to communicate with utility operators, other smart transformers, and consumers. Alex Huang, director of the FREEDM Systems Center[318] that is developing these types of devices, says, "If smart meters are the brains of the smart grid, devices such as solid-state transformers are the muscle." Smart transformers could help facilitate the two-way flow of power on the grid.[319]

SCE is actively studying issues related to circuit protection as part of its PV Generation Studies.[320] For example, SCE is evaluating better overall circuit protection coordination and the use of bidirectional overcurrent relays instead of one-way relays as ways to avoid unnecessary tripping of distribution facilities with reversed power flows. These studies will help determine the need for and value of replacing older relay systems that use electromechanical technology with new microprocessor-based relays to manage faults safely and efficiently when DG is present on the line. As part of its smart grid plan, PG&E proposes to test the efficacy of commercially available voltage control systems (Volt/VAR optimizations tools) in its laboratory

316 Dockets #11-IEP-1G, 11-IEP-1H "Distribution Infrastructure and Smart Grid", Comment of Sacramento Utility District, July 20, 2011, p. 2-3.

317 SDG&E Smart Grid Development Plan:2011-2020 Section 8-Benefits Estimates page 256.

318 The FREEDM Systems Center proposes a smart-grid paradigm shift that will enable the United States to take advantage of advances in renewable energy for a secure and sustainable future. http://www.freedm.ncsu.edu/index.php?s=1.

319 *Technology Review*, Kevin Bullis, "A Way to Make the Smart Grid Smarter," December 22, 2010, http://www.technologyreview.com/energy/26979/.

320 June 22, 2011, IEPR Workshop, presentation by Bob Yinger, SCE, Operational Challenges with High Inverter Penetration, http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

and in a pilot environment to address concerns about voltage control in areas with high penetrations of solar PV.[321]

At the June 22 workshop, Dr. Alexandra von Meier reported that the Public Interest Energy Research (PIER) Transmission and Distribution Research Program is leading an effort that includes several California utilities to measure and share information on how distributed PV generation impacts circuit voltage, power flow, and harmonics on the distribution system. Once this data is collected and analyzed, utilities will have real-world insights and data on how PV affects circuit operations, which will help them identify strategic upgrades and smart grid technologies needed for safe and reliable operation of the distribution system with increasing levels of PV.[322]

At the state level, the CPUC has responsibility for developing comprehensive cyber security standards through its smart grid rulemaking.[323] Working groups established under the CPUC's smart grid proceeding include cyber security experts from the investor- and publicly owned utilities and staff from the Energy Commission and the California ISO. California's utilities are also working closely with systems integrators, infrastructure suppliers, and standards bodies to develop a robust framework for smart grid cyber security from transmission system to customer meter.

At the June 22 workshop, SMUD representatives discussed a pilot project funded by the U.S. Department of Energy to demonstrate inverter communications via SMUD's smart meter AMI. By December 2012, SMUD plans to develop software that will interface with PV inverters and existing AMI infrastructure in the pilot area, allowing the inverters to communicate data, query for faults, and send control signals.[324] Pilots such as this will prove valuable to future standards development and activity in the areas of distribution infrastructure and cyber security.

Over time, quantifying and attributing the costs and benefits, including societal benefits, of investments in system upgrades and additions related to DG integration must also be determined. PG&E and SCE reported that establishing the value of social benefits associated with state goals (for example, carbon reduction) is unclear, and work needs to be done, with

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321 June 22, 201,1 IEPR Committee Workshop, presentation by Jon Eric Thalman, PG&E, Interconnecting and Integrating DG into the Distribution System, Slide 8, http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

322 June 22, 2011, IEPR Committee Workshop, presentation by Dr. Alexandra von Meier, California Institute for Energy and Environment, "Distribution System Monitoring: Intelligence to Manage Variability and Uncertainty," http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

323 California Public Utilities Commission, Rulemaking 08-12-009, http://docs.cpuc.ca.gov/published/proceedings/R0812009.htm.

324 June 22, 2011, IEPR Workshop Presentation by Jeff Berkheimer of SMUD, http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

utilities and stakeholders, to develop consensus on these values.[325,326] Both utilities suggested a standard approach to assigning value to these benefits; PG&E included these benefits in its smart grid deployment plan but did not quantify them.

The Environmental Defense Fund reported at the June 22 IEPR workshop that it has developed a Smart Grid Evaluation Framework for California – a tool to evaluate the utilities' smart grid plans and ability to deliver benefits required by the CPUC.[327] SMUD also reported that societal benefits to its customers are recognized in the SMUD Board Strategic Directives, and that it includes an anticipated cost of carbon in the evaluation of efficiency programs and resource procurement.[328]

Lessons Learned From Germany and Spain

Germany and Spain have interconnected and integrated high penetrations of renewable DG without significant modifications to their existing distribution grid infrastructures. In Germany, about 18 GW of solar PV capacity have been installed[329] without sweeping changes to distribution infrastructure beyond local distribution upgrades near the distributed generation interconnection.[330] The Energy Commission and California ISO funded a KEMA study on Germany and Spain's experience with integrating large amounts of DG. The study compares key similarities and differences in California's grid structure to identify lessons that can apply from the European experience.[331]

Germany is able to integrate high levels of DG largely because the German distribution grid uses fault and overload protection system design that can accommodate backflow, or two-way flows, on the distribution system. In contrast, much of California's distribution grid cannot

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325 Presentation at June 22, 2011, IEPR Workshop, Interconnecting and integrating DG into the Distribution System, Jon Eric Thalman and John Carruthers, Slide 14, http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

326 Docket 11-IEP and 11-IEP-1H Distribution Infrastructure and Smart Grid, Southern California Edison Follow-up Comments Regarding the Committee Workshop on Distribution Infrastructure Challenges and Smart Grid Solutions to Advance 12, 000 Megawatts of Distributed Generation, p. 12.

327 Environmental Defense Council, Timothy O'Connor Presentation, June 22, 2011, http://www.energy.ca.gov/2011_energypolicy/documents/2011-06-22_workshop/presentations/.

328 Dockets #11-IEP-1G, 11-IEP-1H "Distribution Infrastructure and Smart Grid," Comment of Sacramento Utility District, July 20, 2011, LEG 2011-0372, p.11.

329 Corfee, Karin, D. Korinek, C. Hewicker, M. Pereira Morgado, H. Ziegler, J. Zillmer and D. Hawkins, KEMA. *Distributed Generation in Europe*. California Energy Commission, Renewable Energy Office. Expected to be available December 2011.

330 Ibid.

331 Study discussed at the May 9, 2011, IEPR Committee Workshop on Renewable Localized Generation Christian Hewicker, KEMA, May 9, 2011, IEPR Workshop, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-09_workshop/presentations/04_KEMA_Morning_5-9-11.pdf.

accommodate backflow. A number of similarities and differences between California, German, and Spanish distribution systems are discussed below.[332]

There is a general correlation between nominal voltage levels used for the extra-high, high-, medium-, and low-voltage alternating current (AC) network levels in all three systems. Most of the DG PV in Germany and Spain is not visible to the system operator or equipped with remote curtailment capability. This contributed to a large-scale operating emergency in Germany on September 6, 2010, when a large deviation occurred between the day-ahead forecast and the actual PV output (more than 7,000 MW more than expected due to errors in forecasting and weather changes). This unexpected deviation in PV output far exceeded the negative balancing reserves available in the German grid and resulted in a very costly dumping of electricity to neighboring countries. This highlighted the need for curtailing generation from DG PV to reduce the risk of excess generation, installing telemetry that provides PV output data to grid operators in real time, and improving forecasting methods for DG PV. Germany is taking steps to retrofit existing systems with this technology.[333]

Similarly, in California, transmission system operators can monitor or control very few electricity generation systems smaller than 20 MW.[334] The KEMA study suggests that this lack of observability and control poses a serious constraint to the total amount of intermittent renewables that can be integrated into California's grid.[335] California could encounter problems similar to the German experience described here as the amount of DG PV increases – unless the system operator has telemetry and curtailment capability for a significant portion of the PV or some means of limiting the output from DG PV when excessive levels are forecast.

The California ISO noted that a thoughtful approach is needed to establish observability and control while containing costs.[336] The KEMA study suggests that it would be beneficial to explore the range of DG scheduling/redispatch/ curtailment options that could be implemented in DG interconnection agreements, tariffs, and market models in California to increase participation by DG producers in supporting the operational reliability needs of the distribution

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332 Following the May 9, 2011, workshop, KEMA prepared a draft report highlighting key differences and similarities in response to feedback.

333 New rules introduced in Germany require telemetering and remote control for new and existing PV installations larger than 100 kW. Existing installations will have six months to comply. Technical equipment for remote control is required for PV systems between 31 kW to 100 kW that began operating in 2009 or later. Existing systems have until 2014 to comply; however, telemetering will not be required. PV systems 30 kW and smaller must have either technical equipment for remote control or limit active power to 70 percent of the PV system's capacity and telemetering will not be required. Corfee, Karin, D. Korinek, C. Hewicker, M. Pereira Morgado, H. Ziegler, J. Zillmer and D. Hawkins, KEMA. *Distributed Generation in Europe*. California Energy Commission, Renewable Energy Office. Expected to be available December 2011.

334 Ibid.

335 Ibid.

336 Heather Sanders, California ISO, May 9, 2011 Workshop Transcript, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-09_workshop/2011-05-09_Transcript.pdf, p. 184.

and transmission grids. KEMA further suggests that regulators can help to steer the direction of such options through policies regarding equitable compensation for curtailments, lost opportunity costs, and so forth.[337]

Many California distribution lines have voltage levels similar to medium-voltage (for example, 10 kV to 30 kV) distribution lines in Germany and Spain. However, based on the looped (dual source) arrangement often used for medium-voltage lines in Germany and Spain, the capacity of many medium-voltage lines in California is probably lower than in Europe. Also, most medium-voltage lines in California need key upgrades to protection systems and/or voltage regulating equipment to accommodate high levels of DG.

With appropriate changes to protection and voltage regulation, high-voltage distribution lines in California (such as SCE's 66 kV and 115 kV lines) should be able to handle similar DG levels as high-voltage (45 kV to 132 kV) distribution lines in Germany and Spain. This is also true of SDG&E's 138 kV and 69 kV systems and much of PG&E's 115 kV system, although technically they are considered transmission (not distribution) and are under the California ISO's operational control.

Regarding differences between the California, German, and Spanish distribution systems that could limit DG expansion in California, many of the older medium-voltage distribution lines in California are lower voltage than typical medium-voltage lines in Europe. For example, California has many older distribution lines with a voltage level below 5 kV, which can accommodate much less DG than higher voltage lines. Upgrading the design voltage of existing distribution feeders would be costly.

In Germany, standard distribution protection relay system designs allow backflow on feeders and from distribution to transmission voltages. The existing protection systems on distribution lines and substations in California are not typically designed or configured to handle backflow. Widespread relay modifications would be required to make this possible. The KEMA study identified one solution that could be changing protection system equipment at the feeder level where it may be possible to simply modify settings on newer solid-state (microprocessor-based) relays already installed on some feeders, and in other cases replace older electro-mechanical overcurrent relays with solid-state relaying, to accommodate backflow. [338]

Medium-voltage distribution lines in California typically branch out from a substation to individual end users in a radial configuration, but medium-voltage grids throughout Germany (and in urban areas in Spain) are normally laid out in loops. In general, a looped configuration accommodates higher levels of DG than a radial configuration. Converting existing California feeders to this configuration would be costly.

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337 Corfee, Karin, D. Korinek, C. Hewicker, M. Pereira Morgado, H. Ziegler, J. Zillmer and D. Hawkins, KEMA. *Distributed Generation in Europe*. California Energy Commission, Renewable Energy Office. Expected to be available December 2011.

338 Ibid.

Both medium-voltage and low-voltage (such as 400 V) distribution grids in Germany and Spain use three-phase construction, and in many cases low-voltage grids also use a looped or networked design. Almost all low-voltage ("secondary") grids in California are a radial design and use single-phase construction, and many sections of the medium-voltage grid in California are also single-phase. Widespread conversion of low-voltage (secondary) grids in California to three-phase design is infeasible.

Another approach to connect significant amounts of DG at relatively low cost is simply to restrict the amount of DG that can be interconnected to feeders, substations, and/or local load areas of the system. Establishing a uniform cap on DG deployment levels, even as an interim measure, lowers the risk of backflow and other impacts on grid operation.[339] Spain limits the amount of DG that can interconnect to each load area, medium-voltage distribution facility, and low-voltage distribution facility to 50 percent of the respective demand level. They also impose strict limits on DG short-circuit contribution.[340] As a result of implementing these restrictions, Spain has experienced only minor backflow issues to date.[341]

Enhanced forecasting of wind and solar (see Chapters 5 and 9) can improve integration by providing grid operators with better information about expected generation from such facilities. While Germany and Spain have developed excellent forecasting methods for these technologies, forecasting improvements have not yet been widely adopted at the distribution level in Germany. However, a new requirement that Germany implement adequate forecast methods by April 1, 2011, will address situations like the September 6, 2010, event in Germany mentioned earlier.[342]

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339 E3 study for CPUC Energy Division staff as cited in Appendix B of Feed-in Tariff for Renewable Generators Greater Than 1.5 MW Energy Division Staff Proposal March 27, 2009. Available as Attachment A to CPUC Administrative Law Judge's Ruling on Additional Commission Consideration of a Feed-In Tariff, Rulemaking 08-08-009, http://docs.cpuc.ca.gov/efile/RULINGS/99105.pdf. See also *2009 IEPR*, http://www.energy.ca.gov/2009publications/CEC-100-2009-003/CEC-100-2009-003-CMF.PDF, p. 198.

340 Corfee, Karin, D. Korinek, C. Hewicker, M. Pereira Morgado, H. Ziegler, J. Zillmer and D. Hawkins, KEMA. *Distributed Generation in Europe*. California Energy Commission, Renewable Energy Office. Expected to be available December 2011.

341 Ibid.

342 The position paper mentioned here is Bundesnetzagentur. Positionspapier zur verbesserten Prognose und Bilanzierung von Solarstromeinspeisungen. November 2010. As cited in KEMA, Memo 2, p. 15.

CHAPTER 7:
Investment and Financing Issues

The 2008 financial crisis and the lingering economic recovery have significantly affected the development of renewable energy projects, and investors, developers, and consumers are still feeling repercussions. Federal stimulus funding through the American Recovery and Reinvestment Act of 2009 (ARRA) offered short-term relief, but ARRA programs are nearing their end. Renewable development in California will then rely on traditional financial markets and project finance strategies under uncertain economic times.

Consumer education, renewable technology advancement, and generous financial support have enabled market growth during these troubled economic times. However, when compared to other infrastructure-dependent sectors, such as transportation, renewable energy development is still a young asset class. Renewable development does not enjoy the same technological, financial, and marketplace advantages afforded to traditional infrastructure with more mature supply markets and support structures in place.

About This Chapter

This chapter identifies key financing issues facing renewable technologies and efforts to address those issues, including:

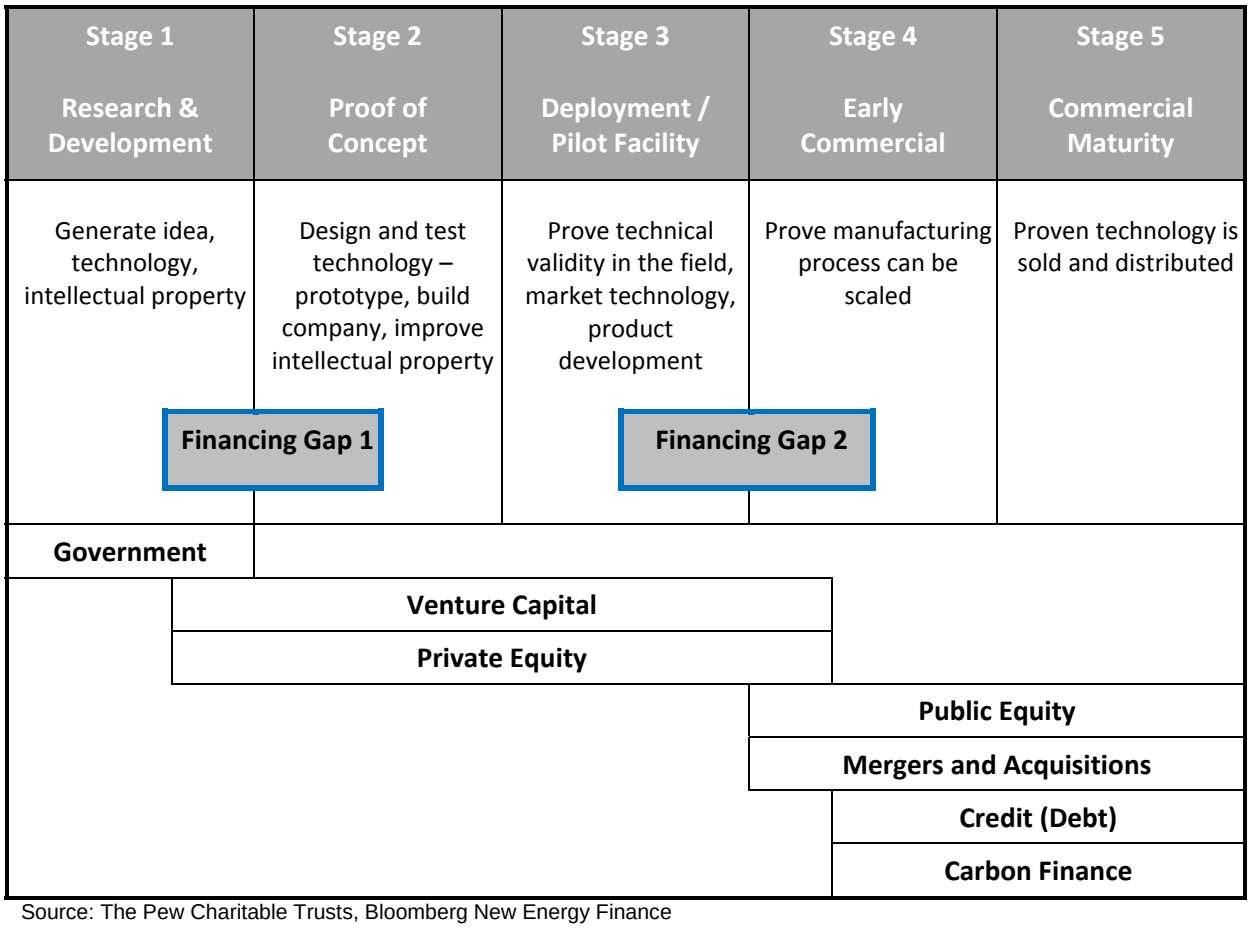
- Financing challenges, specifically funding gaps that occur during the research and development (R&D) and early commercial stages that can affect project development.
- The role of private and public investment in energy-related R&D, including "angel" and venture capital investors, universities' investment in research, and the role of power purchase agreements and financing instruments, like debt and tax equity, in resolving barriers to renewable development.
- Efforts underway to address financing challenges for utility-scale renewable projects including supporting technology innovations and reducing significant capital requirements through tax incentives, accelerated depreciation, and loan and bond financing programs.
- Efforts underway to address financing challenges for distribution-scale renewable projects, including case studies to illustrate technologies and finance programs in use.
- Efforts to finance renewable development in neighboring states and internationally.

Description of Challenges

Financing renewable energy – from research and development to project deployment – is dynamic and capital-intensive. Each stage of development requires significant resources, and

financing gaps must be addressed for emerging technologies to move to commercial maturity in a timely manner.[343,344]

Figure 21: Primary Capital Investment for Renewable Development



Source: The Pew Charitable Trusts, Bloomberg New Energy Finance

Successful development of renewable technologies includes five stages (Figure 21):

- **R&D** generates ideas and tests intellectual property. If developed successfully, intellectual property can leverage needed funds further along the development continuum. Nevertheless, R&D is a high-risk stage for potential investors given high failure rates.
- **Demonstration/proof-of-concept** builds the company, designs and tests prototypes, and further develops intellectual property needed to demonstrate the feasibility of an idea or technology.

343 Bloomberg New Energy Finance, *Crossing the Valley of Death: Solutions to the Next Generation Clean Energy Project Financing Gap*, June 21, 2010, http://bnef.com/free-publications/white-papers/.

344 The Pew Charitable Trusts, *Who's Winning the Clean Energy Race? G-20 Clean Energy Factbook*, 2010, http://www.pewtrusts.org/our_work_report_detail.aspx?id=57969.

- **Pilot facility** moves the technology out of the laboratory to the field where data and results are quantified to improve the prototype and to provide technical information to potential investors. In this phase, companies also begin to market the technology.
- **Early commercial** enables a company to demonstrate the viability of its technology at scale and prove that manufacturing and/or power generation can be economically scaled.
- **Commercial maturity** is the widespread adoption of a technology, when it is commercially proven, sold, and distributed at scale.

The inherent uncertainties in R&D can make it difficult to obtain financing, and significant capital is required in the early commercial stage to address technology performance issues and regulatory risk. These two key financing gaps can affect the ultimate development of a renewable project as described in the following.

Financing Research and Development – Financing Gap 1

California is endowed with abundant natural resource assets. These assets lend themselves to renewable development but first require research and development, resource assessment, and use impacts. As such, California requires public and private investment in research and development that differs from the other states due to its variety of renewable resources. A recent American Enterprise Institute report[345] indicates that, despite a clear innovation imperative, neither public nor private sectors currently invests the resources required to accelerate clean energy innovation and drive down the cost of clean energy. Private firms do not invest adequately in new technologies for various reasons, including the higher price of clean energy technologies, knowledge spillover risks from private investment in research, inherent technology and policy risks in energy markets, the scale and long time horizon of many clean energy projects, and a lack of widespread clean energy infrastructure.

R&D externalities and challenges can lead to financing gaps (see Financing Gap 1 in Figure 21) and less than socially optimal technology innovation. The International Energy Agency estimates that globally, solar and wind energy technologies face an annual R&D shortfall of between $2.68 billion and $6.28 billion.[346] To a large extent, knowledge is a public good. In economic terms, it is nonexcludable and nonappropriable because it is difficult for owners to establish enforceable property rights or to dole out usage rights to particular individuals. Because almost anyone can access the knowledge developed in R&D and a private firm cannot monetize all the public benefits and spillovers of its R&D, private companies tend not to invest in the level of R&D that is most beneficial to society. Patents help reduce this concern but generally offer limited protection for intellectual property rights. The underinvestment in R&D can be further exacerbated for clean energy technologies because the positive environmental

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345 American Enterprise Institute, *Post-Partisan Power: How a Limited and Direct Approach to Energy Innovation Can Deliver Clean, Cheap Economic Productivity and National Prosperity*, October 2010, http://www.aei.org/docLib/Post-Partisan-Power-Hayward-101310.pdf.

346 International Energy Agency, *Global Gaps in Clean Energy RD&D*, 2010, http://www.iea.org/papers/2010/global_gaps.pdf, p. 15.

attributes of these technologies, like greenhouse gas emission reductions, may not be adequately valued in the market.

Other R&D challenges increase risk due to the high variance of the distribution of expected returns, the specialized and sunk (and as such not transferable) nature of the asset, and intangibility. Uncertainty and intangibility[347] make financing through capital markets difficult since investors typically want some certainty of return on their investment. Information asymmetry, where one party has better information than another, can exacerbate uncertainty since a technology developer is in a better position to assess the potential of a technology than investors, so investors will require bigger return to address this uncertainty.

These challenges – and given that startup markets are decentralized and involve multiple firms – contribute to a financing gap for R&D, particularly energy-related R&D. Although overall R&D investment in the United States has grown annually by 6 percent, investment in energy-related R&D is about $1 billion less than a decade ago. The private sector's share of energy R&D investment has also declined to 24 percent from nearly half in the 1980s and 1990s, with total private sector energy R&D less than the R&D budgets of a few large individual biotech companies.[348]

Corporate R&D spending (reinvestment) can be a significant driver of new technology development. However, according to the National Science Foundation,[349] corporate R&D spending as a percentage of domestic sales in 2008 was 25 percent for communications, 15 percent for software, and only 0.3 percent for energy, which is spent primarily on technology improvements and not on new technology development. This underinvestment in the renewable energy sector affects the development of next generation, lower-cost technologies and illustrates the important role of the public sector in accelerating the demonstration of new clean technologies in the absence of private funding.

Apart from private and public sector investment trends, venture capital investments continue to increase and are still on the same scale as private R&D investments by large companies. Venture capital firms' contribution to innovation is especially important since studies have found that, in general, venture capital investment is three to four times more effective than R&D at stimulating patenting.[350]

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347 Intangibility in marketing describes the inability to assess value gained from engaging in an activity using any tangible evidence. Palmer, Adrian (2000). *Principles of Marketing*. Oxford: Oxford University Press. p. 631.

348 Nemet, G.F. and D.M. Kammen (2007), "U.S. energy R&D: declining investment, increasing need, and the feasibility of expansion," *Energy Policy* 35(1): 746-755, http://www.sciencedirect.com/science/article/pii/S0301421505003551. Authors note: figures were for pre-ARRA funding. The current trend of R&D is unclear given uncertainty about the effect of ARRA funding.

349 National Science Foundation, *US Business Report 2008 Worldwide R&D Expense of $330 Billion: Findings from New NSF Survey*, May 2010, http://www.nsf.gov/statistics/infbrief/nsf10322/nsf10322.pdf.

350 Kortom S. and Lerner J. 2000. "Does Venture Capital Spur Innovation?" *Rand Journal of Economics* 31, pp. 674-692.

The biggest private sector participants in R&D are "angel investors" – an individual or a network of individuals that provide capital to startups in exchange for ownership equity or convertible debt.[351] Angel capital fills the gap between seed funding—usually provided by the startup members and friends and family—and venture capital, and typically ranges from hundreds of thousands of dollars to less than $2 million.

After declines of 26.2 percent in 2008 and 8.3 percent in 2009, total angel investments in the United States in 2010 increased 14 percent over 2009 to $20.1 billion According to a study by the University of New Hampshire's Center for Venture Research, the clean tech sector received about 8 percent (about $1.6 billion) of those investments. The study also reveals that angel investors have lessened their interest in the startup stage of technological development, with seed or startup capital decreasing in 2010 by 4 percent from 2009.[352]

The financing gap (see Financing Gap 1 in Figure 21) for energy-related R&D may also persist at the proof-of-concept stage as companies continue to require capital for applied research and precommercial growth and activities. The most active private sector participants in this stage are angel investors and venture capital (VC) firms. VC firms invest the financial capital of third-party investors in enterprises that are too risky or too complex for the standard capital markets. Targeted investments are early-stage and high-potential startups that have already received seed investments and have a technology and idea beyond the initial R&D stage. Venture capital investments in clean tech companies have increased, with $3.98 billion invested nationally in 2010. Investments in the first quarter of 2011 were $1.14 billion, a significant increase from the $743.3 million of venture capital invested during the first quarter of 2010, [353] with California accounting for 56 percent of total investments.[354]

California perennially tops the list of regions receiving venture capital. Unlike other regions of the United States, California is home to more than one venture hub: Silicon Valley in the north, San Diego in the south, and a burgeoning new corridor in Orange County. In addition, California-based venture-backed firms and their investors have worked consistently with state policy makers to ensure that young innovative startups and their technologies have the opportunity to grow and succeed within the state's larger business climate. These factors have led to nearly $200 billion in venture investment in California since 1970.[355]

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351 Convertible debt is the option of converting an outstanding balance due to some other form of security or asset.

352 Center for Venture Research, University of New Hampshire, *The Angel Investor Market in 2010: A Market on the Rebound*, 2010, http://www.unh.edu/news/docs/2010angelanalysis.pdf.

353 "US Venture Capital Investment in Cleantech Grows to Nearly $4 billion in 2010, an Increase from 2009," Ernst and Young, February 2011, http://www.ey.com/US/en/Newsroom/News-releases/US-venture-capital-investment-in-cleantech-grows-to-nearly-4-billion-Dollar-in-2010.

354 http://www.ey.com/US/en/Newsroom/News-releases/US-VC-investment-in-cleantech.

355 National Venture Capital Association, *Venture Impact: The Economic Importance of Venture Capital-Backed Companies to the U.S. Economy*, 2009, http://www.nvca.org/index.php?option=com_content&view=article&id=255&Itemid=103.

Historically, federal and state governments have played a pivotal role in funding research and demonstrating high-risk technologies through direct procurement. The federal government is the primary source of funding for basic research across all sectors, providing some 60 percent of funding; the second largest source of basic research funding comes from academic institutions. Universities conduct the majority of basic research in the United States (55 percent in 2008), with business and industry conducting less than 20 percent.[356]

The state funds research primarily through the state and private universities. The University of California research system received more than $4.3 billion in total research funding in fiscal year 2009-2010, produced more patents than any university in the nation, and secured $8 in federal and private dollars for every $1 in research funding provided. In addition to directly funding energy research, the university system contributes to technology transfer and the overall development of the state's expertise in renewable generation technologies.

In addition to universities, the Energy Commission's Public Interest Energy Research (PIER) Program (see Chapter 9) funds public and private entity research and has a significant role in supporting renewable technologies. The PIER Program has also seed funded incubators such as the Sacramento Area Regional Technology Alliance (SARTA) and the Environmental Business Cluster. Fostering R&D through such organizations as SARTA, CleanTECH San Diego, CleanTechOC, Clean Tech Los Angeles, Silicon Valley Leadership Group, Greenwise Sacramento, and the Bay Area Council accelerates the growth of renewable energy technologies and provides economic benefits that accrue to local communities.

The state's Innovation Hub (iHub) initiative stimulates partnerships, economic development, and job creation around specific research clusters through state-designated iHubs. The iHubs leverage assets such as research parks, technology incubators, universities, and federal laboratories to provide an innovation platform for startup companies, economic development organizations, business groups, and venture capitalists.

Financing Early Commercial Development – Financing Gap 2

Another financing gap (see Financing Gap 2 in Figure 21) occurs at the early commercial stage of development. Early commercial can be defined as one of the first three to five deployments at a scale that generates revenue and within the size range consistent with a company's long-term rollout plan.[357] In this stage, companies and technologies face the convergence of high capital needs and scarcity of capital. Significant capital is needed to finance projects to demonstrate the viability of a technology at scale, as well as to prove that the manufacturing and/or power generation can be economically scaled.

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356 "Sparking Economic Growth: How Federally Funded University Research Creates Innovation, New Companies, and Jobs," The Science Coalition, April 2010, http://www.sciencecoalition.org/successstories/.

357 California Clean Energy Fund, *From Innovation to Infrastructure: Financing First Commercial Clean Energy Projects*, June 2010, http://calcef.org/2010/06/01/from-innovation-to-infrastructure-funding-first-commercial-clean-energy-projects/.

There is a significant difference in installed renewable capacity between the residential and commercial sectors for early commercial technologies that can be attributed to 1) greater federal tax benefits and accelerated tax depreciation provided to commercial systems, (2) the larger commercial project size,[358] and (3) the appropriate project finance structure. Small-scale renewable systems, often found on residential and small commercial properties, have limited financing options and must resort to using established financing tools such as equity loans and cash combined with applicable public programs. Other options include leases, small-scale power purchase agreements, and on-bill financing.[359] New financing opportunities, such as third-party models, open up for community-scale systems. Partnering with an investor such as project developers and other organizations can also take advantage of tax and depreciation benefits through various partnership structures and power purchase agreement models to reduce costs.[360] Utility or large-scale renewable projects are most commonly financed by a combination of equity and debt. Financing options include corporate balance sheets, use of debt (loan guarantees), equity (federal Section 1603 cash grants),[361] and asset depreciation.

The U.S. Partnership for Renewable Energy Finance indicates where several emerging renewable technologies are currently or are anticipated to be at this early commercial juncture in the next three years. In particular, concentrating solar-power towers, advanced solar manufacturing, and energy storage will encounter Financing Gap 2. These technologies are seeking approval for U.S. Department of Energy Loan Guarantee Program funding, which could be leveraged for additional private capital. Funding for traditional renewable technologies such as solar PV, wind, and geothermal could also advance these technologies in the market.[362]

Traditionally, private equity, debt, and tax equity markets have served as options to firms in the early commercial stage. However, since the financial crisis, these options are either impractical given economic conditions, depend on government incentives to function well, or do not provide sufficient returns for investors. Finance options and structures have evolved in response to the patchwork of incentives and the preferred choice depends on several factors such as return and yield rates, presence of a tax investor, cash and financial position (balance sheet financing), exit strategies, and risk-adjusted mitigation measures. Financial innovations are increasingly reducing investment barriers such as high upfront costs, technology and performance risk, and low tax credit appetite. These mechanisms allow investors to extract maximum value from myriad local, state, and federal support programs.

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358 Ernest Orlando Lawrence Berkeley National Laboratory, *Financing Non-Residential Photovoltaic Projects: Options and Implications,* January 2009, http://eetd.lbl.gov/ea/EMS/reports/lbnl-1410e.pdf.

359 http://www.nrel.gov/docs/fy09osti/44853.pdf.

360 http://www.b-e-f.org/business/files/downloads/2011/02/49930.pdf.

361 http://eetd.lbl.gov/ea/ems/reports/63434.pdf.

362 U.S. Partnership for Renewable Energy Finance, *The Importance of the Loan Guarantee Program in Financing Innovative Renewable Technologies,* February 2011, http://reffwallstreet.com/us-pref/wp-content/uploads/2011/06/The-Importance-of-the-DOE-LGP-in-Financing-Innovative-Renewable-Technologies-v2.3.pdf.

Equity

Financing Gap 2 poses a challenge for equity investors such as angel investors, venture capital firms, and other early-stage investors accustomed to traditional technology companies' speedy and relatively low-cost paths to commercialization. Capital requirements for renewable energy projects can be tens to hundreds of millions of dollars, depending on size and technology, for a single project. This is beyond the capacity and appetite of the great majority of VC firms. Renewable projects also rely heavily on project finance, which is not the traditional business model used by VC firms. Project financing relies on the complex management of project risks, mitigation strategies, legal and commercial structuring, significant debt financing, and coordination with a variety of stakeholders, including contractors, large industrial partners and potential customers. Lastly, private equity firms, particularly VC firms, anticipate higher equity returns than those expected from renewable energy projects.

Debt

Project developers can also access debt financing through loans or bonds. Some developers use their own balance sheets to guarantee repayment on such debt; however, if that is not possible or preferred, a project finance structure is pursued. Access to project finance debt requires sufficient equity from the developer or a sponsor company, external investors, and/or strategic partners. This equity would be invested in a special purpose project company. In either case, the combination of this equity with limited recourse project-level debt would fund the capital cost of the project.

The 2008 financial crisis significantly impacted the debt markets.[363] Financial institutions found it difficult to secure money to lend and to syndicate and underwrite loans. Therefore, available capital became limited and competitive within a financial institution's varying business priorities. This led to lending costs rising substantially and unfavorable loan terms, with many banks reluctant to offer long terms for debt. Noncore or new clients found accessing debt very difficult. Recent stimulus financing solutions (United States Department of Treasury cash grant program and the Department of Energy loan guarantee program) have enabled renewable energy projects to aggressively pursue debt financing.

Tax Equity

Tax credit incentives and the tax equity market have been key drivers of financing and investment in renewable energy projects until the financial crisis. The tax equity market developed because of the need to monetize tax attributes (federal and state investment tax credits) that incentivize renewable energy development. Renewable energy developers typically do not generate taxable income necessary to use these tax credits and, therefore, monetize them by partnering with tax equity investors who can more efficiently use the project's tax benefits. A tax equity investor also seeks a return on its investment from the project. The tax equity market reached $6.1 billion in 2007, dropped to $1.2 billion in 2009, rebounded to about $3 billion in

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363 United Nations Environment Programme Sustainable Energy Finance Initiative, Virginia Sonntag-O'Brien, *Private Financing of Renewable Energy – A Guide for Policymakers,* December 2009, http://www.unep.fr/energy/finance/pdf/Finance_guide%20FINAL.pdf.

2010, and is expected to remain stable through 2012. However, the credit crisis has increased the required returns by tax equity investors. While in 2008 the internal rate of return for renewable energy deals was around 7.5 percent, estimates now suggest the rate may need to be as much as 15 percent or higher to attract investors.[364]

Power Purchase Agreements

Power purchase agreements (PPA) are important in financing projects and securing debt because they provide greater certainty of project revenues.[365] Without a PPA, a project may not receive the financing needed to monetize a project's revenue stream. The PPA is critical in addressing the early commercial financing gap, especially for large commercial projects.

Feed-In Tariffs

A FIT guarantees payment for electricity, access to the grid, and a stable long-term contract. FITs provide a relatively guaranteed revenue stream, are easy to monetize if they are simple and have a transparent incentive structure, and support low-cost private financing. The FIT's predictability and transparency attracts investors[366] which can make distributed generation (DG) projects, especially wholesale DG, easier to finance without relying on currently available public incentive and tax programs. This predictability can result in steady growth in DG procurement, which supports markets for private investment in renewable labor and technology. The reduction of cost, risk, and time associated with DG can lead to a greater number of local project installations, providing increased economies of scale, and reduced local system procurement and installation costs.[367]

Globally, the FIT remains the most widely implemented renewable policy for accelerating renewable deployment and accounts for a greater share of renewable development than either tax incentives or renewable portfolio standard (RPS) policies.[368] In California, the three large investor-owned utilities have offered limited FITs for smaller renewable energy projects. Publicly owned utility efforts include the fully subscribed 100 megawatt (MW) FIT offered by the Sacramento Municipal Utility District (SMUD) and a proposed Los Angeles Department of Water and Power (LADWP) FIT for up to 150 MW.[369]

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364 National Renewable Energy Laboratory, *Renewable Energy Project Financing: Impacts of the Financial Crises and Federal Legislation,* July 2009, http://www.nrel.gov/docs/fy09osti/44930.pdf.

365 Power Purchase Agreement Checklist for State and Local Governments, NREL, October 2009.

366 Deutsche Bank Climate Change Advisors, *Paying for Renewable Energy: TLC at the Right Price*, December 2009.

367 Clean Coalition public comment received October 7, 2011.

368 National Renewable Energy Laboratory, *A Policymaker's Guide to Feed-in Tariff Policy Design*, July 2010.

369 For SMUD, see http://www.smud.org/en/community-environment/solar-renewables/pages/feed-in-tariff.aspx. For LADWP, see http://www.ladwp.com/ladwp/cms/ladwp014295.jsp.

A 2010 KEMA study recommends specific FIT design characteristics to help keep risk low from an investor's perspective and attract financing for renewable energy projects.[370] However, not all of the recommendations reduce ratepayer risk or costs. A FIT should provide a long-term contract (15 to 20 years) with price certainty for all revenues and, because generation costs vary among renewable technologies, a separate FIT price level for each technology is recommended.[371] The price level offered for future projects should be adjusted periodically to reflect market conditions and place pressure on manufacturers to lower costs of generation over time. The adjustments should maintain a sufficient rate of return for each technology category.

Renewable Auction Mechanism

The Renewable Auction Mechanism (RAM) is a simplified and market-based procurement mechanism for renewable DG projects up to 20 MW on the system side of the meter. The CPUC adopted the RAM in December 2010 as the primary procurement tool for system-side renewable DG "because it will promote competition, elicit the lowest costs for ratepayers, encourage the development of resources that can utilize existing transmission and distribution infrastructure, and contribute to RPS goals in the near term."[372]

The RAM streamlines the procurement process for developers, utilities, and regulators. It allows bidders to set their own price, provides a simple standard contract for each utility, and allows all projects to be submitted to the CPUC through an expedited regulatory review process. Given the newness of the mechanism, time should be given to be implemented fully with proper assessment of the results.

Financial Incentives

California provides various financial incentives to promote development of renewable distributed generation (DG) including:

- The California Solar Initiative (CSI) offers rebates to solar customers of the investor-owned utilities with different incentive levels based on solar panel performance.[373] The goal of the program is installation of about 1,940 MW of new solar generation capacity by 2016. The rebates automatically decline in "steps" based on the volume of MW of confirmed incentive reservations within each utility service territory.

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370 California Energy Commission, *Feed-In Tariff Designs for California: Implications for Project Finance, Competitive Renewable Energy Zones, and Data Requirements*, 2010, http://www.energy.ca.gov/2010publications/CEC-300-2010-006/CEC-300-2010-006.PDF, p. 2.

371 FERC, October 21, 2010. "FERC said a proposal to employ a multi-tiered resource approach for determining avoided costs ... could comply with the Public Utility Regulatory Policies Act and FERC regulations." http://www.ferc.gov/media/news-releases/2010/2010-4/10-21-10-E-2.asp.

372 For more information, see: http://www.cpuc.ca.gov/PUC/energy/Renewables/hot/Renewable+Auction+Mechanism.htm.

373 For more information, see: http://www.gosolarcalifornia.ca.gov/csi/index.php.

- The Emerging Renewables Program (ERP) provides rebates for small wind turbines and fuel cells using renewable fuels.[374]
- The New Solar Homes Partnership (NSHP) provides incentives to homebuilders to encourage installation of solar energy systems on new residential construction, with a goal of 400 MW of installed PV electricity generation by 2016.[375]
- The Self-Generation Incentive Program (SGIP) provides various per-watt incentives for specified DG facilities such as wind turbines, fuel cells, and advanced energy storage systems.[376]
- Net Energy Metering (NEM) allows customer-generators to receive a financial credit for power generated by their onsite systems that is fed back to the utility. The credit offsets the customer's electricity bill and is an important tool supporting direct customer investment in grid-connected DG. NEM promotes efficient sizing of customer-generation to meet customers' annual load, with recent analysis indicating that only a small percentage of NEM customers receive compensation for surplus energy delivered to the grid.[377]

Efforts to Address Financing Challenges for Utility-Scale Renewable Projects

Government plays a crucial role in the following areas of renewable energy development: addressing gaps in R&D financing by promoting and funding basic research and early technology innovation; easing the significant capital costs faced by early stage commercial companies and projects; and improving access to capital through loans and bonds by reducing credit risks. Beyond these efforts, the federal and state governments also play an important role in developing and maintaining stable, predictable regulatory policies that increase investor confidence, allow greater leverage of private funding, and promote favorable financing structures and partnerships.[378] Providing regulatory certainty assists with the funding gaps discussed in this chapter, and with moving technologies across all innovation stages. While federal and state programs have had significant successes, there is room for improvement, expansion, and innovation. Policies and incentives must be given time to gain customer acceptance, and further program and policy analysis is needed to make prudent use of public funds, foster market participation where appropriate, and incorporate improvements and innovation.

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374 For more information, see: http://www.energy.ca.gov/renewables/emerging_renewables/index.html.

375 For more information, see: http://www.gosolarcalifornia.org/about/nshp.php. The NSHP was funded under the Public Goods Charge which sunsets in December 2011 unless reauthorized by the California Legislature.

376 For more information, see: http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/.

377 Itron, Inc., *CPUC California Solar Initiative 2010 Impact Evaluation*, Final Report, revised June 24, 2011, http://www.cpuc.ca.gov/PUC/energy/Solar/impactevaluation2010.htm.

378 Barradale, M., *Impact of Policy Uncertainty on Renewable Energy Investment: Wind Power and PTC*, 2010, http://www.iaee.org/en/students/best_papers/Merrill_Barradale.pdf.

Supporting Technology Innovations

Due to the high failure rates inherent in the first two stages of technological discovery, private markets underinvest in this type of basic research. The public sector is filling this financing gap by way of national government laboratories such as the National Renewable Energy Laboratory (NREL) and the Lawrence Berkeley National Laboratory (LBNL). In addition, such programs as the Advanced Research Projects Agency-Energy (ARPA-E) within the U.S. Department of Energy (DOE) and the California Energy Commission's Public Interest Energy Research (PIER) Program offer financing opportunities.

National Laboratory Research

The 21 facilities comprising the national laboratories and technology centers provide information on various aspects of the environment, science, and energy used by myriad international governments, industries, and academia.[379]

For example, NREL provides a unique service called Renewable Energy Project Finance, which analyzes project financing, market issues, and policies. This service includes two tools: the Renewable Energy Finance Tracking Initiative (REFTI)[380] and the Cost of Renewable Energy Spreadsheet Tool (CREST).[381] The REFTI project tracks renewable energy project financing terms including debt interest rates, equity returns, financial structure applied, PPA duration, and other information to help developers, new investors, utilities, and regulators understand project financing terms by technology and project size. CREST is an economic cash flow model to enable public utility commissions and the renewable energy community to assess projects, design cost-based incentives (like feed-in tariffs), and evaluate the effect of tax incentives or other support structures. CREST comprises three analytic tools for solar (photovoltaic and solar thermal), wind, and geothermal technologies.

Advanced Research Projects Agency-Energy

At the federal level, ARPA-E funds high-risk, high-reward technologies to bridge the gap between basic energy research and industrial applications. As of April 2011, ARPA-E has awarded $363 million in Recovery Act funding to 121 groundbreaking energy projects based in 30 states, with about 39 percent of projects led by universities, 33 percent by small businesses, 20 percent by large businesses, 5 percent by national laboratories, and 3 percent by nonprofits.

One recipient of this funding is Envia Systems in Newark, California. In partnership with Argonne National Laboratory, Envia Systems received $4 million from ARPA-E in December 2009 to develop lithium-ion batteries with the highest energy density in the world. In January 2011, Envia Systems received an additional $17 million in venture capital funds, including $7 million from General Motors Venture LLC.

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379 http://www.energy.gov/organization/labs-techcenters.htm.

380 http://financere.nrel.gov/finance/REFTI.

381 http://financere.nrel.gov/finance/content/CREST-model.

Public Interest Energy Research Program

The Energy Commission's PIER Program provides contracts and grants to support public interest energy research, development, and demonstration. Between 1997 and 2010, the PIER Program provided about $179 million in funding for renewable energy research. The program also provided roughly $4 million of cost-share funding for renewable energy projects that helped to leverage almost $25 million in DOE funds and nearly $ 71 million in match funds. In addition, the Energy Commission's Energy Innovations Small Grant Program provides up to $95,000 for projects to conduct research that "establishes the feasibility of new, innovative energy concepts."[382] For details on past and current PIER Program funding investments, see Chapter 9 and Appendix H.

Reducing Significant Capital Requirements

Energy production has high fixed costs, and renewable energy is no exception. High initial capital costs combined with the associated project risks are difficult for the private market to finance, which results in high attrition of projects as they move into the high capital cost stages of product development (see Financing Gap 2 in Figure 21). Technologies feature different capital intensity characteristics and timelines, and various classes of investors will face different capital constraints in any given project. These diverse challenges cannot be solved by a single policy. Instead, governments provide a number of targeted programs that investors can use to help projects get the upfront cash necessary to get steel in the ground, boost returns over the life of a project, or work directly to decrease the overall project costs.

Tax Incentives

Tax incentives or subsidies have long supported the development of conventional energy but are relatively new in supporting renewable generation.

Large upfront costs are a major obstacle for smaller developers. At the federal level, renewable energy projects are eligible for the business energy investment tax credit (ITC) or the renewable electricity production tax credit (PTC). Under ARRA, the ITC can be converted to a cash grant once 5 percent of a project's overall costs have been incurred in the building process. These grants can offset as much as 30 percent of an eligible project's cost and provide crucial infusions of cash in the beginning project development stages. The PTC provides incentives for electricity generated. In 2005, the United States Energy Information Administration analyzed the effects of the PTC – assuming that the PTC would be extended through 2015. The analysis suggested that the PTC would increase installed capacity of wind power by 580 percent, biomass by more than 65 percent, and geothermal by more than 20 percent.[383]

The ITC provides tax credits of 10 percent or 30 percent, depending on technology. ARRA's Section 1603 allows eligible projects to claim a cash grant in-lieu of the ITC, but projects must begin construction by 2012. As of October 2010, more than $5 billion in cash grants have been awarded, with $491 million going to 337 California projects. Grants are attractive because

382 For more information, see: http://www.energy.ca.gov/research/innovations/index.html.

383 http://tonto.eia.doe.gov/oiaf/aeo/otheranalysis/aeo_2005analysispapers/prcreg.html.

transaction costs can be as much as 60 percent lower than those associated with tax credits,[384] allowing developers to devote more funding to the renewable energy projects themselves.

The PTC is slated to expire in 2012 for wind, and the ITC for solar ends in 2016. This mismatch in availability of the PTC for wind may create some uncertainty about whether wind's competitive prices compared to solar will continue post 2012.

Uncertainty about continuation of the 1603 Program is problematic to the state and to commercial development of innovative technologies.[385] The U.S. Partnership for Renewable Energy Finance notes that the anticipated total financing available for renewables in 2011 was expected to decrease by roughly 56 percent from that available in 2010,[386] with about $7.5 billion in renewable energy projects in California that would not proceed without an extension. The cash grant was extended at the end of 2010 through the end of 2011, but its fate post-2011 is uncertain.

The California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) in the State Treasurer's Office offers renewable energy companies sales and use tax exclusions on property used for "design, manufacture, production, or assembly." CAEATFA's SB 71 Program,[387] the Advanced Transportation and Alternative Sources Manufacturing Sales and Use Tax Exclusion Program, reduces some of the capital requirements of renewable energy manufacturers, allowing these manufacturers to address gaps in private lending. As of September 2011, 33 projects have successfully applied for this exclusion, which will potentially result in $100 million saved on more than $1 billion in qualified property. CAEAFTA also has authority to develop a similar program for renewable energy generation projects and will begin program development in February 2012.

Accelerated Depreciation

The federal government has recently promoted the use of accelerated depreciation to help provide project capital at the front end. Most renewable energy assets can be depreciated over a five-year period, which reduces taxable income. A 2009 LBNL study found that the accelerated depreciation schedule reduces total PV system costs by 26 percent.[388] The Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010 extended the bonus or accelerated depreciation to allow 100 percent first-year depreciation reduction for qualified renewable energy projects that are placed in service before January 1, 2012.

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384 http://financere.nrel.gov/finance/content/treasury-cash-grant-transaction-costs.

385 Alternative Energy Projects Affected by 1603 Expiry, US PREF, December 2010.

386 Prospective 2010-2012 Tax Equity Market Observations v1.2, U.S. Partnership for Renewable Energy Finance, July 2010.

387 Senate Bill 71 (Padilla), Chapter 10, Statutes of 2010, http://www.leginfo.ca.gov/pub/09-10/bill/sen/sb_0051-0100/sb_71_bill_20100324_chaptered.html.

388 Bolinger, M. (2009). *Financing Non-Residential Photovoltaic Projects: Options and Implications*. Lawrence Berkeley National Laboratory. LBNL-1410E.

Loan and Bond Financing Programs

Loan and bond financing programs aim to provide capital at below-market rates. Firms often face major challenges in securing sufficient capital because they lack appropriate project development experience and/or use unproven technologies, therefore posing credit risks. The federal government has stepped up significantly to reduce this risk.

Under ARRA, DOE has offered competitive loan guarantee programs to "support innovative clean energy technologies that are typically unable to obtain conventional private financing due to high technology risk." Private lenders provide the loan, but federal underwriting protects investors from the risk of default and lowers interest rates on borrowed capital.

Established in 2005 to spur investment through private lending, DOE's Section 1703 loan guarantee program partially addressed high technology risk and financing gaps for innovative technologies. In 2009, the Section 1705 loan guarantee program (LGP) was established under ARRA to address commercial technologies. Both 1703 and 1705 programs are significant financial tools for progressing commercial technologies. The LGP has received more than 400 applications and committed nearly $36 billion to support 38 clean energy projects across 21 states.[389] This represents a greater investment in clean energy generation projects than was made by the entire private sector in 2009 ($10.6 billion), and almost as much as was invested in such projects in 2008 – the peak financing year to date ($22.6 billion). Nine California projects have taken advantage of the LGP, which expired on September 30, 2011, for a total value of more than $11 billion.[390] However, the LGP is currently facing political controversy as a result of a September 2011 bankruptcy filing by California-based company Solyndra, which received a $535 million loan guarantee in 2009.[391]

The lesser-known United States Department of Agriculture's (USDA) Rural Utilities Service (RUS) program provides renewable energy developers with Treasury and municipal rate loans and loan guarantees. The RUS loan and loan guarantee programs, which can also be used for other electrical utility infrastructure (distribution, transmission, and utility facilities), were funded at $6.6 billion for fiscal year 2009 and at $7.1 billion for fiscal year 2010. In 2010, $313 million was awarded in loans and loan guarantees to renewable energy applicants.

Using bonds to finance projects can be a straightforward option. The federal new Clean and Renewable Energy Bonds (CREBs) program – tax-exempt bonds issued by public entities – has provided more than $2.4 billion in authority with California having issued about $640 million in project financing. The Federal Qualified Energy Conservation Bonds (QECBs) program – tax credit bonds issued by public entities – has provided more than $3.2 billion in authority with

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389 https://lpo.energy.gov/?page_id=45.

390 "Cleantech Loan Guarantees: A Tangled Tale," Pete Danko, May 2011, http://www.earthtechling.com/2011/05/cleantech-loan-guarantees-a-tangled-tale/.

391 Bloomberg News, "White House Orders Review of DOE Loan Program," October 28, 2011, http://www.bloomberg.com/news/2011-10-28/white-house-orders-review-of-energy-department-loan-program-1-.html.

California having issued nearly $381 million in project financing.[392] Several state and local entities issue bonds including CAEATFA, the California Infrastructure and Economic Development Bank (I-Bank), and local municipalities.

Pension Fund Investments

The California Public Employees' Retirement System (CalPERS) invests state funds, and its private equity investment has a total market value of $28.8 billion, with a California value of $2.9 billion or 10.1 percent. The Alternative Investment Management (AIM) Environmental Technology Program invests in clean technologies such as renewable energy across stages of development, strategies, geographies, and structures.[393] Since 2007, CalPERS has committed $600 million to AIM's investment managers.

On-Bill Financing

On-bill financing programs rely on capital from the energy consumer to finance the upfront costs of efficiency and renewable energy systems. Repayments for the system are automatically added to the consumer's utility bill. Ideally, the payments are less than the energy savings from the renewable energy project, saving the consumer money from the first day of operation. The debt obligation lies with the account holder who signs the loan documents.

Though not widely implemented yet, on-bill financing programs have the opportunity to increase the access to affordable capital to install renewable energy systems. Despite the opportunities with on-bill financing programs, several hurdles must be overcome before widespread adoption. Programs such as these require legislative and regulatory approval as well as engagement with customers through appropriate marketing and outreach. Participating utilities also face uncertainty with program administration, billing logistics, and default scenarios.[394]

Efforts to Address Financing Challenges for Distribution-Scale Renewables

Historically, few financing options have been available for DG. Public grants and tax credits greatly reduce the cost of DG systems; however, the customer is still left with significant upfront expenses. Lending institutions may provide equipment loans for DG systems, but the loan costs and terms are often unfavorable, with monthly repayments far exceeding the energy savings, leaving early adopters of renewable technologies with little choice but to use traditional financing methods such as equity loans, mortgages, lines of credit, or cash.[395] High transaction costs associated with project financing essentially eliminate this as an option for small-scale projects.

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392 Note: All federal funding for CREBs and QECBs has been allocated.

393 http://www.calpers.ca.gov/.

394 http://www.nrel.gov/docs/fy11osti/49340.pdf.

395 Whole paragraph: http://www.nrel.gov/docs/fy09osti/44853.pdf, p. 24.

Fortunately, opportunities exist to make DG systems less expensive and easier to finance. Leases, comparable to those for cars, can reduce or eliminate the upfront costs to consumers while keeping monthly payments less than or equal to energy savings. In this case, an outside company would rent a DG system to consumers for a monthly payment, and the company may take care of maintenance and provide an option to purchase the system at the end of the lease.[396]

Power purchase agreements are similar to leases in that an outside company owns the DG system and is able to take advantage of incentives. However, unlike a lease, the consumer purchases electricity generated by the system from the company rather than renting the equipment, even though the DG system would be located on the customer's property. This arrangement closely resembles traditional electricity purchases from a utility.[397]

When obtaining DG systems through a lease or power purchase agreement, commercial owners can take advantage of additional incentives not available through traditional financing methods. While both residential and commercial owners may take advantage of the federal Section 1603 cash grant and Business Energy Investment Tax Credit (ITC) programs, only commercial owners may accelerate depreciation on the system. As described earlier, depreciation provides a tax benefit of 26 percent of the total system cost, greatly lowering the overall cost of the DG system to both the commercial owner and the consumer.

With property tax assessments, a city or county provides funding for property owners to purchase and install DG systems. The initial investment from the city can be financed through bonds or from the general fund and is paid back through a special property tax.[398] Using property tax assessments for DG is a relatively new concept. As such, implementation is challenging, and its feasibility is unproven.

AB 811 (Levine, Chapter 159, Statutes of 2008) authorized cities and counties to create local Property Assessed Clean Energy (PACE) programs. Under this program, citizens can opt to have the cost of energy efficiency and renewable energy generation infrastructure added to their property tax bill, allowing them to reap the benefits of energy savings without paying significant upfront costs. These property tax assessments also stay with the home should the deed be transferred, ensuring that those who benefit from the energy savings are the ones paying the bill. In July 2010, the Federal Housing Finance Agency (FHFA) directed Fannie Mae and Freddie Mac to revise their lending policies, effectively halting PACE programs on federally backed mortgages.[399] Halting PACE in the residential sector has created a considerable setback to DG financing. However, a recent report indicates commercial PACE programs are active in the counties of Placer and Sonoma, and the cities of Berkeley, Fresno, Los Angeles, and Palm Desert – representing $9.7 million and 71 projects. The report suggests that solutions using

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396 Ibid, p. 28.

397 Ibid, p. 31.

398 Ibid, p. 33.

399 http://www.comstocksmag.com/Archive/1010_F_A-Slow-Pace-.aspx.

PACE for the commercial sector should explore underwriting criteria, loan-to-value ratios, different financing structures, and credit enhancements.[400]

Other PACE-related efforts include federal legislation introduced in July 2011, the PACE Assessment Protection Act of 2011 (HR 2599), to address FHFA concerns regarding residential and commercial PACE programs. In California, AB X1 14 (Skinner, Chapter 9, Statutes of 2011), which was signed into law August 2, appropriates up to $50 million for CAEATFA to work with the Energy Commission to assist in financing and administration of the Clean Energy Upgrade Program. The program would provide financial assistance to participating financial institutions that make loans to residential and small commercial property owners for the installation of energy efficiency improvements, electric vehicle charging infrastructure, and DG renewable energy. The law also requires CAEATFA to submit an annual report to the Legislature that summarizes benefits provided by the program.

The USDA Rural Energy for America Program (REAP) provides competitive grants and loans of up to $25 million for rural energy projects and efficiency improvements.[401] The REAP Guaranteed Loan Program encourages commercial financing of renewable energy, and the Rural Development Electric Program offers financing assistance for the construction of electric distribution, transmission, and generation facilities.

California Case Studies

Case studies provided here illustrate the combination of renewable technologies, project scale, financing structures, programs, and unique attributes used to finance projects.

County of Yolo

Yolo County installed a 1 MW solar PV project to supply renewable power to a jail and juvenile center.[402] This project represents the first known combined use of QECBs and CREBs in the nation. QECBs and CREBs, known as qualified tax credit bonds, are an inexpensive approach for state and local government to finance renewable energy installation.

The county chose to own the solar PV system and did not select a PPA provider because the PPA's financial benefits were insubstantial. The county used a variety of funding sources to help finance the project including CREBs, QECBs, an Energy Commission Energy Conservation Assistance Act loan, and a Tax Exempt Lease Program (TELP) loan. Yolo County was also eligible for a $2.5 million incentive from California Solar Initiative (CSI) and a $1.9 million Pacific Gas and Electric Company rebate. The total cost of the project with interest payments is $9.4 million, with total utility bill savings estimated at $18.1 million over 25 years. Without these low-cost finance options, the county might not have been able to finance the project. The county negotiated a lag time of six months between the system going on-line and when initial

400 Ken Hejmanowski, Scott Henderson and Mark Zimring, Renewable Funding, Clinton Climate Initiative, Lawrence Berkeley National Laboratory, Property Assessed Clean Energy (PACE) Financing: Update on Commercial Programs, March 2011, http://eetd.lbl.gov/ea/ems/reports/pace-pb-032311.pdf.

401 http://www.rurdev.usda.gov/ca/bi/REAP%20index.htm.

402 http://www.nrel.gov/docs/fy11osti/49450.pdf.

payments were due. This allowed the county to generate funds from the utility savings that were used to make the first payment.

Jefferson Union High School District

Perpetual Energy Systems (PES) financed a 1.5 MW solar energy project at the Jefferson Union High School District located south of San Francisco. The project includes more than 8,500 solar PV panels and generates more than 2.3 million kWh of solar energy during the year. The project required no upfront costs from the school district because it was funded by PES. The district will buy power from PES at a lower rate than the PG&E rate. In return for the financing, the company will get tax and investment credit. The school expects to save 3 percent on annual energy costs over the next 25 years.[403]

Hudson Ranch Project

Hudson Ranch I is a 49.9-MW geothermal generating power facility in the Salton Sea area in California. EnergySource is the project developer. The electricity produced from the geothermal facility will be sold under a 30-year PPA. The local water board granted the project 800 acre-feet of water annually to the facility. In addition, the facility took advantage of ARRA tax incentives worth more than $100 million. This $399 million project is expected to create 200 jobs and provide $3.5 million in annual property taxes.[404]

Dixon Ridge Farms[405]

Dixon Ridge Farms (DRF), located in Winters, grows, buys, and processes California organic walnuts on its 1,200-acre farm site. In 2007, DRF was faced with rising energy costs and established a goal of making its facility energy self-sufficient by 2012. DRF began working with the Community Power Company of Colorado to evaluate the installation of a 50 kW biogas powered generator (BioMax 50) that converts walnut shells into energy, powers a 12,000 square-foot freezer, and uses waste heat for their operations. The BioMax 50 produces about $40,000 worth of electricity a year and $12,000 of gas to offset propane use. The total project cost $400,000, with DRF providing $30,000 and the Energy Commission providing the balance as a PIER Program grant. DRF also installed solar PV financed through a mix of incentives and equity. For details on the DRF project, see Chapter 9.

Other Renewable Energy Financing Efforts

Neighboring States

California and its neighboring states provide different incentives to encourage investment in renewable energy generation facilities and manufacturing facilities. Arizona and Oregon have personal and corporate tax incentives, while Arizona and Nevada have sales tax incentives for renewable energy.

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403 Personal communication: Dustin Keele, Executive Vice-President, Photon Energy Services Inc., May 20, 2011.

404 http://www.hannonarmstrong.com/press/pfhrdoty_article.pdf.

405 http://www.dixonridgefarms.com/.

Arizona's solar energy generation potential is estimated at 101 million MWh per year.[406] Key efforts include Arizona Renewable Energy Standard and Tariff of 2006, which is similar to California's Renewables Portfolio Standard.[407] Arizona project development is also bolstered by net metering, state corporate production tax credit, income tax credit, a property tax exemption and incentive, and a sales tax exemption.[408] Most of these efforts do not expire until 2018, providing certainty to the market. While existing in-state solar generating capacity is relatively low at about 50 MW, more than 2,200 MW of solar projects have been announced or planned.[409] Renewable energy manufacturing equipment also has a sales and use tax exemption.

Nevada has a large geothermal resource that produces nearly 4 percent of its electricity,[410] and the state has the potential to generate about 83 million MWh per year of solar energy.[411] Renewable energy development is supported by a renewable portfolio standard, net metering, various rebates and incentives, and laws that prohibit siting restrictions on solar and wind energy systems.[412] Nevada, like California, has state legislation for a Property Assessed Clean Energy (PACE) Program. The Renewable Energy Producers Property Tax Abatement provides a property tax abatement of up to 55 percent for up to 20 years for real and personal property used to generate electricity from renewable energy resources including solar, wind, biomass, fuel cells, geothermal, or hydro. Generation facilities must have a capacity of at least 10 MW. The Nevada Energy Renewable Generations Rebate Program provides solar rebates from $2.30 per watt AC; wind rebates from $2.50 per watt; and small hydro rebates from $2.00 per watt.

Oregon's Small-Scale Energy Loan Program (SELP) was created as a result of a voter-approved constitutional amendment that authorized the sale of bonds to finance small-scale local energy projects that save energy, produce energy from renewable resources, create products from recycled materials, use alternative fuels, and reduce energy consumption during construction or operation of a facility. Generally, the loans range from $20,000 to $20 million. The Energy Trust of Oregon provides cash incentives and development assistance for renewable energy projects that have a capacity of 20 MW or less. Funding is available for grant writing, feasibility studies, or technical assistance with design, permitting, or utility interconnection. The Energy Trust will pay up to 50 percent of eligible project costs for a maximum of $40,000. Incentives are based on the project's costs in comparison to the market value of energy produced.

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406 Renewable Energy Atlas of the West, p. 27.

407 http://www.cc.state.az.us/divisions/utilities/electric/environmental.asp.

408 http://www.acore.org/files/pdfs/states/reamerica_mar11.pdf, p. 19.

409 http://www.acore.org/files/pdfs/states/reamerica_mar11.pdf, p. 18.

410 Renewable Energy Atlas of the West, p. 47.

411 http://www.acore.org/files/pdfs/states/Nevada.pdf.

412 http://www.acore.org/files/pdfs/states/reamerica_mar11.pdf, pp. 72- 73.

International Efforts

Mexico achieved the biggest increase in renewable energy investment in Latin America, excluding Brazil, due in part to the Renewable Energy Development and Financing for Energy Transition Law enacted in November 2008. Mexico's renewable investment grew 348 percent, stimulated by major wind projects and geothermal. Mexico's government raised renewable energy capacity from 3.3 percent in 2009 to 7.6 percent by 2012, and wind is intended to make up 4.3 percent by 2012. Projects are expected to reach $8 billion in 2011 by foreign investment into Mexico with primary interest in the borderland between northern Mexico and southern United States. The Baja California region has grid connectivity with California and the potential of exporting renewable energy to the state. Historically, most foreign investment in Mexico comes from the United States. As an example, San Diego-based Cannon Power Group is investing $2.5 billion in Mexico to build wind farms to generate more than 300 MW of electricity.[413]

Canada has invested $CDN 4.9 billion in renewable energy. Canadian incentives for investment[414] include: 1) a 50 percent accelerated capital cost allowance for clean energy generation; 2) underwriting R&D activities that lead to new, improved, or technologically advanced products or processes; 3) a $CDN 1.5 billion investment to increase clean electricity from renewable sources; and 4) a $CDN 230 million investment in clean energy science and technology that will fund RD&D to support next-generation energy technologies. The province of Ontario has also successfully implemented a FIT program and a micro-FIT program (for projects less than 10 kW) over the past 18 months.

Germany and Spain are active participants in expanding renewable energy generation, investing $4.3 billion and $10.4 billion, respectively, in 2009. The bulk of investment in these countries has been in the solar and wind sectors, supported by carbon markets, renewable energy standards, clean energy tax incentives, FITs, and government procurement requirements. As of 2009, 29 percent of German power capacity and 30.1 percent of Spanish power capacity was generated from renewable sources.[415] Germany and Spain's FITs have resulted in the installation of thousands of MW of renewable capacity. Germany has already achieved its renewable energy goals and was able to increase generation targets by 5 percent. Spain's FITs are also highly utilized.[416] Because of higher than expected demand for FITs, regulators were forced to cap annual eligible installations and reduce incentives.[417] This

413 http://www.cannonpowergroup.com/.

414 http://investincanada.gc.ca/eng/default.aspx.

415 The Pew Charitable Trusts, *Who's Winning the Clean Energy Race? G-20 Clean Energy Factbook,* 2010, http://www.pewtrusts.org/our_work_report_detail.aspx?id=57969.

416 http://www.renewableenergyworld.com/rea/news/article/2011/01/spains-solar-sector-sues-government-over-retroactive-tariff-cuts?cmpid=rss.

417 KEMA, *California Feed-In Tariff Design and Policy Options*, draft consultant report prepared for the California Energy Commission, September 2008, http://www.energy.ca.gov/2008publications/CEC-300-2008-009/CEC-300-2008-009-D.PDF, pp. 15- 19.

disruption provided market uncertainty and resulted in a period of excess panels supply, and decreasing prices, as global supply outpaced demand. Spain's incentive policy was not a long-term sustainable design nor was it market responsive. This led to taxpayer backlash and market uncertainty as a boom/bust effect was felt in the growing solar PV market.[418]

China's 2009 total renewable energy investment of $34.6 billion led the world. China's renewable investment has primarily been in the wind energy sector, accounting for 71.1 percent of the total investment. Similar to Germany and Spain, China supports renewable energy with a renewable energy standard and clean energy tax incentives. In August 2011, China announced a national FIT for solar power installations. The government offers green energy bonds to encourage development.[419] Chinese-manufactured solar panels entered the market at a time when global demand was high and supply was low.

418 http://www.nytimes.com/gwire/2009/08/18/18greenwire-spains-solar-market-crash-offers-a-cautionary-88308.html?pagewanted=2.

419 Whole paragraph: The Pew Charitable Trusts, *Who's Winning the Clean Energy Race? G-20 Clean Energy Factbook,* 2010 , http://www.pewtrusts.org/our_work_report_detail.aspx?id=57969, p. 26.

CHAPTER 8: Cost Issues

A variety of cost challenges influence developing the generating facilities needed to meet California's renewable energy goals. Development costs are a major driver of the prices sought by renewable energy developers in contracts with utilities, which must be approved by the California Public Utilities Commission (CPUC) for investor-owned utilities (IOUs) or a board of directors for publicly owned utilities. According to the CPUC's Division of Ratepayer Advocates, project failure seen in Renewables Portfolio Standard (RPS) contracts is most often due to difficulties in securing financing, permits, and transmission, in that order.[420]

About This Chapter

This chapter discusses cost issues facing renewable technologies, including:

- The levelized cost of generation studies, how renewable costs can vary by project, and information on cost trends seen in recent years.
- How tax benefits affect levelized cost calculations.
- A comparison of subsidies for new and emerging technologies.
- Issues associated with net energy metering.
- The value of a mix of renewable energy sources in the state's electricity portfolio and the value of renewable energy to society, currently not considered in levelized cost calculations.
- The areas of environmental review, permitting, interconnection, and construction.

Levelized Cost of Renewable Technologies

Levelized cost is the present value of the total cost for financing, building, and operating a generating plant over its economic life, converted to equal payments per megawatt-hour (MWh). The Levelized Cost of Energy (LCOE) consists of seven main components grouped into "fixed" and "variable" costs.[421] Fixed costs include capital and financing costs, fixed operating and maintenance costs (primarily labor to operate a facility), insurance costs, ad valorem taxes (based on value of real estate) , and corporate taxes (both federal and state). Variable costs depend on how much a unit operates and include costs for fuel and for operating and maintaining a facility. Variable costs may represent 50 to 80 percent of the calculated levelized costs for a combined cycle natural gas plant, depending on fuel price trajectories; the LCOE for most renewable generation technologies (with the exception of biomass) consists primarily of fixed costs.

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420 California Public Utilities Commission Division of Ratepayer Advocates, *Green Rush, Investor-Owned Utilities' Compliance with the Renewables Portfolio Standard*, February 2011, p. 9, http://www.dra.ca.gov/NR/rdonlyres/0CB0B986-E93B-462A-BA62-804EDAE43B82/0/DRAReportPUBLICVERSIONFeb2011.pdf.

421 Transmission costs to interconnect a facility to the grid are sometimes included in the LCOE calculation.

Although levelized costs are often presented as representative average costs, specific project costs can depend on variable cost components. For example, transmission interconnection costs vary by project location, the purchase price of a wind turbine depends on manufacturer inventory levels, and financing costs differ among investor-owned utilities, municipal utilities, and merchant developers.

Renewable generation projects feature unique characteristics that distinguish them from other capital-intensive projects. Compared to conventional generation, renewable projects generally have higher capital costs and a larger per-megawatt (MW) footprint in more ecologically sensitive areas, which leads to larger direct land costs and indirect mitigation costs. Although some renewable technologies like solar photovoltaics (PV) and solar thermal electric may have higher LCOE per MWh than conventional generation, they produce generation when it is most valuable and can actually be competitive with conventional generation on a time-of-delivery basis. Other factors include California's higher property values and stringent environmental regulations, which add time, expense, and business and financial risk.

Figure 22 compares three sets of levelized cost estimates for different renewable generation technologies developed in California. These include LCOE range forecasts prepared by Black & Veatch for the Renewable Energy Transmission Initiative (RETI), estimates developed by the E3 Renewables Portfolio Standard Calculator for the CPUC's Long-Term Procurement Proceeding,[422] and estimates from the Energy Commission's *2009 IEPR* Cost of Generation project. The figure shows that the range of costs for a technology can be more significant than the differences in average costs between technologies. State policy should focus on measures to ensure that developer costs fall on the lower end of the spectrum. For comparison, the LCOE estimates presented in Figure 22 do not include transmission interconnection charges because not all of the studies included this variable and such charges can vary significantly for remote projects.

Other variables can further spread the range of levelized costs for different generation technologies. For example, Figure 23 shows how total cost (including transmission, LCOE, and integration) varies by project.[423] Major transmission cost drivers include the length of the transmission line, the number of substations required for the pathway taken, and the line utilization.[424] These cost curves, developed in 2009 (and the 2010 costs presented in Figure 22) do not take into account significant cost reductions that have occurred over the past few years. Nor do they consider time-of-delivery payments and integration cost factors. Recent market trends show that factoring in time of delivery appears to have made solar technologies cost

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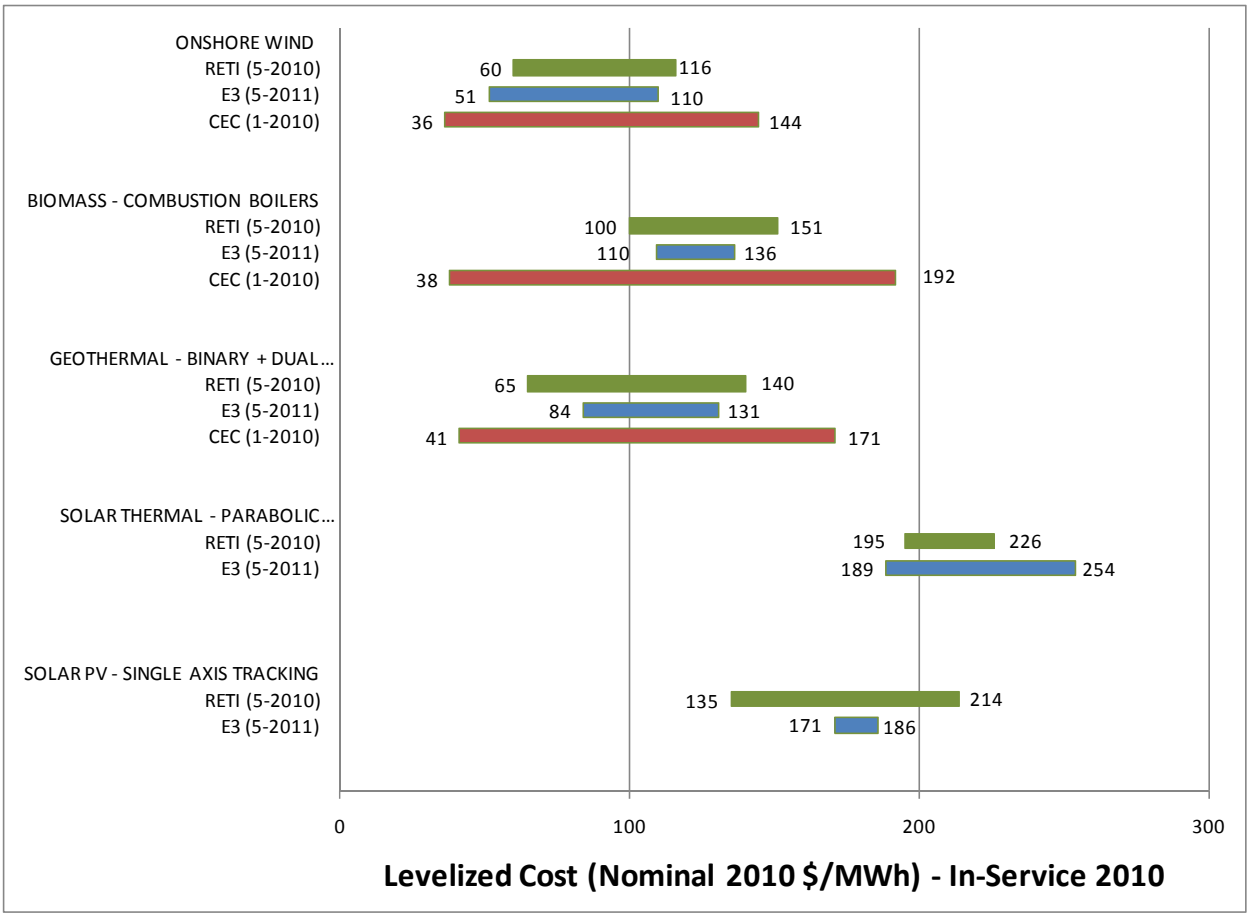
422 http://www.energy.ca.gov/siting_lessons/notices/2010-12-02_Order_Instituting_Informational_Proceeding_TN-59112.pdf.

423 This figure represents the average total costs used in the RETI Phase 2b cost-ranking model. The graph does not reflect uncertainty, which is estimated to be 25 to 35 percent for wind projects and 12 to 20 percent for all other renewable technologies. http://www.energy.ca.gov/2010publications/RETI-1000-2010-002/RETI-1000-2010-002-F.PD, pp. 7-10.

424 http://www.energy.ca.gov/2010publications/RETI-1000-2010-002/RETI-1000-2010-002-F.PDF, pp. 6-29.

competitive. The majority of solar thermal power tower technology contracts that have been signed and are pending are below the 2009 Market Price Referent (MPR), a proxy for the levelized cost of a new 500-MW natural gas combined cycle plant. In SCE's 2010 reverse bid under its Renewable Standard Contract, all of the lowest bids by levelized cost were for solar PV.[425] Further, all of the bids' levelized costs were below the MPR. .

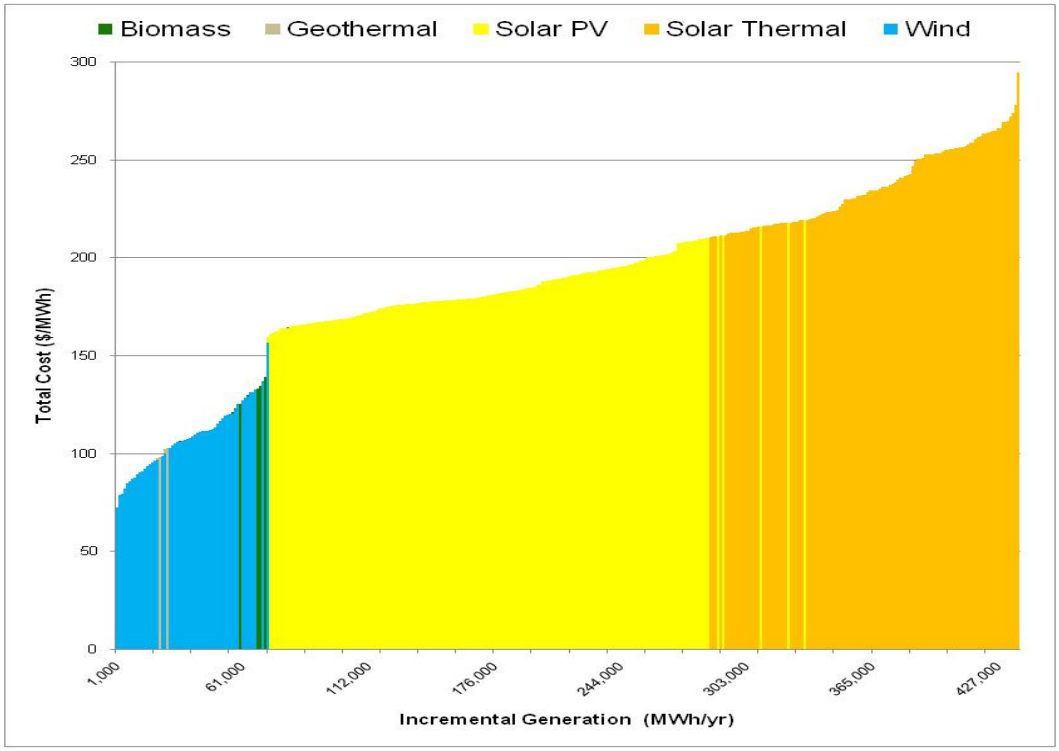
Figure 22: Comparison of Levelized Cost of Generation Studies



Sources: (1) CEC 2009 IEPR Cost of Generation Report: http://www.energy.ca.gov/2009publications/CEC-200-2009-017/CEC-200-2009-017-SF.PDF. COG values not included for PV due to significant decline in PV costs since 2009 study; (2) RETI Phase 2B RETI Report: http://www.energy.ca.gov/reti/documents/index.html; (3) E3 Renewable Energy Costing Tool: http://www.ethree.com/public_projects/renewable_energy_costing_tool.html.

425 SCE's Advice letter 2547-E, http://www.sce.com/NR/sc3/tm2/pdf/2547-E.pdf. "On September 15, 2010, SCE received a large number of offers for the 2010 RSC Program, representing over ten times the program's goal of 250 MW... SCE seeks approval in this Advice Letter for 20 contracts executed through the 2010 RSC Program. All of the RSC Contracts are for 20-year terms and are for solar photovoltaic ("PV") projects constructing new facilities. ... All RSC Contracts are priced below the approved 2009 market price referents ("MPRs"), the most current MPRs available when the offers for the RSC Contracts were received."

Figure 23: RETI Renewable Supply Curve – California Only



Note: The renewable net short is estimated to be between 35,000 and 47,000 GWh in 2020.
Source: http://www.energy.ca.gov/reti/documents/phase2B/CREZ_name_and_number.xls

Although a comparison of levelized costs is useful in understanding the challenges faced by renewable energy developers, it does not tell the whole story. Other factors that affect project viability include environmental and cultural concerns, out-of-state renewable goals, time-of-delivery energy prices, overgeneration during off-peak periods, and integration costs.[426, 427]

A larger amount of low-cost renewable energy is potentially available for California's RPS in the WECC-wide supply curve than in the California-only supply curve. However, out-of-state resources may face greater risk than in-state renewable resources because they may need to build transmission to avoid falling under one of the capped RPS facility categories.[428]

426 California Independent System Operator, *Initial Testimony of the California Independent System Operator Corporation, PART II*, A.06-08-010, March 7, 2007, http://www.caiso.com/1b95/1b95e891277b0.pdf, pp. 58-61.

427 Ibid.

428 To avoid being in a capped category, an RPS facility must have its first point of interconnection to a California Balancing Authority, first point of interconnection to a customer of a California balancing authority, or generation from the facility must be scheduled for delivery without substitution to a California balancing authority. If the capped RPS categories are fully subscribed, out-of-state renewable resources may need transmission lines crossing multiple states to bring renewable energy to California. The RETI Phase 2B study indicates that the costs of multi-state transmission lines tend to make resources located far from California more expensive than other renewable resources.

Because most of the cost to develop a renewable generating facility is upfront capital cost, appropriate government policy and regulation can provide value in minimizing the expense and delays associated with these capital costs. For example, soft costs, such as permitting and inspection, can add $5,000 to a typical $20,000 to $30,000 residential rooftop PV system in California. Two-thirds of these soft costs could be avoided.[429] Regulatory barriers can also increase costs; for example, barriers experienced by the Fiscalini Farms dairy digester in Modesto more than doubled the initial estimate of the project's cost from $2 million to $4.5 million.[430]

Cost Trends

In a 2009 "Levelized Cost of Energy Analysis," the investment firm Lazard observed that, in some cases, renewable technologies are cost-competitive with conventional generation technologies, even without factoring in societal value and other benefits.[431] The study found that, with solar PV technologies, there is a significant potential over time for economies of scale along the entire production value chain. In contrast, mature conventional generation technologies are experiencing capital and fuel cost inflation, with little prospect for cost-reducing manufacturing improvements.[432] Variations in levelized costs depend on a complicated set of assumptions on financing, operational costs, capacity factors, and tax credits. This comparison of costs is used for general screening purposes since these technologies are not interchangeable in their value to the system.

The CPUC's MPR has been used as a proxy for long-term natural gas prices when evaluating renewable procurement contracts. This metric is used because marginal capacity added to the California grid is typically from combined cycle natural gas plants, which would presumably be displaced by renewable generation. Recent MPR prices have been stable, with low expected growth over time. The MPR is still in use today while the CPUC reformulates the MPR under Senate Bill X1-2 (Simitian, Chapter 1, Statutes of 2011), with a proposed decision expected in December 2011.[433]

Studies used to estimate the levelized costs in Figure 22 were completed before 2010. Since then, a number of variables affecting the cost drivers have changed. For example, PV costs are lower than shown in Figure 22. Figure 24 provides the calculated average installed cost of electricity

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429 http://www.fresnobee.com/2011/05/01/2370247/permit-process-clouds-solar-energy.html.

430 http://www.dairyherd.com/dairy-news/latest/Commentary-Dairy-industry-pioneer-thwarted-by-regulations-124810264.html.

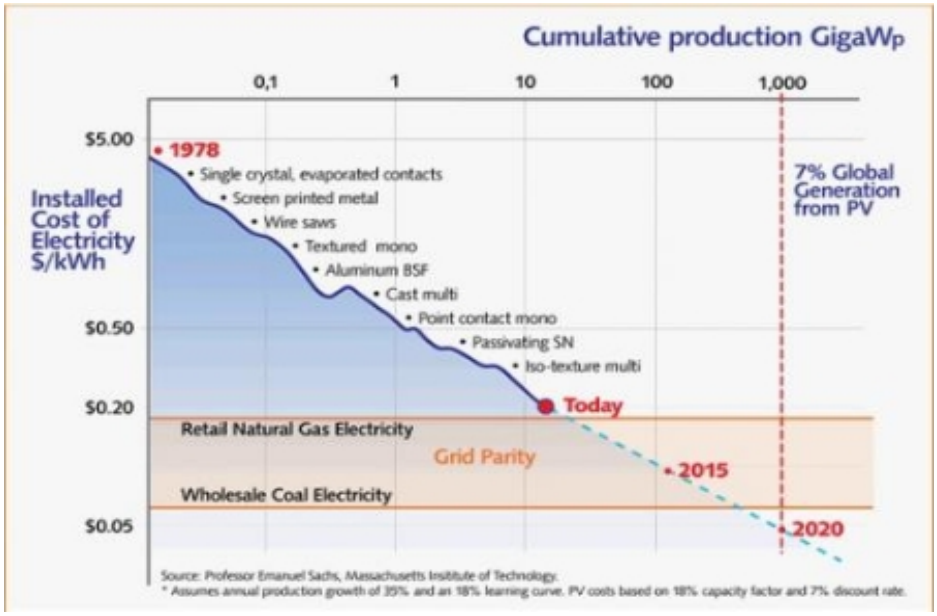
431 "Levelized Cost of Energy Analysis – Version 3.0," February 2009, http://blog.cleanenergy.org/files/2009/04/lazard2009_levelizedcostofenergy.pdf, accessed July 21, 2011.

432 Variations in levelized costs depend on a complex set of assumptions about financing, operating costs, capacity factors, and tax credits. The comparison of costs is used for general screening purposes since technologies are not interchangeable in their value to the system.

433 http://docs.cpuc.ca.gov/published/proceedings/R1105005.htm. For a breakdown of eight factors proposed in SB X1-2 to calculate the Market Price Referent, http://docs.cpuc.ca.gov/efile/RULINGS/138055.pdf, p. 6.

($/kWh) for a new solar PV project built in each of the next 10 years, assuming the 30 percent federal tax credit is renewed before it expires in 2016.

Figure 24: 10-Year Average Installed Cost of Electricity for a Solar PV Project



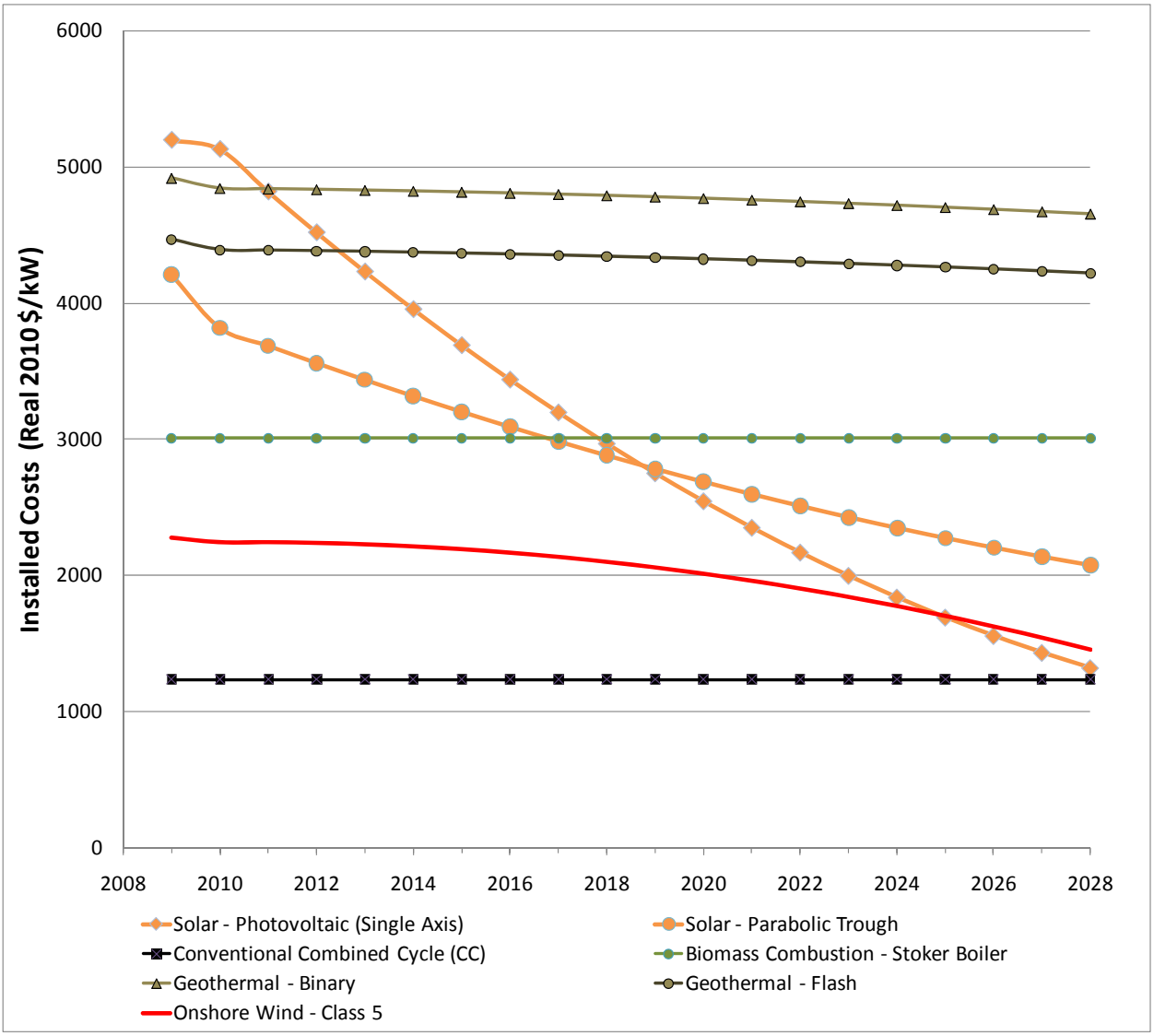
Source: http://www.renewableenergyworld.com/rea/news/article/2011/07/anatomy-of-a-solar-pv-system-how-to-continue-ferocious-cost-reductions-for-solar-electricity.

The figure reflects the trends utilities have seen in solar PV bid prices. Bids come in at an anticipated price for panels once the project makes it through permitting and interconnection studies. Typically this takes about two years, so developers are also banking on increased cost reductions for solar PV panels.

The Energy Commission conducted surveys to determine the long-term changes in cost variables that drive the levelized cost estimates of different generation technologies, particularly capital costs. Figure 25 summarizes the long-term projection of capital costs in real 2009 dollars. Utility-scale solar PV generation has experienced significant cost reductions in the last five years, and more improvements are expected near the end of the study period that could bring capital costs within range of natural gas-fired combined cycle units. Installed costs do not reflect the cost of fuel and maintenance over the life the project. Most renewable technologies have low to zero fuel costs, and maintenance costs may be much lower than conventional generation. Further, installed costs do not take into account any additional savings that may occur in a world with cap and trade.

The Energy Commission will provide an updated analysis that reflects recent technological advances in renewable generation technologies, updates the cost driver information used to calculate levelized costs in the *2013 IEPR* cycle, and evaluates both utility-scale and DG technologies.

Figure 25: Expected Installed Cost Trends



Source: California Energy Commission, *Comparative Cost of California Central Station Electricity Generation*, Staff Report, January 2010, http://www.energy.ca.gov/2009publications/CEC-200-2009-017/CEC-200-2009-017-SF.PDF.

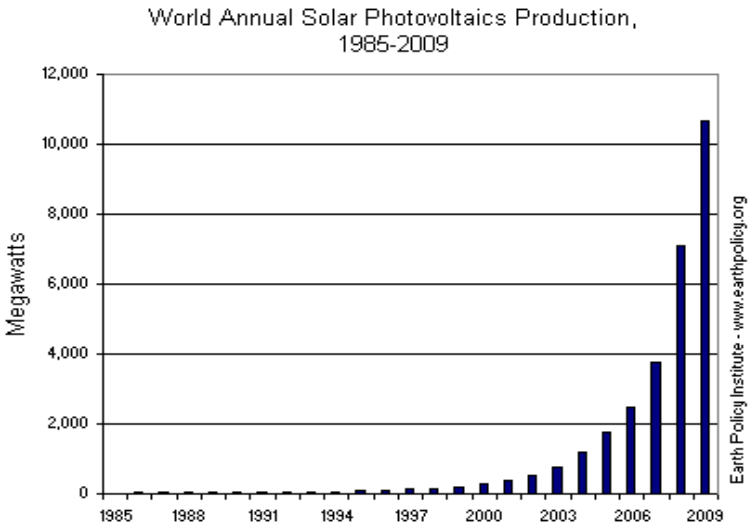
Developers of about 1,850 MW of concentrated solar thermal projects have switched to PV due to long-term declining cost trends for PV (and environmental considerations).[434] In Southern California Edison's prior solicitations, wind, solar thermal, and geothermal bids were predominant; in its most recent solicitations, most of the bids received were based on solar PV technology.[435] Global production capacity of PV panels (mainly based in China) was 10,700 MW

434 http://news.cnet.com/8301-11128_3-20076065-54/solar-thermal-plants-scrap-steam-for-photovoltaic/.

435 http://www.energy.ca.gov/2011_energypolicy/documents/2011-09-14_workshop/comments/SCE_Comments_On_Draft_Renewable_Power_in_California-S_TN-62526.pdf.

in 2009, which has doubled every two years since 2002 (Figure 26).[436] Simultaneously, the costs of PV panels, which account for roughly half of the cost of PV systems, decline roughly 20 percent each time this capacity is doubled.[437]

Figure 26: World Annual Solar Photovoltaic Production, 1985-2009



Source: EPI from Worldwatch; Prometheus Institute; Greentech Media

A Lawrence Berkeley National Laboratory study[438] released in 2011 concludes that PV module prices declined 51 percent from 1998 to 2010, and based on preliminary data for the first half of 2011 may have declined again by 11 percent from 2010 prices in systems installed through the California Solar Initiative (CSI). The trend in PV cost reductions is also illustrated in a recent evaluation of the CSI program, which notes that PV costs under the CSI have decreased rapidly (Figure 27).[439]

PV system prices continue to decline rapidly, with first quarter 2011 system prices 15 percent lower than those in the first quarter of 2010.[440] Nonmodule costs for inverters, mounting hardware, labor, permitting and fees, shipping, taxes, and installer profit also dropped 40 percent during that period. Over the past few years, the study suggests that this drop in wholesale module prices translates into a "large reduction in installed costs in 2010." The current price of PV panels is dropping so steeply that by 2012, panels will amount to less than

436 http://www.earth-policy.org/indicators/C47/.

437 http://www.arb.ca.gov/cc/etaac/ETAACFinalReport2-11-08.pdf.

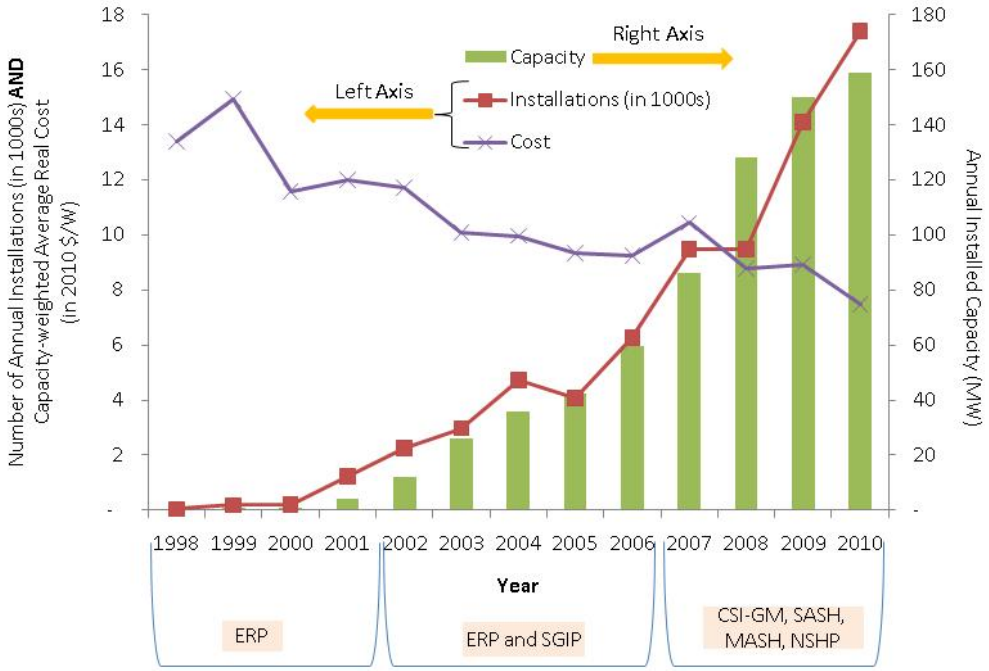
438 Barbose, Galen, Naim Darghouth, Ryan Wiser, Tracking the Sun IV: The Installed Cost of Photovoltaics in the U.S. from 1998-2010, September 2011, http://eetd.lbl.gov/ea/ems/reports/lbnl-5047e.pdf.

439 Itron, Inc., *CPUC California Solar Initiative, 2010 Impact Evaluation*, June 2011, http://www.cpuc.ca.gov/NR/rdonlyres/E2E189A8-5494-45A1-ACF2-5F48D36A9CA7/0/CSI_2010_Impact_Eval_RevisedFinal.pdf.

440 http://www.greentechmedia.com/articles/read/US-Solar-Market-Stats-Q1-2011-by-the-Numbers-/.

half of system costs (from 55 percent in 2010), and the focus of cost-reduction efforts is likely to shift toward the balance of system cost components.[441]

Figure 27: California IOU Public Purpose Program PV Systems – Trends



Source: Itron Inc.
Programs include the Emerging Renewables Program (ERP), the Self-Generation Incentive Program (SGIP), the CSI General Market (CSI-GM), Single-family Affordable Solar Homes Program (SASH), Multi-family Affordable Solar Housing (MASH), and the New Solar Homes Partnership (NSHP)

According to the Department of Energy (DOE), the largest nonmodule capital cost is installation, followed by inverter, racking hardware, wiring, and indirect project costs.[442] However, declining costs for some renewable technologies could be addressed by a resurgence of overall economic demand or commodity inflation (especially for rare earth and other metals needed for solar modules and wind turbines).

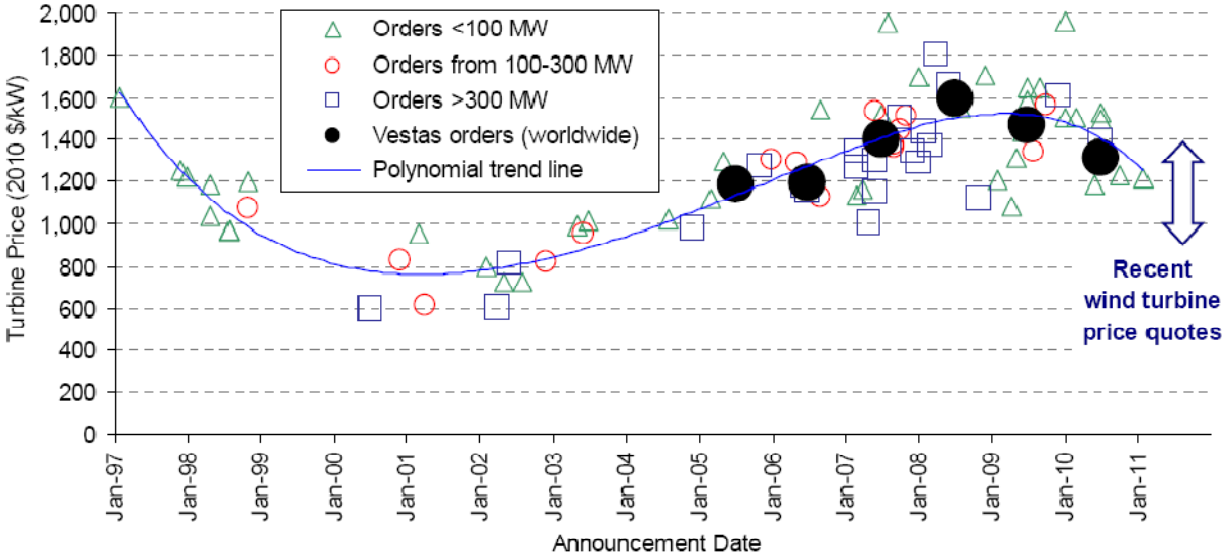
A recent LBNL report[443] shows the manufacturing capacity of wind energy manufacturers is more localized than it was half a decade ago, reducing transportation costs and currency risks. It is unclear whether these factors alone will allow the price trend of wind energy to continue downward; long-term, stable policies supporting wind power may prove decisive.

441 http://www.greentechmedia.com/articles/read/solar-pv-balance-of-system-costs-to-surpass-modules-by-2012-according-to-gt/.

442 Presentation by John Lushetsky, "The Prospect for $1/Watt Electricity from Solar," August 10, 2010, http://www1.eere.energy.gov/solar/sunshot/pdfs/dpw_lushetsky.pdf.

443 http://eetd.lbl.gov/ea/ems/reports/lbnl-5119e.pdf.

Figure 28: Wind Turbine Prices in the United States



Source: http://eetd.lbl.gov/ea/ems/reports/lbnl-5119e.pdf.

Given the importance of federal and state subsidies and tax incentives in reducing the overall cost of renewable energy projects, there are questions about how the industry may be affected if existing programs expire over the next few years. Nonethanol federal renewable energy subsidies totaled about $12.2 billion from 2002 to 2008, whereas fossil-fuel subsidies are permanently written into the federal tax code and totaled nearly $75 billion during the same period.[444] One possibility is that as subsidies decline, so will the cost of raw material.

According to a recent article in the *San Francisco Chronicle*, the price for solar-grade silicon, the main raw material in solar panels, "fell to $53.40 a kilogram ($24.27 a pound) in June, the lowest in more than six years, from $78.90 in March." The article attributes price declines to cuts in European government solar incentives,[445] which could in turn reduce the costs of PV systems. Another article in *Photon International*[446] describes survey results that suggest – despite similar component prices across different countries – PV system prices vary significantly due to government incentives affecting anticipated rates of return.[447] In other words, with costs falling but prices supported by government incentives, producers, distributors, and installers in such countries could end up collecting the increasing difference.

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444 http://www.elistore.org/Data/products/d19_07.pdf. Fossil fuel subsidies are not specific to electricity generation.

445 *San Francisco Chronicle*, "Asia Doubles Solar Silicon Factories, Pursuing Gain in Slump," July 11, 2011, http://www.sfgate.com/cgi-bin/article.cgi?f=/g/a/2011/07/11/bloomberg1376-LNWOBG1A74E901-18V2TMP81AU917V753QK4RH4QD.DTL&ao=2, accessed July 22, 2011.

446 *Photon International*, "A Price for Every Market." Matthias Krause, May 2011. Survey of PV markets throughout Europe and U.S.

447 Production costs and module and inverter prices were found to have insignificant variation across markets. Installation, transportation, and certification accounted for some, but not all, of the differences reported in the study.

Effect of Tax Benefits

Tax benefits can have a significant effect on levelized cost calculations, particularly for renewable technologies given the possibility that tax benefits may expire or change over time. For details on tax benefits, see Chapter 7.

Tax benefits fall into three categories: accelerated depreciation, tax credits and deductions, and property tax exemptions (for solar units only). Solar has the largest benefits of any of the technologies. Natural gas power plants have minor tax benefits reflected in the levelized cost of generation estimates. However, there are a number of subsidies and depreciation benefits applied to natural gas exploration, production, and sales. There are also hedging opportunities not available for renewable generators. It is difficult to actually quantify the subsidy and hedging effects on the embedded natural gas prices that are applied to the levelized cost estimates to illustrate a comparable benefit available to renewable generators.

Table 21 identifies the dollar value and technologies that are eligible for renewable energy production tax credits (PTC) and renewable energy production incentives (REPI) for municipal utilities. The table also identifies the cost benefits for those plants eligible for federal business energy or investment tax credits (BETC/ITC) under the 2005 and 2008 federal Energy Policy Acts (EPAct) and the American Recovery and Reinvestment Act of 2009 (ARRA).

The degree to which costs can be reduced from tax credits varies by technology:

- Biomass: 29 to 34 percent
- Geothermal: 48 to 50 percent
- Hydroelectric: 18 to 51 percent
- Solar: 53 to 55 percent
- Wind: 49 percent

ARRA made most of the technologies that had been eligible for the PTC also eligible for the ITC if the latter provided a larger benefit. The ARRA also allows those technologies claiming the ITC to recover the entire benefit in a single year as a “grant” rather than capping the ITC that can be claimed at the amount of net taxable income in any single year. The REPI amount is adjusted for the proportion actually paid from available federal funds, which is currently 19 percent of amounts eligible. Many of these tax credits and exemptions are slated to phase out in the next five years and will affect developer costs and ultimately the terms for power purchase agreements.

Table 21: Summary of Tax Credits

Federal Renewable Energy Tax Incentives - 2008 EPAct and 2009 ARRA

Technology	Coal IGCC[1]	Wind	Biomass Open Loop (Ag waste)	Biomass Closed Loop	Geothermal[2]	Small Hydro	Ocean Wave	Solar[3]
Production Tax Credit								
Credit (2008$)/MWh	$ 1.26	$ 21	$ 10	$ 21	$ 21	$ 10	$ 10	
Credit (1993$)/MWh		$ 15	$ 7.50	$ 15	$ 15	$ 7.50	$ 7.50	
Duration (Years)	10	10	10	10	10	10	10	
Expiration	2009	2012	2013	2013	2013	2013	2013	
Eligibility	Merchant	Merchant	Merchant	Merchant	Merchant	Merchant	Merchant	
Investment Tax Credit								
Credit	20%				10%			*30%/10%*
Depreciable Value reduced	10%				5%			*15%/5%*
Expiration	2009				NA			2016
Loss Carryforward Period (Yrs)	20				20			20
Eligibility	Merchant/ IOU				Merchant/ IOU			Merchant/ IOU
ARRA Grant								
ITC in-lieu of PTC	30%	30%	30%	30%	30%	30%	30%	30%
Expiration	2014	2014	2014	2014	2014	2014	2014	2014
Eligibility	Merchant/ IOU	Merchant/ IOU	Merchant/ IOU	Merchant/ IOU	*Merchant*	Merchant/ IOU	Merchant/ IOU	Merchant/ IOU
Production Incentive[4]								
Tier I Payment		$ 4.10		$ 4.10	$ 4.10		$ 4.10	$ 4.10
Tier II Payment			$ 3.90					
Duration (Years)		10	10	10	10		10	10
Expiration		2017	2017	2017	2017		2017	2017
Eligibility		POU/ Coops	POU/ Coops	POU/ Coops	POU/ Coops		POU/ Coops	POU/ Coops

1. IGCC Production Credit is separate from REPTC, but similarly structured. Based on "refined coal" = $4.375/(13900 Btu/ton for anthracite / HR*(1+ParasiticLoad) for IGCC). Expiration date for ARRA ITC ambiguous.
2. Geothermal ITC does not expire. Unclear as to whether the ARRA increased the ITC for geothermal to 30% until 2014, and whether self-sales are eligible
3. Solar ITC reverts to 10 percent in 2016
4. REPI payments scaled based on 2007 shares paid to applications

Source: California Energy Commission, *Comparative Costs of California Central Station Electricity Generation (2009 Edition)* – Final Staff Report, http://www.energy.ca.gov/2009publications/CEC-200-2009-017/CEC-200-2009-017-SF.PDF, page 63.

Energy Subsidies for New Energy Technologies Over Time

According to a recent study by DBL investors, the development of renewable energy has been underfunded relative to other forms of energy, especially fossil fuels.[448] Governments provide energy subsidies "1) to promote a new technology during the early developmental stages and 2) to pay the difference between the value of an activity to the private sector and its value to the

448 Pfund and Healey, *What Would Jefferson Do?*, September 2011, DBL Investors.

public sector."[449] Historically, the federal government has provided land grants for timber and coal in the 19th century, tax benefits for oil and gas in the 20th century, and R&D funding for hydroelectric and nuclear power.[450] Subsidies include not only tax benefits and R&D funding, but also federal procurement, government services (such as deepening port channels for oil tankers), grants, below-market royalty rates, preferential financing (loan guarantees and bonds), and risk reduction measures (such as government insurance and liability caps in case of events such as nuclear meltdowns or oil spills).[451]

Compared to the average annual subsides for oil and gas, nuclear, biofuels, and renewables for the first 15 years of each technology, renewables have received less than 10 percent of the funding received by oil and gas (Figure 29).[452]

The federal government has continued its policy of underwriting oil and gas long after these industries have matured. In 2010 dollars, cumulative federal subsidies received by oil and gas totaled more than $445 billion (1918-2009), compared to less than $6 billion for renewables (1994-2009).[453]

Subsidies for fossil fuels have grown over time. Between 2002 and 2008, federal subsidies for fossil fuels total $72.5 billion (Figure 30); in contrast, traditional renewables received $12.2 billion. Also, unlike renewable energy subsidies, the largest subsidies for traditional fossil fuels are permanently written into the tax code. An example of this is the Foreign Tax Credit ($15.3 billion), one of the largest subsidies, which applies to oil produced overseas.[454] A report jointly produced by conservative and environmental groups projected subsidies for conventional fossil fuels would reach more than $61 billion for 2012 through 2016.[455]

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449 Mona Hymel, Arizona Legal Studies Discussion Paper No. 06-15, "Americans and Their 'Wheels': A Tax Policy for Sustainable Mobility" (February 2006).

450 Pfund and Healey, *What Would Jefferson Do?*, September 2011, DBL Investors.

451 Green Scissors: *Cutting Wasteful and Environmentally Harmful Spending*, 2011.

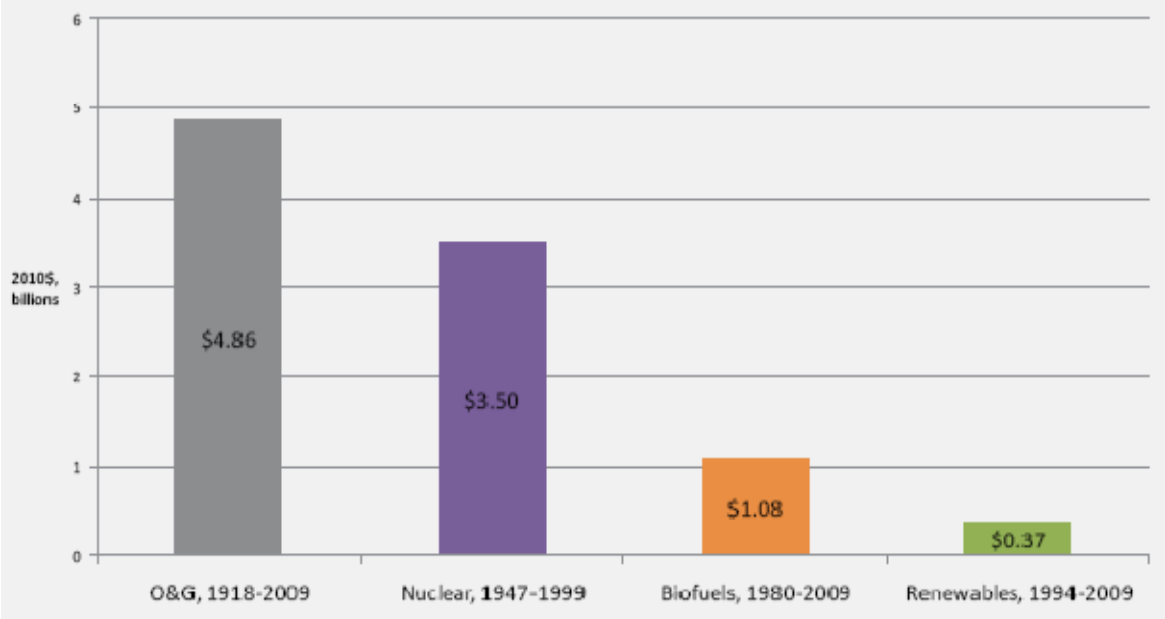
452 Pfund and Healey, *What Would Jefferson Do?, Se*ptember 2011, DBL Investors.

453 Ibid.

454 Environmental Law Institute, "Estimating U.S. Government Subsidies to Energy Sources: 2002-2008," September 2009.

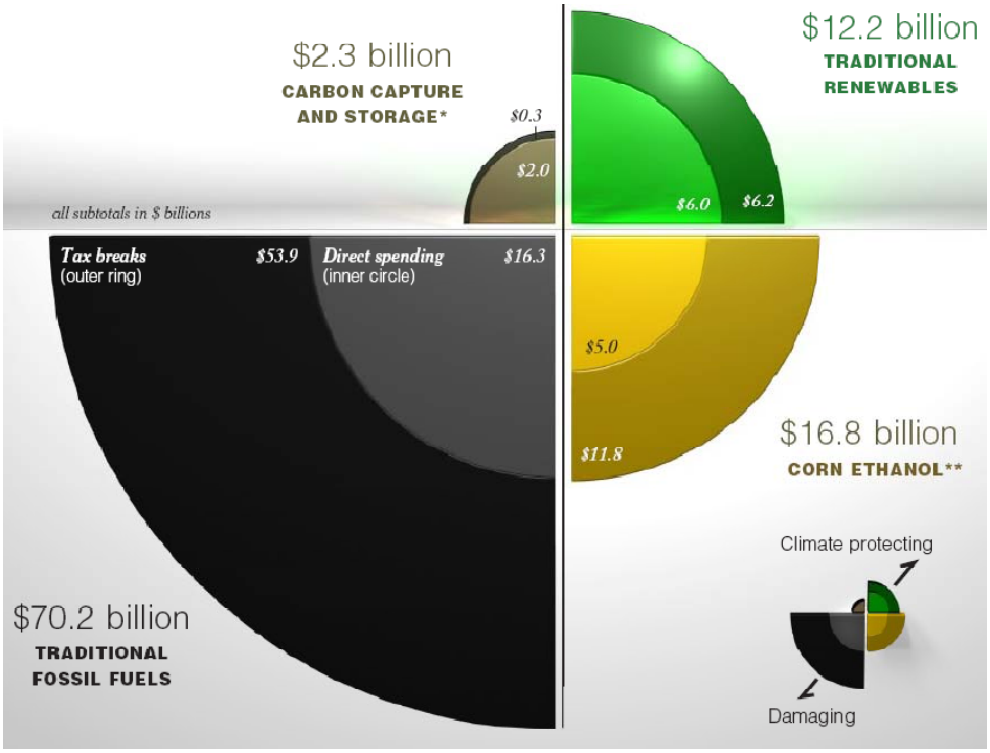
455 Green Scissors: Cutting Wasteful and Environmentally Harmful Spending, 2011.

Figure 29: Historical Average of Annual Energy Subsidies: A Century of Federal Support



Source: DBL Investors, September 2011, *"What Would Jefferson Do?"*

Figure 30: Federal Subsidies, 2002-2008



Source: *Energy Subsidies Black, Not Green*.

Net Energy Metering

As described in the finance section, net energy metering (NEM) compensates qualifying, renewable, distributed self-generation (generally up to 1 MW) for excess electricity produced, as well as exempting the generation from certain charges (such as departing load and standby). Without NEM, renewable self-generation between 1 MW and 5 MW in size is generally uneconomical. NEM is currently limited to 5 percent of peak demand for the IOUs. However, SCE has reported that it is only at 1.1 percent of peak demand; similarly, SDG&E is between 2 and 2.4 percent of its peak demand,[456] while PG&E is only at 2.4 percent of its peak demand and growing at 0.5 percent for the past two years; it will likely be several years before the utilities reach the cap.[457]

Because self-generation reduces overall load on the grid, it has similarities to energy efficiency. Although the demand reduction profiles at the minute-to-minute scale may differ between energy efficiency and self-generation, the annual load reduction may look very similar. NEM is an incentive for renewable self-generation and its associated benefits, such as load reduction – though unlike energy efficiency measures, NEM-qualifying generators may add volatility to the system, and not all costs are passed through.

A common misconception of NEM is that it is a subsidy to those who can afford to purchase rooftop PV panels or other renewable generation, paid for by those who cannot afford to participate in or benefit from such programs. However, in addition to directly purchasing rooftop PV or other qualifying generation, there are several ways for households or businesses to participate in NEM. The more notable include $0 down leasing arrangements between a customer and solar developer, or the California Solar Initiative's Single-Family Affordable Solar Homes (SASH) Program and Multifamily Affordable Solar Housing (MASH) Program ($108.3 million[458] each, or $216.6 million total), which help qualifying low-income families purchase PV outright. Some utilities and developers offer "solar shares" opportunities for customers to purchase part of a larger system and participate through virtual net metering. SCE has stated that the cost of NEM was $52 million from 2001 to mid-2011.[459] As electricity is viewed as a necessity, low-income households further benefit from CARE (which cost more than $3 billion from 1998-2005[460]), which reduces the electricity rate they pay. While such subsidies directly benefit participants of all income levels, society as a whole also benefits from the health and environmental effects of clean energy.

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456 http://www.energy.ca.gov/2011_energypolicy/documents/2011-09-14_workshop/2011-09-14_transcript.pdf.

457 http://www.energy.ca.gov/2011_energypolicy/documents/2011-09-14_workshop/comments/PGandE_Comments_on_the_CEC_Staff_Draft_Report_Renewable_TN-62521.pdf.

458 http://www.gosolarcalifornia.ca.gov/documents/CSI_HANDBOOK.PDF.

459 http://www.energy.ca.gov/2011_energypolicy/documents/2011-09-14_workshop/comments/SCE_Comments_On_Draft_Renewable_Power_in_California-S_TN-62526.pdf.

460 http://www.sandiego.edu/epic/research_reports/documents/060911_PGC_FINAL_000.pdf.

Another concern with NEM is that the rates paid by owners of the renewable generation do not reflect the full cost of interconnecting the generation and supporting it with grid services (such as standby generation), spreading these costs to nonNEM participants. SDG&E has recently sought to raise "the rates of customers who use distributed renewable energy from an average of $11/month to $30 or more/month," though The Utility Reform Network (TURN) opposes this change, stating it would in some cases violate state law and negatively impact the PV installation industry.[461] The California ISO has recently adopted the "cost causation" to its set of guiding principles; if translated into price signals, this may encourage renewable generators to reduce their intermittency via, for example, energy storage.

For those customers that do not chose renewable self-generation as an option, there are still other cost effective ways to reduce load and/or their electricity bill, including energy efficiency, demand response, or time-of-use billing.

Utility tariffs have always set different rates for each rate class. For a number of reasons, residential rates are higher than rates of industrial customers. Before utility profits were decoupled from the amount of electricity sold, their largest (typically industrial) customers benefited from top tiers, which were lower than bottom tiers, the opposite of how tiers are set today. Residential rates have historically been higher than industrial rates (due in part to the higher expense of servicing residential customers). Furthermore, low-income customers receive rate-based subsidies paid for by nonlow-income customers.

Though issues remain to be addressed, NEM is an important step toward more affordable and widely deployable renewable energy, from which all California residents can benefit.

The Value of Renewables in Electricity Portfolios

There is concern that adding renewable energy to California's energy portfolio will drive electricity prices higher. However, even if individual renewable energy projects cost more than conventional generation, diversifying the state's portfolio with renewable energy could ultimately reduce the overall cost of energy to the consumer.[462] The LCOE of renewable energy can be higher, but when adjusted for market risk, it is, in most cases, lower than natural gas. Similar to how diversified investment portfolios can decrease risk and increase returns, incorporating renewable energy into electricity portfolios can provide valuable portfolio benefits without increasing costs.[463]

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461 "SDG&E Seeks Solar Rate Hike," *California Current*, Vol. 9 No. 42. October 21, 2011.

462 Awerbuch, Shimon, "Portfolio Based Capacity Planning: How Renewables Really Impact Overall Generating Cost and Energy Security," Presentation at DC World Bank Energy Week 2005, http://www.awerbuch.com/shimonpages/shimondocs/Awerbuch_Plenary_EW05.pdf.

463 Awerbuch, Shimon, and Raphael Sauter, "Exploiting the oil-GDP effect to support renewable deployment," June 21, 2005, http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B6V2W-4GFNGB6-1-B&_cdi=5713&_user=10&_orig=search&_coverDate=06%2F21%2F2005&_sk=999999999&view=c&wchp=dGLbVlz-zSkzV&_valck=1&md5=8de34c361c9cf3503c71cec8a360a74b&ie=/sdarticle.pdf.

Renewable energy technologies can also act as insurance during periods of economic downturn and fossil-fuel price shocks. Although the per-MWh price of some renewable generating technologies is higher than conventional fossil-fueled generation, this price does not reflect the volatility or unpredictability of future fossil-fuel prices. In 2000, Oak Ridge National Laboratory estimated that this volatility cost the U.S. economy $7 trillion in employment and Gross Domestic Product growth from 1970 to 2000.[464] The security of an energy portfolio solely consisting of fossil fuels is extremely vulnerable to movements in fossil fuel prices, which tend to move together.

The Value of Renewable Energy to Society

Renewable energy provides a number of societal benefits, not all of which can be easily quantified and are therefore often undervalued, such as increased competition among energy generation technologies and mitigation of long-term, strategic risks and costs associated with fossil-fuel price volatility, as noted earlier.

The current pricing of electricity does not include externalized costs to society associated with fossil fuels. For example, air pollution produced by burning fossil fuels plays a well-documented role in asthma attacks. The costs to hospitalize and treat asthma patients are paid by society in the form of higher health insurance premiums, greater use of public emergency rooms, and reduced productivity, but are not included in the price of electricity.

In addition, electricity generation from renewable resources generally produces fewer greenhouse gas emissions and less air pollution than conventional fossil fuel generation. This helps to reduce or avoid the environmental, economic, and health costs associated with conventional power plants. According to the German Federal Ministry for the Environment,[465] the combined costs of climate change and air pollution resulting from natural gas-fired generation are more than 3 times higher than solar PV and 13 times higher than wind energy. The Ministry estimates the societal costs of wind energy at ¼ cent per kWh, solar PV at 1 cent per kWh, and biomass from 2/5 cent to 5 cents per kWh depending on the technology. The cost of natural gas is near 5 cents per kWh, and coal is more than 8 cents per kWh.

An Oregon Forest Resources Institute study suggests that "the environmental benefits of forest biomass use for energy are well in excess of the market value of the electricity produced." [466] Using forest biomass for energy was estimated at more than 11 cents per kWh in 2006, and the value of avoided forest overgrowth at an additional 20 cents per kWh. In other studies, research in the southern San Joaquin Valley sponsored by the California Air Resources Board showed a

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464 Awerbuch, Shimon, "Portfolio Based Capacity Planning: How Renewables Really Impact Overall Generating Cost and Energy Security," Presentation at DC World Bank Energy Week 2005, http://www.awerbuch.com/shimonpages/shimondocs/Awerbuch_Plenary_EW05.pdf.

465 *Renewable Energy Sources in Figures: National and International Development,* Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, June 2010.

466 *Biomass Energy and Biofuel from Oregon's Forests*, Oregon Forest Resources Institute, June 30, 2006.

98 percent reduction in criteria air pollutants from a biomass boiler compared to open field burning.[467]

Other Costs

Environmental and Permitting Costs

Environmental review and permitting costs increase overall technology costs. For details on environmental permitting, efforts such as the Desert Renewable Energy Conservation Plan and permit streamlining, see Chapter 3. Also refer to guidance documents such as the Renewable Energy Action Team's *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects,*[468] the *California Guidelines for Reducing Impacts to Birds and Bats From Wind Development*,[469] the *Energy Aware Facility Siting and Permitting Guide*,[470] the *Energy Aware Planning Guide,*[471] and the *Developing Renewable Generation on State Property* report.[472]

Delays and complexity in the environmental review and permitting of projects can impact actual project (both utility-scale and DG) development. According to Black and Veatch, "many renewable energy project developers report uncertainty about what is needed to obtain permits," which adds risk to the development process. When a delay occurs, which increases costs, developers may be required to resize or refinance a project, and this can lead to project termination, project sale, or a contract failure.[473] For example, many farms and dairies produce waste material that could be converted to electricity, but the high costs and complex local and state permitting requirements present a barrier to electricity generation projects at these sites. Verengo Solar Plus, a residential solar panel installer in Orange County, notes that there are "50 different permitting authorities within 50 miles of [their] office." And a recent article in *The Sacramento Bee* notes that "cumbersome and inconsistent regulations are undermining" the

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467 Emission factors from *Hydrocarbon characterization of Agricultural Waste Burning*, CAL/ARB Project A7-068-30, University of California, Riverside, E.F. Darley, April 1979.

468 Renewable Energy Action Team Report, *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects,* September 2010, http://www.energy.ca.gov/2010publications/REAT-1000-2010-009/REAT-1000-2010-009.PDF.

469 California Energy Commission and California Department of Fish and Game, *California Guidelines for Reducing Impacts to Birds and Bats from Wind Development*, 2007, http://www.energy.ca.gov/2007publications/CEC-700-2007-008/CEC-700-2007-008-CMF.PDF.

470 California Energy Commission, *Energy Aware Facility Siting and Permitting Guide*, December 2010, http://www.energy.ca.gov/2010publications/CEC-600-2010-007/CEC-600-2010-007-D.PDF.

471 California Energy Commission, *Energy Aware Planning Guide*, February 2011, http://www.energy.ca.gov/2009publications/CEC-600-2009-013/CEC-600-2009-013.PDF, Section C.2.2.

472 California Energy Commission, *Developing Renewable Generation on State Property: Installing Renewable Energy on State Buildings and Other State-Owned Property*, staff report, April 2011, http://www.energy.ca.gov/2011publications/CEC-150-2011-001/CEC-150-2011-001.pdf. Please see Chapter 10 for a more detailed description of the findings and recommendations from the report.

473 Black and Veatch, Memo to the Energy Commission: "Renewable Energy Program: Cost Reduction;" B&V File CEC-KEMA; June 16, 2011.

growth of the solar industry, and are "increasing costs to consumers."[474] According to a recent report by the consulting firm AECOM (Architecture, Engineering, Consulting, Operations and Management),[475] statewide permitting reform could add 3,900 jobs and $5.1 billion to California's economy between 2012 and 2020. Demands on local agencies for DG permitting can also affect project development (see Chapter 10).

Environmental mitigation costs such as emission reduction credits (biomass and biogas projects) and habitat impacts can also increase costs of specific projects. For example, mitigation costs for the 370 MW Ivanpah solar tower project located in San Bernardino County were estimated at $34 million, which includes costs for desert tortoise, rare flora, and streambed compensation.[476]

Interconnection Costs

Interconnection procedures can be a lengthy and expensive barrier to developers of both large-scale renewable energy projects and smaller-scale self-generation projects. Initial interconnection costs can include application review fees, interconnection studies, and infrastructure upgrades; ongoing costs include grid services such as departing load and standby charges. While distribution-level rooftop PV and NEM eligible DG (under 1 MW) are exempt from such costs, care must be taken to avoid undue burden on other ratepayers.

The decision to invest in renewable projects and the economic viability of developing such projects also often depend on transmission interconnection costs. Similarly, current DG interconnection procedures can become backlogged in long queues of applications and studies, resulting in costly delays for developers and, in some cases, proposed projects not being built. For details on DG interconnection issues, see Chapter 6.

Construction Costs

As discussed earlier in this chapter, the capital cost of renewable projects can represent a significant portion of levelized cost. The first steps in building a renewable energy facility include buying or leasing land, obtaining permits, and purchasing capital equipment and building materials, or direct capital costs. Indirect capital costs include longer-term and soft costs such as financing, insurance, labor for installation, and taxes during construction. For utility-scale technologies, direct capital costs are the primary drivers of the total capital cost. Overall costs for these technologies are significantly offset by the availability of tax incentives, such as accelerated depreciation, and in the case of single-axis solar PV can be reduced by as

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474 *The Sacramento Bee*, May 1, 2011, "Permit process clouds solar energy projects," http://www.sacbee.com/2011/05/01/3590755/permit-process-clouds-solar-energy.html.

475 AECOM report, *Economic and Fiscal Impact Analysis of Residential Solar Permitting Reform*. July 2011, http://www.sunrunhome.com/uploads/media_items/aecom-executive-summary.original.pdf.

476 California Energy Commission, *Ivanpah Solar Electric Generation System Commission Decision*, September 2010, http://www.energy.ca.gov/2010publications/CEC-800-2010-004/CEC-800-2010-004-CMF.PDF.

much as 55 percent.[477] Table 22 and Table 23 describe major cost drivers for utility-scale, building, and community-scale renewable technologies.

Similar to utility-scale renewables, direct capital costs for DG represent a significant share of the overall capital cost; however, as project size decreases, installation and labor costs have a proportionately larger share of the total capital cost. This is because these costs do not escalate in direct proportion to the size of the project; larger projects benefit from economies of scale.

Table 22: Summary of Cost Drivers – Utility-Scale Technologies

Technology	Cost Drivers
Fluidized Bed	Fuel type, uniformity, & proximity.
Stoker Boiler	Fuel type, uniformity, & proximity.
IGCC	Boiler/gasifier, fuel type, uniformity, proximity.
Binary	Vary significantly by site. Includes: size, exploration, site development, & resource temperatures.
Flash	Vary significantly by site. Includes: size, exploration, site development, & resource temperatures.
Small & developed	Construction, environmental mitigation, and fish & wildlife mitigation.
Incremental	Construction, environmental mitigation, and fish & wildlife mitigation.
Parabolic Trough	Solar field, thermal storage, power block.
PV (Single Axis)	Solar modules, inverters, installation, & steel prices.
Wind – Onshore Class 3/4/5	Turbine cost, permit, grid connect, reliability costs.

Source: California Energy Commission

477 Assumptions to the *Annual Energy Outlook 2010*, EIA.

Table 23: Summary of Cost Drivers – Distributed Generation Technologies

Technology	Significant Cost Drivers
Biogas – Anaerobic Digester	Capital cost, type of food or manure used, amount of cleanup equipment needed, and electric/thermal load at facility
Biogas – Landfill Gas	Capital cost to include turbine modifications to run on low to medium fuel, gas clean-up equipment
Biogas – Wastewater Treatment	Equipment, skilled labor, & maintaining consistent temperatures
Solar PV Residential Fixed Tilt Commercial Fixed Tilt Ground-based Tracking	Solar module raw materials; inverters, installation, and steel prices.
Wind – Community-scale	Turbine cost, permit, grid connect, reliability costs
Geothermal Heat Pump	Equipment, design (type and size of system), land, drilling, and installation
Integrated Solar Space & Water Heating	Installation cost, building retrofits, proximity of buildings, size of building, use of building, and local climate

Source: California Energy Commission

CHAPTER 9:
Research and Development to Support California's Renewable Generation Goals

Investments in energy-related research and development (R&D) are essential in the development of technologies to displace fossil fuels with renewable energy. Developing innovative, cost-effective, and efficient clean energy technologies will strengthen California's economy, protect the environment, and increase energy independence.

Past R&D efforts have been instrumental in developing the renewable industry, but meeting the 2020 Renewables Portfolio Standard (RPS) and longer-term greenhouse gas (GHG) emission reduction targets will require additional R&D investments to develop new technologies, infrastructure improvements, and integration strategies. A recent California Council on Science and Technology report indicates that "significant levels of research, development, invention, and innovation" will be necessary to develop the technologies needed to achieve the state's 2050 GHG emission reduction target. The report discusses the need to develop emission-free electricity production by 2050 while dealing with an expected doubling of electricity demand, which will require a combination of strategies that could include new energy storage technologies and advances in the smart grid.[478]

Private companies have little financial incentive to invest in R&D when there is no certainty of return on their investment. Government has an important role in addressing this financing gap by funding research that provides significant societal and economic value from discovery to technology demonstration and deployment. Other key research challenges include resolving intermittency and integration issues – cost and reliability barriers impeding broader adoption of renewables.

About This Chapter

This chapter outlines past, current, and future R&D efforts to address the major challenges facing renewable development, as described in earlier chapters, including:

- Planning, permitting, and environmental challenges for renewable generation and transmission.
- Integration issues associated with distributed generation (DG) and intermittent utility-scale renewable development in the state.
- Integrating smart technologies, renewable generation, and communication devices on the distribution system into a "smart grid."
- Demand response (DR) and energy storage to provide ancillary services and grid support to integrate renewable resources into the transmission grid.

478 California Council on Science and Technology, *California's Energy Future – The View to 2050*, May 2011, http://www.ccst.us/publications/2011/2011energy.pdf.

- Cost reduction and financing.

The PIER Program funded projects described in this chapter are organized by the challenge they will help address, with completed projects discussed first, followed by those underway or planned. For more details on these projects, see Appendix H.

Overview of PIER Program

In California, the primary government-funded research effort is the Energy Commission's Public Interest Energy Research (PIER) Program, which was established by the California Legislature in 1996. Recognizing the need to continue energy-related public interest R&D after deregulation of the state's electricity industry, the Legislature shifted administration of public interest R&D from the state's investor-owned utilities (IOUs) to state government and established a public goods surcharge on electricity retail sales to fund this effort.

The PIER Program provides about $86.5 million annually for R&D projects that in turn provide tangible benefits to ratepayers in the following areas:

- Increased energy efficiency in buildings, appliances, lighting, and other applications.
- Increased use of renewable energy resources, improved transmission and distribution of electricity generated from renewable energy resources ,and reduced or eliminated consumption of water or other finite resources.
- Reduced GHG emissions from electricity generation and cost-effective approaches to evaluating and resolving environmental effects of energy production.
- Advanced transportation technologies that reduce air pollution and GHG emissions.

Figure 31 shows the PIER Program funding allocations for these activities from 1997 to 2010. Over the 13-year life of the PIER Program, the Energy Commission has leveraged millions of dollars in matching funds from private and public sources for R&D that benefit California's ratepayers. These efforts have resulted in $1.7 million in total research for every $1 million of PIER funds invested. In addition, in 2010, the PIER Program successfully leveraged more than $500 million in federal stimulus funding under the American Recovery and Reinvestment Act (ARRA) of 2009 and $900 million in private investment funds using only $20 million of PIER Program funding. Additional benefits include nearly $1 billion in annual energy cost savings for electric and natural gas ratepayers as a result of PIER-funded energy efficiency projects whose results have been incorporated into California's building and appliance efficiency standards.[479]

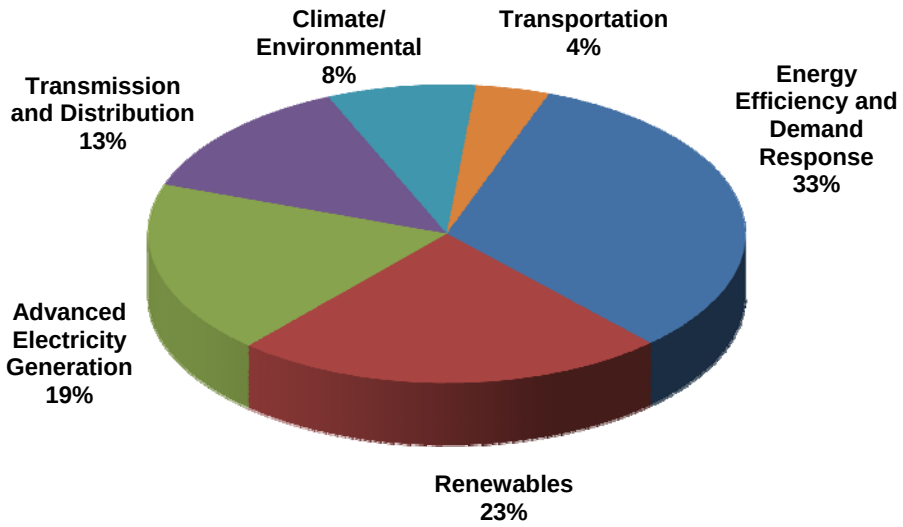
The PIER Program has provided roughly $179 million in R&D funding for a wide variety of activities in support of California's renewable energy goals. These include R&D aimed at mitigating environmental concerns of renewable development, enhancing transmission and distribution grid reliability, promoting renewable integration, and improving renewable technology performance and costs. These investments are not limited to basic research – more

479 California Energy Commission, *Public Interest Energy Research 2010 Annual Report*, March 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-031/CEC-500-2011-031-CMF.PDF.

than half of PIER renewable funding awarded between 2004 and 2010 was for technology demonstrations (Figure 32).

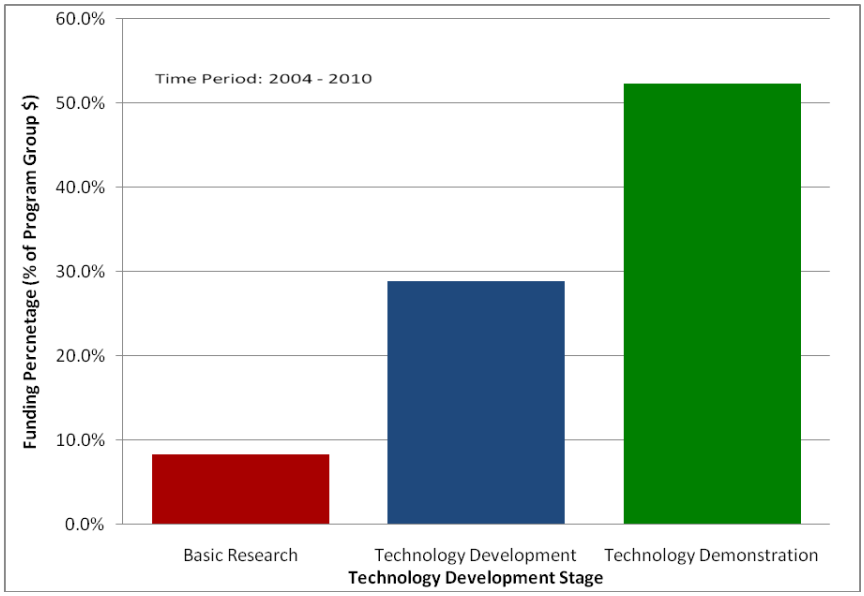
Figure 31: PIER Program Electric and Natural Gas Research Budget Allocations

($ millions)



Source: California Energy Commission

Figure 32: PIER Program Renewable Investments by Technology Development Stage



Source: California Energy Commission

Research to Address Permitting and Environmental Challenges

Given the number and scale of proposed renewable facilities in California, it is essential to understand and identify ways to reduce the potential environmental effects of these facilities to help provide information for the permitting process. The PIER Program has funded dozens of projects to evaluate and resolve the environmental effects of energy production, delivery, and use in California and to explore how new electricity applications and products can solve environmental problems. For example, past PIER-funded research has focused on:

- The environmental impacts of emissions, resource consumption, and energy use associated with the production of electricity by existing and emerging DG technologies.[480]
- Potential environmental impacts of increased use of forest biomass for energy production with suggested areas for future research that regulators can use to develop guidelines for using woody biomass for energy production.[481]
- Reducing the impacts of wind energy development on birds and bats and reducing bird deaths from electrocution and collision with power lines.[482]
- Forecasting hydroelectric reservoir inflow and providing reservoir managers with tools to choose among competing demands like flood control, water supply, environmental protection, and electricity generation.[483]
- The efficiency and effectiveness of environmental flow evaluations conducted during the Federal Energy Regulatory Commission's hydropower relicensing process – one of the most contentious issues during relicensing, yet essential to the successful future relicensing of about 4,000 MW of in-state hydropower capacity.[484]

Going forward, continuing and new PIER-funded research will contribute toward reducing the environmental impacts of renewable development and assist in the permitting of renewable electricity generation facilities, particularly in the California desert. Projects underway include:

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480 National Renewable Energy Laboratory, *Life Cycle Assessment of Existing and Emerging Distributed Generation Technologies in California*, July 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-001/CEC-500-2011-001.pdf.

481 William Stewart et al, *Potential Positive and Negative Environmental Impacts of Increased Woody Biomass Use for California*, July 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-036/CEC-500-2011-036.pdf.

482 See http://www.energy.ca.gov/research/environmental/reports.html for a list of reports on PIER projects addressing this topic.

483 *Hydrologic Research Center, Integrated Forecast and Reservoir Management (INFORM) for Northern California: System Development and Initial Demonstration*. March 2007, http://www.energy.ca.gov/pier/project_reports/CEC-500-2006-109.html.

484 Peter Moyle et al., *Improving Environmental Flow Methodologies Used in California FERC Relicensing*, August 2011, http://www.energy.ca.gov/pier/project_reports/CEC-500-2006-109.html.

- Six ongoing PIER-funded environmental research projects to address the major siting issues (for example, rare plant transplanting and desert tortoise survival) facing utility-scale solar energy development in the desert and causing uncertainty and delays.[485, 486,]
- Research to identify the lowest-risk sites for wind turbines and improve the accuracy and cost-effectiveness of bird and bat surveying and monitoring methods, such as radar, to reduce bird and bat deaths.[487]

Research to Address Transmission Challenges

The existing transmission grid must be able to handle the large amount of new renewable generation needed to meet statewide goals. Examples of optimizing the existing grid include building double-circuit lines rather than single-circuit lines to make best use of existing transmission rights-of-way and increasing power flow through existing lines by removing thermal and dynamic stability physical constraints that limit the allowed capacity of the lines. The PIER Program's Transmission Research Program has funded various projects largely focused on preparing the transmission system for large penetrations of both utility-scale and distributed renewable generation.

Past Research Efforts

Past research efforts were used to develop:

- A prototype Real-Time Dynamic Measurement System (RTDMS) installed at the California ISO for monitoring and testing[488] to allow greater awareness of impending problems, increased grid capacity, and improved grid reliability.
- Power system regulation services [489] sharing between two control areas (California ISO and the Bonneville Power Administration in the Northwest), using two types of energy storage (flywheels in the California ISO for fast regulation and hydro in the Northwest for smooth/slow regulation) to demonstrate fast, cost-effective, and efficient ancillary services for balancing renewable generation in the power grid.

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485 California Energy Commission, *Decision Support Tool for Desert Tortoises Near Solar Installations Fact Sheet*, April 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-FS/CEC-500-2011-FS-007.pdf.

486 California Energy Commission, *Minimizing Conflicts between Desert Tortoises and Energy Development Projects in the Mojave Desert Fact Sheet*, January 2011, http://www.energy.ca.gov/2010publications/CEC-500-2010-FS/CEC-500-2010-FS-015.PDF.

487 California Energy Commission, *Assessing Bat and Bird Movements and Mortality Relative to Wind Turbines Fact Sheet*, March 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-FS/CEC-500-2011-FS-013.pdf.

488 http://www.phasor-rtdms.com/.

489 Pacific Northwest National Laboratory, *Wide-Area Energy Storage and Management System Phase 2*, August 2010, http://uc-ciee.org/images/downloadable_content/electric_grid/Final_WAEMS_Report_CIEE.pdf

- The Western Electricity Coordinating Council (WECC) Wind Generator [490] to model how four types of wind generators behave during sudden changes in the power grid and the impacts of that behavior on reliability throughout the Western grid.
- Forecasting tools [491] for wind and solar generation to allow the California ISO to better manage the California electric grid by predicting system ancillary services for ramping and forecasting power flow congestion issues.
- Projects using synchrophasor measurements for real-time situational awareness, diagnostics, and control of the entire electric grid by transmission system operators.[492]
- Research projects [493] on oscillation detection to reduce instabilities in the Western electric transmission system that can cause large, expensive blackouts, and to allow full use of transmission lines now limited by concerns about instabilities.
- Projects to improve the reliability of systems that protect grid equipment and people from excess power flows, including adapting protection relays for different situations encountered on the grid at various times.[494]
- Successful field demonstration of a prototype fault current controller to inform how to deploy a new grid device that can limit maximum current flows.[495]
- A field test of the 3M High-Temperature Low-Sag (HTLS) Conductor,[496] using new core materials, to allow replacement lines to be operated at much higher temperatures, allowing more power to be transferred over the same towers in the right-of-way.
- New modeling and stochastic analysis techniques used to develop and test a small-scale network model and the science and conceptual framework and advanced mathematical

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490 National Renewable Energy Laboratory, *WECC Wind Generator Development*, March 2010, http://uc-ciee.org/downloads/WGM_Final_Report.pdf.

491 Project fact sheet, http://uc-ciee.org/images/downloadable_content/electric_grid/OT_FactSheet.pdf.

492 Lawrence Berkeley National Laboratory, *Real-Time Grid Reliability Management 2005*, February 2007, http://uc-ciee.org/images/downloadable_content/electric_grid/RTGRM2005_FactSheet.pdf and Real-Time Grid Reliability Management, December 2008, http://www.energy.ca.gov/2008publications/CEC-500-2008-049/CEC-500-2008-049.PDF.

493 Pacific Northwest National Laboratory, *Oscillation Detection and Analysis*, August 2010, http://uc-ciee.org/images/downloadable_content/electric_grid/ODA_Final_Report.pdf.

494 Stuart Consulting, *Multi-Area Real-Time Transmission Line Rating Study*, October 2007, http://uc-ciee.org/images/downloadable_content/electric_grid/IGPS_Final_Report.pdf.

495 http://www.energy.ca.gov/pier/portfolio/Content/ar07/Development%20of%20Fault%20Current.htm.

496 http://www.energy.ca.gov/pier/portfolio/Content/06/ESI/High%20Temperature%20Low%20Sag%20Conductor2.htm.

techniques needed to analyze and predict extreme events (for example, wide-area blackout).[497]

- SCE/Waukesha Electric Systems, Inc., project to develop, fabricate, and install a superconducting transformer on SCE's utility host site to increase the ability to handle fault currents.[498]

Future Research Efforts

The Energy Commission will encourage utilities to work in collaboration with the PIER Program to identify opportunities to deploy new technologies to further optimize the use of the existing transmission system. Future technologies should include:

- New grid operating tools to accommodate solar and wind generations' unique characteristics with increasingly higher levels of penetrations.
- Solar generator dynamic stability models, similar to the Wind Generator Models developed with PIER Program and U.S. Department of Energy (DOE) funding.
- Solar and wind forecasting to improve accuracy and precision.
- Dynamic Thermal Circuit Rating (DTCR) monitors that communicate data on real-time transmission line conditions to allow the system operator to load existing transmission lines more closely to their "full" capacity and reduce the need for new transmission.[499,500]
- Voltage-source converter high-voltage direct current cables to replace conventional high-voltage direct current (HVDC) cables currently used for bulk transmission lines over long distances, to allow lower capacity amounts carried on the line. These cables can also be run underground and used for interconnecting wind and offshore power sources.[501,502]
- Tracking experience with high capacity cables, which can operate continuously at high temperature without loss of tensile strength and with less sag, to increase the current carried on the line.
- Testing of highly efficient fault current controllers to reduce the need for traditional circuit breakers that may not be economical or efficient.

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497 The Extreme Event Research project fact sheet can be found at http://uc-ciee.org/images/downloadable_content/electric_grid/EE_FactSheet.pdf.

498 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf.

499 *Demonstration of Advanced Conductors for Overhead Transmission Lines*, 1017448, EPRI, July 2008, p. 6-1.

500 *Dynamic Circuit Thermal Line Rating*, California Energy Commission Publication P600-00-036, October 1999. http://www.energy.ca.gov/reports/2002-01-10_600-00-036.PDF, ES-2.

501www.abb.com/industries/us/9AAC30300394.aspx.

502 http://www.energy.siemens.com/us/en/power-transmission/hvdc/hvdc-plus/.

- Power flow control devices to provide the grid operator additional ability to control power flows and to complement power flow control of energy storage, leading to even greater efficiency in the use of grid infrastructure.

Research to Address Integration Challenges

Meeting the goal of adding 20,000 MW of new renewables, including 12,000 MW of renewable DG, will place increasing burden on the state's existing transmission and distribution systems. (See Chapters 5 and 6.) This section identifies further PIER-funded research on activities that will support integration at both the transmission and distribution levels. Because of the major roles that the smart grid, energy storage, and DR will play in the future integration of renewables, this section outlines state policies in these areas, describes specific technologies, and highlights PIER Program research in these areas.

Transmission-Level Integration – Smart Grid

Senate Bill 17 (Padilla, Chapter 327, Statutes of 2009) makes development of smart grid technology state policy. SB 17 defines "smart grid" as modernization of the state's electrical transmission and distribution system to maintain safe, reliable, efficient, and secure electrical service, with infrastructure that can meet future growth in demand and cost-effectively achieve all of the following, which together characterize a smart grid:

- Increased use of digital information and control technology. Dynamic optimization of grid operations and resources.
- Deployment and integration of distributed resources and generation, including renewable resources.
- Development and incorporation of demand response, demand-side resources, and energy-efficient resources.
- Deployment of smart technologies that optimize appliance operations and metering devices, grid communications, and distribution automation.
- Integration of smart appliances and consumer devices.
- Deployment and integration of advanced electricity storage and peak-shaving technologies.
- Provision of timely information and control options to consumers.
- Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.
- Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services.

The Electric Power Research Institute provides a simplified definition of the smart grid: "…one that incorporates information and communications technology into every aspect of electricity

generation, delivery and consumption in order to minimize environmental impacts, enhance markets, improve reliability and service, reduce costs, and improve efficiency."[503]

As directed by SB 17, the investor-owned utilities filed smart grid deployment plans with the CPUC in July 2011 that include a smart grid vision statement, deployment baseline, smart grid strategy, grid security and cyber security strategy, smart grid roadmap, cost and benefit estimates, and metrics. The smart grid deployment plans and pathways are unique to each utility and to its customers.[504]

Past Research Efforts

Smart grid development began first in the transmission system. With the goal for adding new renewable DG and the expected large rollouts of electric vehicles over the next few years, further research is needed on smart grid technologies to support the distribution system.

The *2010 IEPR Update* noted, "California is receiving $1.3 billion for smart grid projects, representing a tenfold increase in smart grid funding from PIER's past spending levels of $10 million to $14 million." Over the next three to four years, the PIER Program will work actively with – and learn from – more than 20 smart grid projects. Many of these projects include an energy storage component and are described in more detail later in this chapter and in Appendix H.

Other PIER-funded smart grid related research includes:

- Development of a common California utility Smart Grid 2020 vision and roadmap to support smart grid deployment and to help the Energy Commission develop information for requirements currently defined under SB 17.[505]
- Performance testing protocols and a distributed generation database to promote the adoption of DG and combined heat and power (CHP) units by providing performance data comparisons for power generating systems.[506]
- A storage viability and optimization tool to help customers determine if energy storage and photovoltaics (PV) together are appropriate for their facility.[507]

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503 Electric Power Research Institute, http://www.smartgrid.epri.com/.

504 CPUC Press Release, "Independent Evaluation of PG&E's Smart Meters," http://docs.cpuc.ca.gov/PUBLISHED/NEWS_RELEASE/115561.htm.

505 Electric Power Research Institute, *California Utility Vision and Roadmap for the Smart Grid of 2020,* July 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-034/CEC-500-2011-034.pdf.

506 Final report, http://www.energy.ca.gov/2010publications/CEC-500-2010-017/CEC-500-2010-017.PDF. Database, http://www.dgdata.org.

507 Ernest Orlando Lawrence Berkeley National Laboratory, *Storage Viability and Optimization Web Service* : http://der.lbl.gov/sites/der.lbl.gov/files/LBNL-4014E_approved_0.pdf. The Storage Viability and Optimization Tool can be downloaded from: http://der.lbl.gov/microgrids-lbnl/current-project-storage-viability-website.

- Modeling validation benefits of distributed energy resources to the power grid to identify the best sites for distributed energy resources.[508]

Current Research Efforts

The Energy Commission is working closely with the CPUC on smart grid issues and has developed a research program to assist in their regulatory determinations. In December 2010, the Energy Commission conducted a joint workshop with the CPUC to highlight the PIER Program's three smart grid research, development, and demonstration road mapping projects that will support the state's goals to develop a smart grid and provide a research framework for smart grid deployment plans.[509] Roadmaps are being developed for IOUs, publicly owned utilities, and the commercial industry to reflect the distinctly different markets and opinions for each of these entities.

At the December 2010 workshop, stakeholders identified that the following smart grid issues need to be addressed in the future:

- Collect and share lessons from the more than $1 billion of California Smart Grid efforts ongoing as part of the DOE ARRA funding.
- Ensure that integration issues critical to the success for the future California Smart Grid are raised and solutions are shared.[510]
- Sponsor additional microgrid research efforts like SDG&E's work in exploring microgrid implementation advancing technology.[511]
- Ensure that new smart grid activities are compatible with the national smart grid standards that are being approved by the National Institute of Standards and Technology.[512]

Other ongoing PIER-funded research in support of the smart grid includes:

- A smart grid demonstration project [513] – in conjunction with the Los Angeles Department of Water & Power (LADWP) – to measure and validate energy savings and fossil fuel

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508 New Power Technologies, *Verification of Energynet® Methodology*, December 2010, http://www.energy.ca.gov/2010publications/CEC-500-2010-021/CEC-500-2010-021.PDF.

509 Workshop presentations and a full transcript, http://www.energy.ca.gov/2011_energypolicy/notices/index.html.

510 California Energy Commission, *Transcript of the December 17, 2010 joint IEPR Committee/CPUC Workshop on Smart Grid Research Road Mapping Projects*, comments by Kevin Dasso, Southern California Edison, http://www.energy.ca.gov/2011_energypolicy/documents/2010-12-17_workshop/2010-12-17_Transcript.pdf.

511 California Energy Commission, *Transcript of the December 17, 2010 Joint IEPR Committee/CPUC Workshop on Smart Grid Research Road Mapping Projects*, comments by Lee Kravet, San Diego Gas & Electric, p. 130, http://www.energy.ca.gov/2011_energypolicy/documents/2010-12-17_workshop/2010-12-17_Transcript.pdf.

512 California Energy Commission, *Transcript of the December 17, 2010 Joint IEPR Committee/CPUC Workshop on Smart Grid Research Road Mapping Projects*, comments by Mike Montoya of SCE, p. 63, http://www.energy.ca.gov/2011_energypolicy/documents/2010-12-17_workshop/2010-12-17_Transcript.pdf.

513 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf.

emissions reductions associated with an electric vehicle (EV) program by specifying, acquiring, and installing a sufficiently sized EV demonstration network.

Future Research Efforts

Future smart grid research should encompass two distinct approaches: (1) assessing and developing individual component technologies; and (2) examining the interaction of these component technologies at the system level. Individual smart grid technologies provide increased information and control over various components of the system. To manage different aspects of the grid, the following technologies must work in conjunction with the legacy hardware:

- Telemetry on generators.
- Renewable resource forecasting.
- Hardware and software control of generators, including inverters.
- Voltage regulation.
- Protection hardware, advanced relays, and algorithms.
- Advanced switchgear and algorithms for circuit reconfiguration.
- Automated metering infrastructure (AMI).
- Hardware and software to enable demand response, including home area networks (HAN).
- Interfaces for the above, where applicable, for transmission and distribution operators.

Several items in the previous list are particularly urgent because advancements in these areas are needed to help with integration of renewable resources as mandated by state policy:

- Intermittent resource forecasting to provide grid operators with practical, real-time tools to better anticipate rapid changes and ramp rates due to variable generation to enable more economic use of firming resources.
- Advances in generator modeling and control, including inverters, to provide electric output with desired characteristics (such as reactive power, voltage control, and dynamic response to help stabilize grid frequency).
- Research on how subsystems work together from the standpoint of overall system performance and operating reliability. Some specific research areas that follow the systemic approach include:
    - Develop tools to predict and assess the impacts of large contributions from variable and switch-controlled generators on wide-area stability (for example, inertia), and reliability on increasingly shorter time scales.

- Analyze the optimal management of specific sets of resources such as geographically and technically diverse storage resources, and explore how to manage highly diverse portfolios efficiently and economically.
- Investigate approaches and algorithms for the expected growth in information flow and control, focusing on how resources might be most effectively bundled or coordinated to collectively provide services to the grid.

Transmission-Level Integration – Energy Storage

Energy storage has the ability to radically change the electric power system from one where electricity must be instantaneously generated and used at the same time, to one where instantaneous balancing of supply and demand becomes less of an issue. The many benefits of energy storage include reducing reliability risks, enhancing economic efficiencies, mitigating environmental impacts, and accommodating growing amounts of renewable generation and electric vehicles.

For information on how the potential for energy storage technologies – including pumped hydroelectric, compressed air energy storage, batteries, flywheels, and thermal energy storage – can increase the reliability and dispatchability of California's energy supply, see Chapter 5. There is a strong connection between energy storage and the smart grid because these technologies can help integrate intermittent renewables, provide ancillary services, manage peak demand, and relieve transmission and distribution congestion. Building a portfolio of energy storage options will address these system challenges and balance the development of newer, distributed storage technologies like batteries and flywheels with development of well-established technologies such as pumped storage and compressed air energy storage. For more information on energy storage technologies, see Appendix H.

Current Research Efforts

The following PIER projects illustrate the scale and scope of energy storage R&D efforts in California:

- Strategic analysis of energy storage technologies to identify and define the necessary research on the energy storage technologies and applications for achieving greater penetration of renewable energy resources.
- PG&E sodium sulfur energy storage demonstration to provide critical data on the use of large-scale battery energy storage technologies to meet California's future renewable energy needs.[514]
- SCE 32 MWh lithium-ion battery system and smart inverter at the Monolith Substation near the Tehachapi Wind Resource Area to demonstrate the ability of the battery storage system

514 http://www.next100.com/2010/02/pges-big-battery.php.

to enhance grid operations and integrate intermittent wind power in a remote, transmission-constrained area.[515]

- Primus Power Corporation project to develop, field test, and install and evaluate a 25 MW/75 MWh grid-connected zinc-based flow battery energy storage system.[516]
- Solid-state batteries for grid-scale energy storage project by Seeo Inc. to develop and deploy a 25 kWh prototype battery system based on Seeo's proprietary nanostructured polymer electrolytes.[517]
- Sacramento Municipal Utility District (SMUD) to install a fleet of two Premium Power Corporation's zinc bromine flow battery energy storage systems in two locations to explore its utility in improving microgrid operations and emergency operations (including campus islanding) and augmenting peak period campus operation with nonpeak-generated electricity and to demonstrate fleet control of multiple distributed storage devices.[518]
- Amber Kinetics, Inc., to demonstrate a prototype utility-scale flywheel energy storage system that employs technology advances in composite flywheel rotor materials, magnetic bearing systems, and high-efficiency motor-generators[519] to demonstrate the economical and technical viability of bulk flywheel energy storage and renewable energy integration for the electric grid.
- EnerVault Corporation (EnerVault) and Ktech Corporation to demonstrate and analyze the commercial viability of EnerVault's novel iron-chromium redox flow BESS[520] and compare the results to the baseline to quantify benefits and operating costs.
- PG&E to design, build, and demonstrate the world's first advanced, "second generation" compressed air energy storage (CAES) design system that requires less fuel, uses standardized less expensive turbo-machinery, and captures the waste heat from the compression cycle as well as a "third generation" system that would completely eliminate the use of fuel for a CAES plant.[521]

Future Research Efforts

The Energy Commission held public workshops on November 16, 2010, and April 28, 2011, to address energy storage technologies and the actions necessary to make energy storage more

515 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf.

516 Ibid.

517 Ibid.

518 Ibid.

519 Ibid.

520 Ibid.

521 Ibid.

available in the future.[522] In addition, a December 17, 2010, workshop on smart grid issues also included discussions about energy storage issues.

The November workshop focused on the current state of energy storage technology and the activities ongoing in California and the United States to demonstrate the capability and value of energy storage technologies. This workshop also addressed automated demand response and how it can provide equivalent services to that of energy storage in some areas of ancillary services, and how a combination of both energy storage and automated demand response provides California ratepayers a cost effective solution to some of the renewable integration challenges.

Stakeholder recommendations at the workshops identified areas to address in the future to encourage the increased use of energy storage and automated demand response:

- The Energy Commission's PIER Program needs to continue to support and sponsor field demonstration of new and commercially available energy storage technologies. For distribution-level integration, energy storage projects in the 1 MW to 5 MW range are the highest priority for these demonstrations.[523]
- Research should be completed to better estimate the amount of energy storage and automated demand response necessary to meet the integration challenges of the RPS by 2020.[524]
- Research and workshops on financial models and tariffs need to address how a fee system can be developed to allow energy storage systems to be compensated for all the value they provide the grid such as: reliability improvements, integration of renewables, ancillary services, power quality improvements, and others.[525]
- The results of the many ARRA and PIER-funded energy storage and automated demand response demonstrations need to be made available as soon as possible so these results can be used in developing future demonstrations.[526]

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522 Presentations and written transcripts, http://www.energy.ca.gov/2011_energypolicy/notices/index.html.

523 California Energy Commission, *Transcript of the November 16, 2010 Staff Workshop on Energy Storage and Automated Demand Response Technologies to Support Renewable Energy Integration*, comments of Janice Lin, California Energy Storage Alliance, http://www.energy.ca.gov/2011_energypolicy/documents/2010-11-16_workshop/2010-11-16_Transcript.pdf, page 111.

524 California Energy Commission, *Transcript of the November 16, 2010 Staff Workshop on Energy Storage and Automated Demand Response Technologies to Support Renewable Energy Integration*, comments of Albert Chui, PG&E, http://www.energy.ca.gov/2011_energypolicy/documents/2010-11-16_workshop/2010-11-16_Transcript.pdf, p. 111.

525 California Energy Commission, *Transcript of the December 17, 2010 Joint IEPR Committee/CPUC Workshop on Smart Grid Research Road Mapping Projects*, comments by David M. Tralli of JPL (p. 96) and Chris Villareal of the CPUC (p. 127), http://www.energy.ca.gov/2011_energypolicy/documents/2010-12-17_workshop/2010-12-17_Transcript.pdf.

526 Compilation of various comments received at the November 16, 2010 Staff Workshop on Energy Storage and Automated Demand Response Technologies to Support Renewable Energy Integration; the December 17, 2010, joint

Transmission-Level Integration – Demand Response

Demand response (DR) consists of changes in electric usage by consumers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to lower electricity use at times of high wholesale market prices or when system reliability is jeopardized. For details on DR and grid-level integration, see Chapter 5. While DR has already been an area of considerable research over the last few years, additional R&D efforts will be necessary to ensure that DR can play an important role in integrating renewable resources.

Past Research Efforts

The Energy Commission has more than eight years of history in R&D for new DR technologies and capabilities. The focus of these efforts over time has evolved from manual individual customer or small clusters of DR capabilities for commercial, industrial, and residential customers to the automation of DR and the opportunity to provide thousands of MWs of load reduction energy responses to the grid as peak load reductions and ancillary services. Currently, most of these DR services are implemented through utility programs as opposed to markets solutions as in some other states.[527]

Past PIER-funded research in this area includes:

- Industrial sector research conducted in 2008 by PIER's Demand Response Research Center (DRRC) at Lawrence Berkeley National Laboratory (LBNL) to look at DR opportunities at industrial wastewater facilities.
- Development, evaluation, testing, and demonstration of a standard open architecture protocol called Open Automated Demand Response (OpenADR).[528]
- PG&E's Participating Load Pilot in 2009 with three large commercial and industrial facilities with OpenADR, which successfully demonstrated using demand response as a nonspinning reserve product in the California ISO market.
- Research conducted in 2010 by the PIER Program's DRRC to summarize the response time, duration, and market characteristics of building and process automation with the corresponding requirements of spin, nonspin, and regulation services.[529]

IEPR Committee/CPUC Workshop on Smart Grid Research Road Mapping Projects; and April 28, 2011, IEPR Committee Workshop on Energy Storage for Renewable Integration, http://www.energy.ca.gov/2011_energypolicy/documents/index.html#11162010.

527 http://drrc.lbl.gov/system/files/lbnl-212e.pdf.

528 Piette, Mary Ann, Girish Ghatikar, Sila Kiliccote, Ed Koch, Dan Hennage, Peter Palinsky, and Charles McParland. *Open Automated Demand Response Communications Specification (Version 1.0)*, 2009. LBNL-1779E.

529 Kiliccote, Sila, Pamela Sporborg, Imran Sheikh, Erich Huffaker, and Mary Ann Piette. 2010. *Integrating Renewable Resources in California and the Role of Automated Demand Response*, (LBNL-4189E), http://drrc.lbl.gov/sites/drrc.lbl.gov/files/lbnl-4189e.pdf.

- DRRC work on communication and automation infrastructure needed to deliver consistent and dependable load reductions is the key to employing DR for renewable integration purposes.
- LBNL study demonstrated DR as spinning reserve through the cycling off of SCE customers' air conditioning systems and coordinated through a central energy management system.[530]

Current Research Efforts

- The Integrating Renewable Resources (IRR) Pilot Project collaboration assesses the feasibility of providing load-following and ramping products to the California ISO using thermal and process storage technologies.[531]
- PIER research evaluates how much energy storage and automated demand response is needed to support integrating high levels of renewables on the California grid.[532]
- DRRC demonstrations in 2011 to evaluate the speed of response of several potential DR loads for ancillary services.[533]
- Next phase ADR research to integrate larger quantities of ADR onto the grid using the OpenADR protocol not only in the commercial and industrial markets, but also into the residential market.
- Several projects (for example, Residential Energy Display Survey) to demonstrate the potential value of AMI installations.[534]

Future Research Efforts

PIER-sponsored research has demonstrated that it is technologically feasible to provide spinning reserve using DR, and that relying on DR response may be preferable because it can be targeted geographically and its performance is superior to generation resources. As a result, research has now successfully transitioned from a demonstration project to pre-commercialization activity largely funded by California's IOUs. In addition, the research has provided a technical basis for the development of new market products by the California ISO to

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530 Eto, J., J. Nelson-Hoffman, E. Parker, C. Bernier, P. Young, D. Sheehan, J. Kueck, and B. Kirby. 2009. *Demand Response Spinning Reserve Demonstration – Phase 2 Findings from the Summer of 2008*. (LBNL-2490E), http://certs.lbl.gov/pdf/lbnl-2490e.pdf.

531 Kiliccote, Sila, Pamela Sporborg, Imran Sheikh, Erich Huffaker, and Mary Ann Piette. 2010. *Integrating Renewable Resources in California and the Role of Automated Demand Response*, (LBNL-4189E), http://drrc.lbl.gov/sites/drrc.lbl.gov/files/lbnl-4189e.pdf.

532 *Automated Demand Response as a Grid Balancing Resource for the Integration of Renewables***.** Prepared for the California Energy Commission. In Press. 2011; *Research Evaluation of Wind and Solar Generation, Storage Impact, and Demand Response on the California Grid*, 2010, Prepared for the California Energy Commission. http://www.energy.ca.gov/2010publications/CEC-500-2010-010/CEC-500-2010-010.PDF.

533 Ancillary services field demonstrations are in process and funded by PG&E's Emerging Technology Program.

534 Draft specification for the REDS gateway, http://drrc.lbl.gov/news/residential-energy-display-survey-reds-pilot.

take advantage of the unique characteristics of demand response in providing this critical reliability function. Research also needs to be done to show that DR can provide load following and address the use of new technologies such as electric vehicle charging.

Distribution-Level Integration

Many of the PIER projects discussed earlier in this chapter, particularly related to the smart grid, will help integrate renewable resources at the distribution level. This section outlines additional PIER research initiatives underway that will support the deployment of renewable DG and discusses future research pathways and major initiatives that could have a significant effect in helping California achieve DG goals. Many of these future research pathways will also help achieve the Governor's goal of adding 6,500 MW of combined heat and power systems. For details on the challenges associated with integrating high levels of renewable DG into the state's distribution system, see Chapter 6.

Current Research Efforts

PIER research initiatives that will support the deployment of renewable DG include:

- Renewable Energy Secure Communities projects [535] (see Appendix H) to develop and demonstrate mixed renewable technologies coupled with advancements in energy efficiency, demand response, smart grid integration, energy storage, combined cooling, heating and power, and coproduction of value-added products like biofuels to help build the market connectedness of renewable technologies with grid integration, storage, and efficiency, while reducing costs.
- Several projects to develop and demonstrate advanced energy technology solutions for wastewater treatment facilities.[536]
- Several projects to demonstrate advanced energy technology solutions to turn waste products from California's industrial and agricultural communities into energy.
- Gills Onions, located in Oxnard, to demonstrate an onsite process that converts onion peel waste products in an anaerobic digester to produce biogas for high-efficiency fuel cells.[537]
- Several projects to demonstrate energy storage at commercial and industrial facilities, including a 150 kWh battery energy storage system – connected on the customer side of

535 RESCO project summaries can be found at: http://cal-ires.ucdavis.edu/research/.

536 2010 Pacific Southwest Organic Residuals Symposium presentation, *Steam Hydrogasification Research Overview, September 2010,* http://www.epa.gov/region9/organics/symposium/2010/4-Park-SHR%202.pdf.

537 California Energy Commission, *The Natural Gas Research, Development, and Demonstration Program Proposed Program Plan and Funding Request for Fiscal Year 2009-2010*, April 2009, http://www.energy.ca.gov/2009publications/CEC-500-2009-069/CEC-500-2009-069.PDF. Press release on State Leadership in Clean Energy (SLICE) award, http://www.energy.ca.gov/releases/2010_releases/2010-11-01_slice_awards.html.

the meter – that will store power during off-peak hours and discharge during peak hours.[538]

- Data collection coordination among California IOUs from distribution feeders to analyze and predict the impacts of DG on distribution circuits.
- Several research projects to demonstrate how smart grid technologies can support the integration of renewable resources in California's residential communities.
    - SDG&E research to demonstrate how smart grid technologies such as microgrids can coordinate and manage various integrated distributed resources.[539]
    - SMUD project to demonstrate the integration of DG, renewable technologies, combined heat and power systems, and energy storage and the ability of microgrid to successfully separate from the utility system and provide reliable power.[540]

Future Research Efforts

Additional distribution research through PIER should focus on:

- Modifications that must be made to protection practices to accommodate current levels of DG interconnected to the system.
- Advanced systems to develop new and better islanding protection algorithms, equipment, and practices needed to accommodate high penetrations of DG.[541]
- The time- and location-dependent relations between feeder segment loads and PV output.
- The impact of increased DG through detailed modeling of voltage profiles that will be necessary to manage voltage sags, imbalances, transients, and harmonics in the future.
- Exploration of smart grid technologies such as using smart meters to enable dynamic conservation voltage reduction that adjusts automatically to keep voltages within Rule 2 limits.
- Distribution feeder modeling research to generalize from these models and predict impacts of increasing DG penetrations in specific situations.

In addition to the research areas in the previous list, addressing the state's energy needs will require new systems-based approaches to optimally package, deploy, and integrate next-generation energy technologies into California's communities. Research will focus on funding

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538 California Energy Commission, Staff Decision Memo for Premium Power Corporation, Demonstration on Zinc Flow Energy Storage System, http://www.energy.ca.gov/business_meetings/2010_packets/2010-07-14/2010-07-14_Item_08/.

539 http://cal-ires.ucdavis.edu/files/events/2011-resco-symposium/torre-william_cal-ires-resco-sdge.pdf.

540 2010 Microgrid Symposium presentation, Microgrid and Smart Grid Activities at SMUD, July 2010, http://der.lbl.gov/sites/der.lbl.gov/files/vancouver_rawson.pdf.

541 As described in Chapter 6, *islanding* refers to a situation in which a DG generator continues to provide energy, even though power from the utility is no longer present.

advanced technology development and demonstration and on demonstrating the integration of DG, CHP, energy storage, smart grid, and other advanced technologies in buildings, districts, municipalities, and counties.

Research to Address Cost and Financing Challenges

By reducing technology costs and improving efficiency, R&D can demonstrate to the financial community, utilities, ratepayers, and the environmental community that these technologies are ready for the marketplace. In addition, as mentioned earlier in this chapter, PIER cost-share funding helped to leverage more than $500 million in ARRA funds and more than $900 million in private investment funds to help finance renewable research efforts.

Current Research Efforts – Solar

- GreenVolts, Inc., project in Northern California to demonstrate a new concentrating photovoltaic (CPV) system with low installation and manufacturing costs, technical performance improvements, and minimal ground footprint to speed the deployment and adoption of CPV technology in various applications.
- UC Merced project to demonstrate the efficacy of a dual-axis concentrating photovoltaic (PV) system with integrated panel-level microinverters[542]to provide valuable lessons learned toward the goal of developing cell-level microinverters for use with PV systems.
- Silicon Valley Leadership Group (Silicon Valley, California) project to demonstrate best practices for solar PV plug and play advanced technologies, optimizing energy generation and use profile through overall system design and monitoring, and developing innovative financial models and market mechanisms to ease the financing and permitting processes.
- EDTEK hybrid prototype Solar-Fossil Thermophotovoltaics (SFTPV) cogeneration power system that can produce electric power and thermal energy on a 24-hour basis through conversion of sunlight to electricity with 25 percent overall efficiency and natural gas to electricity at an overall efficiency of 20 percent while producing process-grade hot water at a recovery efficiency of 83 percent.

Current Research Efforts – Biomass

- Valley Fig Growers, Inc.,(Fresno, California) anaerobic digester pretreats wastewater before disposal in the municipal sewer system to demonstrate to other food processors the quantifiable economic and environmental benefits gained by installing and operating a digester.
- University of California, Davis, demonstrates the anaerobic-phased solids (APS) digester technology,[543] in conjunction with a clean burn engine-generator, to illustrate an environmentally sound, cost-effective distributed energy system capable of degrading high solid wastes (food residues, community green wastes, and agricultural by-products) while producing renewable energy, soil amendments, and fiber products.

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542 https://ucmeri.ucmerced.edu/research-focus-areas/solar-concentration/current-research and http://www.energy.ca.gov/2010publications/CEC-500-2010-FS/CEC-500-2010-FS-004.PDF.

543 http://www.energy.ca.gov/pier/portfolio/Content/06/Ren/Development%20and%20 Demo%20Wastes.htm.

- Community Power Corporation's BioMax 50 (Yolo/Solano County) to demonstrate a 50 kW small modular biopower system to convert a wide range of biomass residues such as nutshells, forest thinnings, and wood scraps, into clean and green power and heat.
- Makel Engineering project to demonstrate generation of up to 200 kW of electric power using the homogenous charge compression ignition (HCCI) technology while meeting or exceeding California's emissions standards.

Current Research Efforts – Wind

- Wind Turbine Company development of a 250 kilowatt two-bladed, downwind, horizontal-axis wind turbine with flexible blades as a proof-of-concept vehicle for demonstrating cost savings by reducing the weight and manufacturing cost of key wind turbine components. This project led to a demonstration of a more commercially viable 500 kilowatt version.
- Wind Tower Systems project to design a space frame tower that would expand California's recoverable wind resource in marginal areas by permitting developers to economically reach higher wind speeds available at greater heights above ground level.
- Under a subcontract with SMUD, Clipper Windpower designed/built/tested a commercial scale (1.5 MW) DG drive train and controller and used lessons learned to develop the Liberty 2.5 MW wind turbine that splits torque between four permanent magnet generators.

Current Research Efforts – Geothermal

- Northern California Power Agency project to drill a dual horizontally completed injection well at The Geysers demonstrates a substantially more effective means to inject and distribute an increasing supply of wastewater for additional recovery of injection derived steam.
- Schlumberger Carbon Services project applies new marine magnetotelluric technology to delineate potential geothermal reservoirs extending beneath the Salton Sea, which will help developers effectively explore, develop, drill fewer dry holes, and reduce the cost of electricity generation.
- Lawrence Livermore National Laboratory/DOE development of a silica extraction technology that produces high-purity silica from geothermal waters potentially marketable to various industrial users of silica, including the solar industry, thus providing a second revenue stream to geothermal operators.
- Stanford University project uses three related approaches to examine the best way to determine the measurement of fluid-filled spaces (fluid saturation) in the rock at The Geysers and to develop a more efficient strategy in determining where and how to engineer future large- and small-scale injection programs.

Future Research Efforts

- Survey best practices and policies used to reduce costs in other states and nations to determine the greatest opportunities for cost savings.

- Develop strategies to encourage solar manufacturers to standardize the manufacture of components, and to design ground-up integrated systems to make it easier and faster for installers (plug and play).

- To expand the use of biomass and biogas for electricity generation, [544] the PIER Program has funded more than 40 bioenergy projects and studies and will build on those efforts in the future in the following research areas:

    - Colocation of biopower or biofuel refineries with other biomass to energy projects, manufacturing facilities, or waste diversion, composting, transfer, processing, or disposal facilities.
    - Biomethane gas cleanup cost reductions to meet gas quality standards for injection into the natural gas pipeline.
    - Update and renew an existing web-based database to provide location, volume, quality, and seasonality of biodegradable waste suitable for codigestion at wastewater treatment plants.

544 California Energy Commission, *2011 Bioenergy Action Plan*, http://www.energy.ca.gov/2011publications/CEC-300-2011-001/CEC-300-2011-001-CTF.PDF.

CHAPTER 10: Environmental Justice, Local Government Coordination, Workforce Development, and Public Leadership

In addition to the specific challenges to renewable energy development discussed throughout this report, there are four broad cross-cutting issues associated with achieving California's renewable goals: environmental justice, local government coordination, workforce development, and developing renewables on state properties.

About This Chapter

This chapter identifies a variety of challenges and efforts to address each of the following topics:

- **Environmental justice** is defined in California law as "the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies."[545] Environmental justice organizations have voiced concerns about the environmental impacts on their communities from fossil-fueled electricity generation and have supported the state's higher renewable targets, including those for renewable distributed generation (DG).[546] Rooftop solar photovoltaic (PV) in urban areas has the potential to help environmental justice communities by reducing the environmental impacts of fossil plants and by creating local green jobs.
- **Local government coordination** is critical to pursuing renewable policies and practices. City and county governments have key roles in meeting California's statewide renewable energy goals, have shown strong leadership in developing renewable resources in their jurisdictions, and are working to attract and retain renewable technology companies. In recognition of local governments' contribution to meeting the state's renewable and greenhouse gas emission (GHG) reduction goals, and to enhancing local economic development opportunities, it is therefore crucial for state and local governments to be partners in developing and implementing renewable energy policy goals.
- **Workforce development** is critical to providing the well-trained workforce needed to sustain the growth of California's renewable industry and to meet statewide renewable energy goals. The clean energy economy is creating many jobs in manufacturing, installation, fabrication, and operations, and new opportunities exist in specialized areas like power plant design and operations, facilities management, and consulting and research.

545 Government Code Section 65040.12.

546 California Environmental Justice Alliance press release, April 12, 2011, http://www.environmentalhealth.org/PDFs/PressRelease_SBX1_2_FINAL.pdf.

The state must continue to develop basic and advanced job training, job placement assistance, and hands-on apprenticeship programs.

- **Public sector leadership** refers to state government's efforts to increase the amount of renewable development on state-owned buildings, properties, and rights-of-way. Public sector leadership is an important first step in market transformation, with government creating entry markets and setting an example for other sectors to adopt renewable energy technologies. This also provides a significant opportunity to reduce energy use in state facilities and operations while saving taxpayer dollars and avoiding emissions of air pollutants and greenhouse gases.

Cross-Cutting Issue 1: Environmental Justice

Environmental justice (EJ) communities are commonly identified as those where residents are predominantly minorities or low-income; have been excluded from the environmental policy setting or decision-making process; are subject to a disproportionate impact from one or more environmental hazards; and experience disparate implementation of environmental regulations, requirements, practices, and activities in their communities.

Environmental Justice Challenges

EJ communities are often located near oil refineries, power plants, industrial facilities, and other sources of pollution,[547] and these communities may have minimal awareness of environmental hazards, limited resources for organizing, lack of political influence in land-use decisions, and insufficient financial resources to participate in state and local permitting processes. As a result, these communities can be disproportionately affected by environmental hazards associated with conventional energy production and can feel excluded from environmental policy setting or decision-making processes. EJ advocates also believe that these communities will suffer the worst effects of climate change.[548]

A primary concern in the EJ community relates to the types of power plants that will be built to meet increased electricity demand, to replace aging power plants, and replace plants that may retire as a result of the State Water Resources Control Board's (SWRCB) policy on the use of once-through cooling in power plants,[549] particularly in the southern part of the state (which has some of the worst air quality in the nation). Assembly Bill 1318 (Pérez, Chapter 285, Statutes

547 "In California, communities residing within 2.5 miles of major air polluting plants are 63% African American, Latino/a, and Asian/Pacific Islander." Comments of California Environmental Justice Alliance on the 2011 Integrated Energy Policy Report: Committee Workshop on Renewable Localized Generation, submitted May 23, 2011, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-09_workshop/comments/.

548 *Transcript of the 2011 Integrated Energy Policy Report Committee Workshop on Renewable Localized Generation,* May 9, 2011, comments of Nicole Capretz, p. 62. See also Hoerner, J. Andrew and Nia Robinson, A Climate of Change, July 2008, http://www.greendmv.org/reports/climateofchange.pdf.

549 State Water Resources Control Board, *Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling,* May 4, 2010, http://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2010/rs2010_0020.pdf.

of 2009) requires the California Air Resources Board (ARB), in consultation with the Energy Commission, the California Public Utilities Commission (CPUC), the California Independent System Operator (California ISO), and the SWRCB, to prepare a report for the Governor and Legislature that evaluates the electrical system reliability needs of the South Coast Air Basin given the need to ensure compliance with Assembly Bill 32, once-through cooling mitigation requirements, state and federal air pollution laws and regulations, resource adequacy requirements, and renewable and energy efficiency requirements.

At the February 15, 2011, Joint Agency Workshop on Emission Offset Challenges for Fossil Power Plants that discussed the work plan for the AB 1318 report, EJ advocates and environmental organizations stressed the need for agencies to examine load reductions from energy efficiency, the use of energy storage, and how to meet electricity needs with renewable resources – including distributed resources like solar on public buildings, fuel cells for local reliability, and facilities that use landfill gas or wastewater treatment gas.[550] The Air Resources Board anticipates development of a draft AB 1318 report by the end of 2011 with a final report to the Legislature in spring 2012.

EJ advocates are also concerned about the types of fossil generation that need to be built to help support renewable integration. Dispatchable and flexible natural gas turbines ("peakers") can provide the operational characteristics needed to integrate variable renewables; however, because these plants cannot operate as efficiently as baseload resources, they may have increased emission rates that could impact the communities in which they will be located. For details, see Chapter 5.

Efforts to Address Environmental Justice Challenges

Since 1995, the Energy Commission has integrated EJ considerations in its power plant licensing process and has conducted significant outreach to notify, inform, and involve community members, including non-English speakers, to provide every opportunity for affected communities and groups to participate in environmental decisions. For all power plant siting cases, the Energy Commission conducts an EJ analysis that: 1) identifies areas potentially affected by various emissions or impacts from a proposed project; 2) determines if a significant population of minority or low-income people live in an area potentially affected by the proposed project; and 3) determines whether there is a disproportionately high and adverse effect on a significant population of minority or low-income people caused by the proposed project alone, or in combination with other existing and/or planned projects in the area. According to the 2010 census, California leads the nation with the largest minority population (22.3 million, or 57 percent).[551] Therefore, with the exception of large solar power plants

550 Transcript of and written comments on the 2011 Integrated Energy Policy Report Joint Agency Workshop on Emission Offset Challenges for Fossil Power Plants, February 15, 2011, http://www.energy.ca.gov/2011_energypolicy/documents/index.html#02152011. Oral comments by David Pettit, Angela Johnson Meszaros, Jane Williams, and V. John White; written comments submitted by Drew Bennett, Noah Long, Adrian Martinez, and David Pettit on behalf of Natural Resources Defense Council.

551 http://www.census.gov/prod/cen2010/briefs/c2010br-02.pdf.

proposed in remote areas with little population, new power plants – including those that use renewable resources – may be located in more populated areas that could affect minority communities.[552]

While EJ organizations generally support renewable energy to offset the use of fossil fuel technologies, some renewable technologies cause concern. For example, in February 2011, two biomass plants in the San Joaquin Valley, which is home to many EJ communities, were fined for violations of the federal Clean Air Act and local air district rules, including excess emission of air pollutants like nitrogen oxides – a precursor to ozone – and fine particulates.[553] The San Joaquin Valley exceeds national health standards for both ozone and particulate matter.

Potential waste and water impacts from geothermal facilities are also a concern. In 2005, a Department of Toxic Substances Control investigation of geothermal facilities in the Imperial Valley (which also has 50 percent or more minority residents) resulted in fines totaling $910,000 against plant owners, with violations including the illegal storage, treatment, and disposal of hazardous waste; the failure to label and cover hazardous waste containers; and failure to properly train employees.[554] In 2007, a geothermal plant was fined more than $230,000 for exceeding the levels of lead, arsenic, and copper in wastewater sent to the Salton Sea. Air quality problems have also been found in the steam associated with cooling towers in the Salton Sea region.[555]

Participants in the May 9, 2011, IEPR workshop on Renewable Localized Generation noted the value of renewable DG, such as rooftop PV, in EJ communities. For example, rooftop PV in urban environments can potentially provide value to these communities through reductions in the health and environmental impacts of fossil-fueled power coupled with economic revitalization and creation of local green jobs. However, rooftop solar is not always accessible to these communities because of the high upfront cost. In addition, many residents of EJ communities live in multiunit residential rental properties whose landlords may not see the benefits of solar system construction, especially in situations where the owner pays for the systems and additional wiring and tenants receive the benefits of reduced energy costs.

Several options are available to help offset the costs of installing rooftop PV on affordable and low-income housing. The Energy Commission's New Solar Homes Partnership (NSHP) offers

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552 The Council on Environmental Quality's "Environmental Justice: Guidance Under the National Environmental Policy Act," December 1997, defines minority individuals as members of the following groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.

553 GreenEnvironment News, "Central Valley Biomass Power Plants Fined in Excess of $830,000 for Clean Air Act Violations," February 15, 2011, http://www.greenenvironmentnews.com/Environment/Air/Central+Valley+Biomass+Power+Plants+Fined+In+excess+of+$830,000+For+Clean+Air+Act+Violations.

554 Imperial Visions Action Network, "Geothermal Power in Imperial Valley – Only as Clean as the Corporations and Fluid Sources and Fluid Source Allow," December 2010, http://www.ivanonline.org/index.php?option=com_k2&view=item&id=5:geothermal-power-in-imperial-valley.

555 Ibid.

affordable housing projects higher incentives than standard market-rate housing projects. Of the overall 400 megawatt (MW) goal for the entire NSHP program, 36 MW will be made available for new affordable housing during the 10-year program.[556] Under the California Solar Initiative, the CPUC offers the Single-Family Affordable Solar Homes Program (SASH) and the Multifamily Affordable Solar Housing Program (MASH). The goals of these programs include improving energy use and the quality of affordable housing through solar and energy efficiency technologies and decreasing electricity use and costs without increasing monthly household expenses for residents. Programs provide solar incentives for qualifying affordable housing in the service territories of Pacific Gas and Electric, Southern California Edison, and San Diego Gas & Electric.[557] For details on the SASH and MASH programs, see Appendix E.

The SASH Program provides a one-time payment under the Expected Performance Based Buydown structure to help reduce a homeowner's upfront cost of PV solar installation. Homeowners can receive either a partial or full subsidy, capped at $10,000, depending on program eligibility criteria. The program will operate until December 31, 2015, or until all funds are allocated, whichever comes first. As of the first quarter of 2011, the SASH Program achieved its first MW of installed solar PV, with nearly 75 percent of the 466 installed systems between 1 to 3 kilowatts (kW). Another 195 projects are reserved and awaiting installation or interconnection, and another 331 applications are under review.[558]

The MASH program offers two types of incentives. Track 1 provides upfront capacity-based incentives for solar PV systems that offset common area and tenant loads, and Track 2 offers higher incentives to applicants who provide operating costs savings from solar that are shared with tenants. Currently, Track 1 incentives have been filled and a waiting list has been established, and program administrators are developing a statewide application and review process for Track 2 incentives. As of July 2011, 3.8 MW of solar capacity was interconnected under the MASH program on 67 multifamily affordable housing buildings serving 4,213 tenant units. There are also 271 Track 1 projects currently reserved, with capacity of more than 16.7 MW.[559]

Another effort is the nonprofit Grid Alternatives' Solar Affordable Housing Program, which provides training to install solar electric systems for low-income homeowners.[560] This program began in 2004, and as of August 2011 has installed 1,145 solar electric systems in partnership

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556 Go Solar California website, http://www.gosolarcalifornia.ca.gov/affordable/nshp.php.

557 California Public Utilities Commission, CSI Single-Family Affordable Solar Homes Program, http://www.cpuc.ca.gov/PUC/energy/Solar/sash.htm, and CSI Multifamily Affordable Solar Housing Program, http://www.cpuc.ca.gov/puc/energy/solar/mash.htm.

558 California Public Utilities Commission, Single-Family Affordable Solar Homes (SASH) Program, Q1 2011 Program Status Report, April 2011, http://www.cpuc.ca.gov/NR/rdonlyres/BE2A2B11-A16A-4687-A556-39E337E9F1E4/0/2011Q1SASHREPORT.pdf.

559 California Public Utilities Commission, http://www.cpuc.ca.gov/puc/energy/solar/mash.htm.

560 Grid Alternatives, http://www.gridalternatives.org/impact-numbers.

with low-income families throughout California. These systems represent nearly 3 MW of generating capacity and reduce each family's electric bills by about 75 percent. Grid Alternatives has also trained nearly 7,000 community volunteers and job trainees on the theory and practice of solar electric installation.

Another PV effort aimed at low-income communities is the "Solar for All California" program, implemented by the California Department of Community Services and Development (CSD) using funding from the Low Income Home Energy Assistance Program (LIHEAP).[561] This program's goal is to install 1,000 new PV systems on single- and multifamily low-income homes throughout California by October 2011. As of October 27, 2011, the program has installed 386 single-family systems and approved installation for an additional 461 single-family systems and 9 projects that will benefit 666 multifamily units. The CSD used a competitive bid process and asked energy providers to install optimally sized PV systems on single- or multifamily homes; develop creative partnerships to provide systems with no loans, liens, or out-of-pocket costs for the low-income owners or residents; put energy efficiency first to further reduce the energy consumption of each home before installing PV; and develop green jobs by training low-income workers to become solar installers. At the end of the contract term, CSD and providers will determine which approaches were most effective and look for ways to expand and recreate the program statewide. The following selected providers have 18 months to fulfill their contracts:

- North Coast Energy Services proposes to install about 150 PV systems, averaging 3.5 kW in size, in single-family homes in the counties of Lake, Marin, Mendocino, Napa, Solano, Sonoma, and Yolo.
- Community Resource Project intends to install approximately 200 3 kW to 4 kW systems in single-family homes in Sacramento County.
- Fresno County Economic Opportunities Commission, acting as the lead agency to four other CSD LIHEAP providers, intends to install PV systems on a mixture of single- and multifamily homes, totaling more than 150 units and ranging in size from 1.5 kW to 2.5 kW. Systems will be installed in the counties of Fresno, Merced, Madera, Tulare, Kings, and Kern.
- Central Coast Energy Services will partner with 11 existing CSD providers to install up to 600 PV systems on multifamily units, ranging in size from 1.5 kW to 2 kW, in counties throughout California.

The city of Los Angeles is also looking at ways to increase installation of rooftop solar on multifamily units. A recent preliminary study by the Los Angeles Business Council notes there is tremendous capacity for multifamily housing to contribute to a broad-based solar program in

561 California Department of Community Services and Development, Solar for All California, http://www.csd.ca.gov/AboutUs/Solar%20For%20All%20California.aspx.

the city.[562] The study estimates potential capacity for more than 300 MW of rooftop PV, with the multifamily building sector likely to be the second most cost-effective market for solar development in the city after commercial and industrial. Many of the multifamily housing units with the greatest solar potential – those with large, flat rooftops – are in economically depressed neighborhoods. However, the study notes that to achieve this potential, property owners will need to be adequately incentivized. The study indicates that 24 to 26 cents per kWh should encourage broad participation in the multifamily market by paying building owners a reasonable rate of return. The rate could be in the form of direct payment, such as a feed-in tariff, or a combination of payment and rebates, such as net metering. The study also found that a 300 MW program would produce more than 4,500 direct and indirect jobs in local professional services, construction, and ongoing system maintenance.

Recently, the Los Angeles Department of Water and Power (LADWP) announced that it re-launched its Solar Incentive Program with applications accepted beginning September 1, 2011. As part of the program, LADWP staff investigated more options for making solar affordable to low-income customers with the goal of developing leasing options and other proposals for lower-income households.[563]

While each effort is helpful, during the IEPR proceeding EJ advocates suggested the state should set more specific policy goals for the 12,000 MW DG target to ensure EJ communities receive at least their fair share of local environmental and economic benefits. As discussed in Chapter 2, the Energy Commission staff's analysis of regional targets for the 12,000 MW DG goal recognizes the value of these targets to provide opportunities to advance public benefits such as job creation in low-income communities.

Suggestions from the EJ community included:[564]

- Focus investment on communities with the highest need and greatest opportunity for benefit, both urban and agricultural, with at least 50 percent of the 12,000 MW goal focused on projects located on commercial and residential buildings and parking lots.
- Implement policy mechanisms; for example, revamp the California Solar Initiative to capture more low-income homes and multifamily buildings and adopt a feed-in tariff to make small-scale projects affordable and effective.

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562 Los Angeles Business Council, Making a Market: Multifamily Rooftop Solar and Social Equity in Los Angeles, April 2011, http://www.labusinesscouncil.org/online_documents/2011/LABC-Exec-Summary-Brochure-2011-Final-r-1.pdf.

563 Los Angeles Department of Water and Power, "LADWP to Relaunch Solar Incentive Program with Revised Incentive Levels and Streamlined Customer Service," press release, August 2, 2011, http://www.ladwpnews.com/go/doc/1475/1153343/.

564 Comments of California Environmental Justice Alliance on the 2011 Integrated Energy Policy Report: Committee Workshop on Renewable Localized Generation, submitted May 23, 2011, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-09_workshop/comments/.

- Ensure a fair allocation of regional targets to benefit all parts of the state, not just wealthiest communities.
- Set more specific goals than just regional targets to make certain the state meets social, economic, and EJ goals, and use environmental screening to evaluate proposed allocations based on equity and economic development in underemployed and underserved areas.
- Ensure robust community participation in the design and implementation of any program to achieve the 12,000 MW target, with workshops and hearings in different regions of the state to get diverse feedback and make energy policy accessible and understandable to a broader network of Californians.

The Energy Commission intends to continue to work closely with EJ communities throughout California to ensure that their concerns are addressed in both the power plant licensing process and in implementation of the state's Renewables Portfolio Standard (RPS). Early community involvement in power plant siting cases is vital to ensure that residents' interests are appropriately considered in licensing decisions.

Cross-Cutting Issue 2: Local Government Coordination

Renewable development at the local level will be essential to meeting the state's renewable energy goals. Local governments are actively involved in land-use decisions, environmental review, and permitting for a wide range of renewable projects. More than half of the 9,435 MW of large-scale renewable generation permitted in 2010 fell under the purview of local governments.[565] In addition, local governments will be responsible for permitting localized generation that will contribute toward the state's 12,000 MW DG goal.

California has 482 incorporated cities and 58 counties with about 3,400 special districts that are "separate local government(s) that delivers a limited number of public services to a geographically limited area."[566] Because each jurisdiction has different population sizes, demographics, geography, and renewable resource potential, implementing a one-size-fits-all energy policy for renewable development is impossible and unproductive. For example, more than half of California's counties are considered predominantly rural [567] and face challenges in adapting to solutions and tools potentially designed for urban environments. In addition, 45 percent of California's cities have a population of fewer than 25,000, and 65 percent have populations under 50,000.[568] Jurisdictions with lower populations generally have smaller electricity loads, so their renewable energy generation policies may not be as aggressive as those of larger jurisdictions with higher electricity system demands. Demographic differences such as income and education levels, political leanings, and value placed on renewable energy also play

565 See Chapter 2 for totals of renewable facility permits by county.

566 *What's So Special About Special Districts?; A Citizen's Guide to Special Districts in California*, 4th Edition, October 2010.

567 http://www.rcrcnet.org/rcrc/

568 http://www.cacities.org/index.jsp?zone=locc&previewStory=53

a role, as do geographic differences that affect the type of renewable resource best suited for each jurisdiction. State government will need to work closely with local jurisdictions to understand these differences and the unique challenges local governments face in pursuing renewable energy policies and practices, and provide assistance in overcoming those challenges.

Challenges for Utility-Scale Renewables at the Local Level

Local governments, primarily larger counties through their planning and redevelopment agencies, review and permit solar PV and wind energy projects, as well as thermal projects less than 50 MW in size. These projects face the same permitting and land-use challenges as utility-scale renewable facilities, including the potentially large footprint of the facilities and the location of renewable resources in environmentally sensitive areas. Permits typically require a California Environmental Quality Act (CEQA) analysis, and while cost of the review is the responsibility of the project developer, as lead agency local governments will need to provide the staffing and expertise to oversee these reviews, which are typically done by consultants selected by the local government. For details on permitting, see Chapter 3.

Several large-scale solar thermal projects already permitted at the state level are switching to PV technologies due to the decreasing cost of PV as compared to solar thermal technologies. Senate Bill 226 (Simitian, Chapter 469, Statutes of 2011) allows permitted projects larger than 50 MW that switch from solar thermal electric to PV to undergo an Energy Commission license amendment rather than a new permitting and environmental review process conducted by local government. Without SB 226, the addition of these projects, combined with the increased number of PV project applications and the continuing economic downturn, could have strained local governments' ability to process all the applications.

In addition, while some counties and cities have adopted energy elements as part of their general plans and established specific ordinances for permitting generation facilities, many have not. Local governments may lack the regulatory framework and technical expertise to address the growing number and diversity of renewable energy technologies. Without appropriate general plans or energy elements, local governments face difficulties in properly planning and siting renewable energy projects, which can complicate and delay the review and approval of renewable generation projects under their jurisdiction. Many local government land-use plans do not include utility-scale renewable energy facilities as a general plan land-use designation and/or a principal permit land use of a zone district by the zoning ordinance, thereby requiring discretionary approval by the local government. In such cases, a developer of a utility-scale renewable energy facility would have to apply for an amendment to the city or county general plan. If a city or county zoning ordinance does not allow the building of a utility-scale renewable energy facility, the developer must file an application to rezone the land. The developer may also need to apply for a conditional use permit from the city or county.

Another issue for many local governments is siting of utility-scale projects on land in a Williamson Act contract, which provides for long-term agricultural use.[569] If a proposed project site is under a Williamson Act contract, the contract may need to be canceled if it does not stipulate utility-scale generation facilities under its list of uses. The local government's process time for cancelling the contract can be lengthy. The California Department of Conservation updated its guidance on solar projects and the Williamson Act in March 2011.[570]

Local governments may also face challenges with regulating large wind energy projects. As part of developing a guidebook on community planning strategies for successful implementation of wind energy, the American Planning Association, in partnership with the National Renewable Energy Laboratory, Clarion Associates, and the American Wind Energy Association, conducted a national survey to identify challenges local planners face in planning for, regulating, and implementing wind energy facilities.[571] Issues most commonly identified include the need for accurate and unbiased information about wind energy, better public education, and a proper balance between the benefits and potential impacts of wind energy. Survey respondents also identified challenges associated with local ordinances that prohibit, limit, or inadequately address wind energy, as well as difficulties planning for and regulating wind energy as technologies continue to evolve.

Efforts to Promote Utility-Scale Renewable Development at the Local Level

A number of local governments include, or are working toward including, energy elements in their general plans to promote development of alternative energy sources:

- Kern County has a long history of permitting large-scale wind energy projects, with more than 800 MW currently on-line and more than 3,600 MW of new wind capacity in the permitting process. Kern County has also approved applications for nearly 900 MW of large-scale solar development with another 500 MW in process.[572] To facilitate the growth in permit requests, the county has included renewable energy facilities as part of the Kern County General Plan Energy Element as well as the Kern County Zoning Ordinance.[573] By predesignating areas and defining development standards for renewable energy facilities throughout the county, developers have experienced fewer permitting roadblocks from the Kern County Planning Department. In addition, the county has surveyed and designated

569 California Land Conservation Act of 1965 – commonly referred to as the Williamson Act – enables local governments to enter into contracts with private landowners for restricting specific parcels of land to agricultural or related open space use.

570 Solar Power and the Williamson Act, CA Department of Conservation, http://www.conservation.ca.gov/dlrp/lca/Documents/DOCSolarWhitePaper%203%2011%2011.pdf

571 American Planning Association, Wind Energy Planning: Results of the American Planning Association Survey, July 2010, www.planning.org/research/wind/surveyreport.htm.

572 Kern County Planning Department data, http://www.co.kern.ca.us/planning/renewable_energy.asp.

573 Kern County Energy Element of the General Plan: electricity generating sources begin on p. 201. http://www.co.kern.ca.us/planning/pdfs/kcgp/KCGPChp5Energy.pdf. Kern County Zoning Ordinance: Chapter 19.64 establishes a Wind Energy Combining District http://www.co.kern.ca.us/planning/pdfs/KCZOMar09.pdf

areas appropriate for wind and solar development, completed programmatic level environmental impact reports (EIRs) in specific areas, and approved cancellations for Williamson Act contracts to develop renewable energy on unproductive farmland.[574]

- Imperial County has more than 500 MW of installed geothermal generating capacity, and in 2004 adopted a general plan geothermal element to guide development of geothermal energy projects.[575] The county has designated four geothermal overlay zones totaling more than 140,000 acres, and has adopted several Master EIRs that reduce documentation needed for subsequent projects when projects are proposed within those areas.
- Inyo County has more than 300 MW of geothermal capacity and has prepared an overlay district for solar and wind resources, including an in-depth assessment of the best suitable locations for renewable energy development.[576]
- Los Angeles County's Department of Regional Planning is meeting with community stakeholders to develop a needs assessment surrounding renewable energy facility siting and development.
- San Diego County developed a strategic energy plan for 2009 to 2012 that includes policies and directives to facilitate planning for and permitting of renewable energy systems. In addition, the San Diego Association of Governments (SANDAG) adopted its regional energy strategy in 2003, which was incorporated into the SANDAG regional comprehensive plan in 2004. This plan identifies energy policies and objectives such as promoting local production of environmentally sensitive energy, creating opportunities to coordinate energy supply strategies between governments in the greater border region, and locating energy facilities like power plants and transmission lines so that they do not disproportionately affect lower-income and minority communities.[577]
- San Luis Obispo and Fresno counties have adopted general plan policies and updated their zoning ordinances to include sections addressing permitting and approval of energy facilities, including renewable energy sources. San Luis Obispo County is also preparing a climate action plan that relies on small-scale or distributed renewable energy sources as well as larger facilities to meet its GHG emission and renewable energy goals.
- Tulare County, as part of its current 2025 general plan update, is adopting goals and policies to plan and permit renewable energy development and to integrate renewable energy permit processing into its on-line geographic information system.[578]

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574 See http://www.co.kern.ca.us/planning/renewable_energy.asp.

575 Imperial County Planning and Development Services, http://www.icpds.com/?pid=833.

576 http://inyoplanning.org/RE-NOA-GPA2010-03.pdf.pdf.

577 California Energy Commission, *Energy Aware Facility Siting and Permitting Guide*, 2010, http://www.energy.ca.gov/2010publications/CEC-600-2010-007/CEC-600-2010-007-D.PDF, p. 101.

578 See section 8.4 of the Draft 2025 General Plan http://generalplan.co.tulare.ca.us/documents/GeneralPlan2010/GeneralPlan2030Update.pdf. Also, see the

- The city of Fremont recently adopted a general plan 2030 update that has a sustainability element that includes climate protection goals and policies. Notably, the city adopted a 25 percent GHG reduction goal for 2020 over its 2005 baseline emissions.[579]

Other local governments demonstrating leadership and innovation in promoting renewable energy development include:

- In Marin County, Marin Clean Energy is California's first community choice aggregation program, which allows the county to procure electricity on behalf of electric customers in its jurisdiction. Phase I service was launched in May 2010 to more than 7,000 customers, with Phase II to expand to the more than 70,000 remaining customers by the end of 2012. The program delivers 25 percent renewable energy from wind, hydro, geothermal, and other sources, and offers a 100 percent renewable energy product. The program also offers a net metering program in which customers are paid for generating their own energy from rooftop solar and other sources.[580]
- In Santa Rosa, the city's Laguna Treatment Plant, in collaboration with Sonoma State University, is using aquatic vegetation to treat wastewater and produce energy from the harvested vegetation and local organic waste. The Fuel from Aquatic Biomass Project will include two anaerobic digesters to transform harvested biomass into methane-rich biogas, which will be used for on-site power at the plant. This technology could provide other municipalities with a renewable energy source.[581]
- The city of Santa Monica has set a target of 25 percent citywide electricity use coming from renewable sources and 1 percent coming from clean DG by 2010. In addition, the city has a contract with Commerce Energy to purchase renewable energy to meet 100 percent of the city government's electric needs.[582] The city is also very active in development of solar PV, with more than 2.5 MW of solar PV installed at 310 sites throughout the community on both public and private buildings.[583]

In addition to efforts at the local level, the state has provided detailed guidelines to assist local planners in planning and permitting of renewable facilities. In 2007, the Energy Commission and the California Department of Fish and Game published voluntary guidelines to help local permitting agencies avoid, minimize, and mitigate potential impacts to bird and bat

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County's comments regarding on-line permitting interoperability plans http://www.energy.ca.gov/rp3/documents/comments/Tulare_County.pdf.

579http://www.fremont.gov/index.aspx?NID=399.

580 http://www.ca-ilg.org/node/2726.

581 http://ci.santa-rosa.ca.us/departments/utilities/Projects/Pages/FuelFromAquaticBiomass.aspx.

582 City of Santa Monica, Office of Sustainability and the Environment, http://www.smgov.net/Departments/OSE/Categories/Sustainability/Sustainable_City_Progress_Report/Resource_Conservation/Renewable_Energy.aspx.

583 Solar Santa Monica, http://www.solarsantamonica.com/see-our-progress.html.

populations.[584] In 2010, the Energy Commission updated its *Energy Aware Facility Siting and Permitting Guide* to assist local governments with developing general plan energy and transmission elements and provide guidance on electricity generation and transmission planning and permitting.[585] The guide provides information on planning and regulatory structures, laws, and policies to promote renewable resources and transmission, and permitting steps and timelines for generation and transmission facilities. The guide also provides suggestions for permit process streamlining, including one-stop permit centers, pre-application packages and conferences, simplified permit language, a single point of contact for all local permits, cross training of staff, and the use of program-level EIRs. Also in 2010, the Renewable Energy Action Team issued the *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects*,[586] which recommends local and tribal government best practices for desert renewable energy facility permitting.

Challenges for Renewable Distributed Generation at the Local Level

Challenges associated with planning and permitting renewable DG at the local level include the lack of zoning ordinances, varying codes, standards, and fees, and Williamson Act issues; unclear, duplicative, and uncoordinated permitting practices; and unknown environmental review and mitigation requirements. For details on DG challenges, see Chapter 3.

Efforts to Facilitate Renewable Distributed Generation at the Local Level

Identifying suitable areas for renewable energy generation is a key aspect of energy planning. At the July 25-26, 2011, *Governor's Conference on Local Renewable Energy Resources*, a panel on land use and siting presented a discussion paper that identified priorities that should be used to locate local renewable energy to minimize environmental impacts.[587] These priorities correctly stress the importance of identifying the best locations for local renewable energy projects. A key priority would be to place systems on the rooftops of existing buildings and in parking lots to use the existing built environment and reduce the impact to communities. Another priority would be siting systems on land that has no value as habitat, open space, or farmland – in other words, brownfields sites and/or disturbed lands. Finally, localized renewable generation should be located near load centers to improve system efficiency. These priorities can potentially provide critical guidance to long-term energy planning and could be an important strategy to be incorporated into every energy element.

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584 California Energy Commission and California Department of Fish and Game, *California Guidelines for Reducing Impacts to Birds and Bats from Wind Development*, 2007, http://www.energy.ca.gov/2007publications/CEC-700-2007-008/CEC-700-2007-008-CMF.PDF.

585 California Energy Commission, *Energy Aware Facility Siting and Permitting Guide*, 2010, http://www.energy.ca.gov/2010publications/CEC-600-2010-007/CEC-600-2010-007-D.PDF.

586 Renewable Energy Action Team, *Best Management Practices and Guidance Manual: Desert Renewable Energy Projects*, December 2010, http://www.drecp.org/documents/index.html.

587 The Governor's Conference on Local Renewable Energy Resources: California's Path to Local Renewables, Land Use and Siting Panel Discussion Paper, http://gov.ca.gov/docs/ec/Land_Use_and_Zoning.pdf.

The U.S. Environmental Protection Agency (U.S. EPA) has highlighted the importance of location and recognized and is encouraging use of disturbed lands, such as closed landfills, for siting clean and renewable energy facilities.[588] The U.S. EPA's Re-Power America's Land initiative identifies the renewable energy potential of disturbed land sites and provides useful resources for those interested in reusing these sites for renewable energy development.[589] For example, the U.S. EPA developed and provided California brownfields site maps to the public.[590]

The Energy Commission is also exploring the feasibility of siting PV facilities on landfills. The Energy Commission awarded Project Navigator, LTD, of Brea, California, a $120,000 grant to study the effects of PV energy systems on landfill caps and to develop a guidance manual for landfill-based PV. This information will help develop more landfill-located PV solar projects in California. According to Project Navigator, the state has thousands of acres of closed landfills with potential for solar energy technologies.[591]

Retired agricultural land also has potential for renewable energy generation, although there are challenges associated with Williamson Act contracts. Senate Bill 618 (Wolk, Chapter 596, Statutes of 2011) allows landowners with Williamson Act designation to enter into an agreement with the city or county to allow for a solar easement on their property.[592] Removal of this barrier allows local jurisdictions to identify Williamson Act land in the jurisdiction's energy element to allow project developers to work with landowners willing to participate in this type of agreement.

Thousands of special districts in California could potentially have unused or disturbed lands for ground-mounted installations or rooftop surfaces for PV installations. In addition, wastewater and solid waste districts have potential for waste-to-fuel projects. Special districts are already engaged in energy generation, including the Desert Healthcare District in Palm Springs, which equipped 22 canopies over its new parking lot with 1,700 solar panels expected to generate more than 550 MWh of electricity annually.[593] Another example is the Los Angeles County Sanitary District, which has almost 130 MW of generating capacity at its wastewater and solid waste facilities.

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588 Sampson, G., U.C. Santa Barbara, *Solar Power Installations on Closed Landfills: Technical and Regulatory Considerations.* September 2009, http://clu-in.org/download/studentpapers/Solar-Power-Installations-on-Closed-Landfills-Sampson.pdf, p. 1.

589 http://www.epa.gov/renewableenergyland/index.htm.

590 http://www.epa.gov/renewableenergyland/maps_data_ca.htm.

591 http://www.pvnavigator.com.

592 Proposed Senate Bill 618 (Wolk, 2011).

593 California Special Districts Association, Desert Healthcare District Goes Green with Energy Generating Parking Facility, http://www.csda.net/index.php?option=com_content&view=article&id=1290%3Adesert-healthcare-district-goes-green-with-energy-generating-parking-facility&catid=31%3Ain-the-news&Itemid=1.

Identifying areas suitable for renewable development can also help with interconnection. Local governments do not have authority in the lengthy interconnection process, but can facilitate the process by identifying potential project sites near transmission and/or distribution infrastructure, which can reduce the interconnection costs for a project developer. While local governments may not own sites such as roadways, rooftops, and brownfields, they can make the process for siting renewable generation on the land easier through zoning ordinances and permitting. Local governments can coordinate with utilities that demonstrate their commitment to this effort by posting online the capacity of their distribution systems at various locations, as discussed in Chapter 6.[594] Distribution system maps are valuable to project developers to identify potential locations for their projects, especially if they can overlay it with land-use maps.

To address permitting challenges for renewable DG, a number of initiatives are underway to streamline and standardize permitting processes at the national, state, and local levels. The U.S. Department of Energy (DOE) has been particularly engaged in this area, working with local jurisdictions to accelerate the adoption and deployment of solar technologies. In 2007, DOE selected 25 cities nationwide, six of which are in California, as "Solar America Cities" as part of the agency's Solar America Communities program.[595] The following describes this unique federal-local partnership initiative that aims to identify barriers to greater adoption of solar technologies and develop solutions to those barriers.

- San Diego is partnering with the California Center for Sustainable Energy and Envision Solar to develop a "Sustainable Energy 2050 Plan," which will create an energy infrastructure capable of supporting the region on a sustainable path. The plan will address issues such as tariffs, data management, expedited permitting, strengthened private-sector involvement, training and technical expertise, and long-term implementation.[596]
- San Jose has set goals to reach 100 percent renewable energy by 2023 and reduce GHG emissions to 80 percent below 1990 levels by 2045.[597] Part of this effort is the SunShares Program, a solar group-buy model that companies and local governments can use to reduce the costs of installing solar on homes and businesses. Within a year of beginning educational workshops, San Jose city employees achieved the lowest dollar-per-watt cost in California to date and installed nearly 120 kW of new solar power throughout the Bay Area.[598]
- Sacramento's Solar America Cities effort is "Sacramento Solar Access," which "seeks to increase the adoption of solar energy by addressing current market barriers and preparing

594 http://www.sdge.com/builderservices/dgmap/.

595 http://solaramericacommunities.energy.gov/.

596 http://solaramericacommunities.energy.gov/solaramericacities/san_diego/.

597 http://solaramericacommunities.energy.gov/solaramericacities/san_jose/.

598 http://energy.sanjoseca.gov/solar/PDFs/SunSharesGuide.pdf.

infrastructure to optimize solar production in the future."[599] Part of the initiative is to develop design guidelines, best practices, and educational materials on solar integration and how solar can coexist with urban tree canopies.

- San Francisco will pursue a three-point approach to remove market barriers to solar deployment that includes developing a program to group commercial and residential customers into one or more large, combined purchasing pools to be marketed to two types of prospective solar installers; identifying sites for large installations and market to those building owners; and developing a plan to address problems installing solar on multitenant buildings.[600]
- Santa Rosa, in partnership with eight neighboring cities, Sonoma County, and interested stakeholders, developed a countywide Solar Implementation Plan in April 2010 to support the goals of Solar Sonoma County. These include adding 25 MW of new solar generation by March 2011, which will reduce the county's carbon emissions by 8,500 tons annually; replacing 250 MW of peak demand with a combination of solar generation and energy efficiency; and supporting countywide and state GHG reduction targets. Among other things, the plan provides strategies to reduce barriers to installation of solar thermal electric systems.[601]
- Berkeley has created the SmartSolar Program to promote cost-effective investment in solar hot water and solar electric technologies in the residential and small-to-medium commercial/public building sectors. Under its Solar America Cities Special Project, the city will expand its community-based solar advising program to serve the cities of Berkeley, Oakland, Emeryville, Albany, El Cerrito, and Richmond and promote the annual installation of 800 kW of PV at residential and commercial sites.[602]

In addition, DOE has funded the Solar America Board for Codes and Standards (Solar ABCs) that dedicates experts to transform solar markets. As part of the overall strategy to reduce barriers to the adoption of solar technologies and to stimulate market growth, they work to improve building codes, utility interconnection procedures, and product standards, reliability, and safety.[603] Solar ABCs has recommended a national standard permit process for small scale (< 15 kW) PV systems that would expedite and simplify the permitting process.[604]

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599 http://solaramericacommunities.energy.gov/solaramericacities/sacramento/.

600 http://solaramericacommunities.energy.gov/solaramericacities/san_francisco/.

601 http://solaramericacommunities.energy.gov/solaramericacities/santa_rosa/.

602 http://solaramericacommunities.energy.gov/solaramericacities/berkeley/.

603 www.solarabcs.org.

604 *Solar America Board of Codes and Standards, Expedited Permit Process for PV Systems: A Standardized Process for the Review of Small-scale PV Systems*, October 2009, http://www.solarabcs.org/about/publications/reports/expedited-permit/pdfs/Expermitprocess.pdf .

In June 2011, DOE launched the $12.5 million "Rooftop Solar Challenge" that aims to reduce the administrative costs for photovoltaic systems.[605] This is a national competition for local and regional teams of government, utilities, installers, and others to "compete for funds to implement their plan to reduce administrative barriers to residential and small commercial solar PV installations by streamlining, standardizing, and digitizing administrative processes."[606]

State efforts to make DG permitting easier include the Energy Commission's *Energy Aware Planning Guide,* which provides information for local governments to use in encouraging DG in their jurisdictions and suggests a wide variety of implementation strategies to promote DG projects.[607] Some of these strategies include providing a single point of contact at the permit/planning department for all DG permits; developing review timelines consistent with other types of city/county reviews; revising zoning ordinances to promote DG use; providing design standards for typical DG technologies to building permit seekers; expediting and standardizing approval procedures for DG permits of certain sizes; coordinating with home builders and developers for construction of zero energy homes; working with utilities to identify the best locations for grid interconnection to reduce the need for transmission and distribution upgrades; working with neighboring jurisdictions to standardize zoning and permitting requirements; and developing expedited review for PV systems.

Another state effort is Assembly Bill X1 13 (V. Manuel Pérez, Bradford, and Skinner, Chapter 10, Statutes of 2011), which requires the Energy Commission to provide $7 million in grants to qualified counties in California to assist in developing or revising general plan elements, zoning ordinances, and natural community conservation plans to promote development of renewable resources.

Examples of local government efforts to promote renewable DG include:

- The city of Lancaster in Los Angeles County is home to a 5-MW solar thermal power plant built in 2009 by eSolar, which is backed by several venture firms including IdeaLab, Oak Investments, and Google. The project began transmitting power to Southern California Edison in August 2009 and took only 14 months to complete, with the developer crediting the tremendous cooperation it received from the city as instrumental in making that possible.[608] In addition, in 2009 the city partnered with KB Home and China-based battery-manufacturer BYD to build a prototype Earth-friendly home that uses solar, battery, and LED lighting systems along with green building practices to produce more electricity than it

605 http://www.eere.energy.gov/solarchallenge/.

606 http://www1.eere.energy.gov/solar/pdfs/rooftop_solar_challenge.pdf.

607 California Energy Commission, *Energy Aware Planning Guide*, February 2011, http://www.energy.ca.gov/2009publications/CEC-600-2009-013/CEC-600-2009-013.PDF, Section C.2.2.

608 City of Lancaster, Outlook Newsletter and Activity Guide, September 2009, http://www.cityoflancasterca.org/.

consumes annually.[609] The city is also partnering with SolarCity to install 2.5 MW of new solar capacity at six city facilities that, when complete, will be one of the largest city-initiated solar projects in California, providing the city with more than $7 million in energy cost savings over the next 15 years.[610]

- San Diego County's regional planning body, SANDAG, is taking an increasing role in assisting cities within the county to plan for integrating renewable DG.[611]
- The Marin Clean Energy community choice aggregation program offers a net metering program in which customers are paid for generating their own energy from rooftop solar and other sources.[612]
- Many cities and counties have implemented property assessed clean energy (PACE) programs to allow property owners to finance renewable energy projects on their homes or businesses and pay project costs back as a line item on their property tax bill over 20 years. This innovative financing mechanism was first piloted by the city of Berkeley in 2008-2009. As mentioned in Chapter 7, PACE residential programs are suspended pending further direction from the Federal Housing Finance Agency regarding the eligibility of homes with federal mortgage loans, but there are active commercial PACE programs in a number of California cities. Under Energy Upgrade California, the city of Los Angeles Large Commercial Buildings Municipal Financing Program is a commercial-only owner-arranged PACE financing program in collaboration with the Los Angeles Department of Water and Power. This program will also partner with the Clinton Climate Initiative to encourage the adoption of this type of PACE model starting with Placer County and the City and County of San Francisco.
- Several local entities receive funding from the Public Interest Energy Research (PIER) Program's Renewable Energy Secure Communities (RESCO) Program, including Sonoma County Water Agency, Alameda County, Redwood Coast Energy Authority, and El Dorado Irrigation District. These and other RESCO projects are described in more detail in Appendix H.

Cross-Cutting Issue 3: Workforce Development

Development of both utility- and distribution-scale renewable facilities to meet California's renewable energy targets will create thousands of jobs in California. Many of the jobs created by the clean energy boom will require specialized training, but others can take advantage of skills transferrable from other sectors. For example, steel mills and appliance manufacturers can shift

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609 http://www.renewableenergyworld.com/rea/news/article/2011/06/lancaster-ca-determined-to-become-alternative-energy-capital-of-the-world.

610 http://www.solarcity.com/pressreleases/61/City-of-Lancaster-and-SolarCity-Announce-One-of-the-Largest-City-Initiated-Solar-Projects-in-California.aspx.

611 http://www.sandag.org/index.asp?projectid=332&fuseaction=projects.detail.

612 http://www.ca-ilg.org/node/2726.

to building wind turbine components, as is being done in Pennsylvania and Iowa.[613] In California, where the construction industry has been hit particularly hard by the recession, building trades workers can build renewable power plants and install rooftop solar PV.

California far outpaces the rest of the country in the attraction of clean technology venture capital, fueling job creation in renewable energy. As noted in Chapter 7, in 2011 venture capital investment in clean tech companies in the United States increased 54 percent to $1.14 billion in the first quarter of 2011 over the same period last year, with California accounting for 56 percent of total venture capital investments.[614]

Unlike some recent innovation-led economic surges, the green economy is distributed throughout the state, though technologies and types of investment vary widely. In San Diego and Imperial counties, for example, new applied research is transforming the region to the premier hub for biofuel development. In the Mojave Desert, construction is beginning on utility-scale solar projects, and the proliferation of DG and rooftop solar is driving demand for installers and for sales and marketing professionals.

The Next 10 second edition of *Many Shades of Green,* published in 2011, tracks employment and business growth related to California's green economy.[615] Top findings in the report include:

- While total state employment grew by 18 percent since 1995, employment in the green economy has expanded 56 percent during the same period. From January 2008 to 2009, green employment increased 3 percent while growth in total employment was less than 1 percent.
- Employment growth has been particularly noticeable in energy generation, energy storage, and clean transportation.
- Manufacturing has strong employment shares, which represent 26 percent of all green employment but only 11 percent of California's total employment.

These findings are supported by a recent national and regional green jobs assessment by the Brookings Institution that concludes:[616]

- The clean economy employs more workers than the fossil fuel industry, with most jobs in mature segments such as manufacturing and public services like wastewater and mass transit, and a smaller portion in newer segments including the solar PV, wind, fuel cell, smart grid, biofuel, and battery industries. California has 318,156 clean jobs, the highest in

613 Repower America, http://www.repoweramerica.org/solutions/roadmap/renewable-energy/

614 http://www.ey.com/US/en/Newsroom/News-releases/US-VC-investment-in-cleantech.

615 Next 10, *Many Shades of Green*, 2011, http://www.next10.org/next10/publications/pdf/2011_Many_Shades_of_Green_FINAL.pdf.

616 Muro, Mark, Jonathan Rothwell, Devashree Saha, *The Brookings Institution Metropolitan Policy Program, Sizing the Clean Economy: A national and Regional Green Jobs Assessment*, July 2011, http://www.brookings.edu/~/media/Files/Programs/Metro/clean_economy/0713_clean_economy.pdf.

the nation and well over 100,000 more than the next largest state, New York. The Sacramento-Arden-Arcade-Roseville metro area is third is the top 10 of the 100 largest metropolitan areas in the country with the highest share of clean economy jobs; the clean economy in this area grew 59 percent from 2003 to 2010.

- The clean economy grew more slowly than the national economy between 2003 and 2010 but newer clean tech segments such as wind, solar PV, and smart grid produced explosive job gains, and the clean economy outperformed the nation during the recession.
- The clean economy is manufacturing- and export-intensive, with roughly 26 percent of all clean economy jobs in manufacturing compared to 9 percent in the broader economy. On a per job basis, establishments in the clean economy export twice the value of a typical United States job ($20,000 versus $10,000).
- The clean economy offers more opportunities and better pay for low- and middle-income workers than the national economy as a whole.
- The Sacramento region's efforts to become a hub for clean energy technology through the Green Capital Alliance, the Sacramento Area Regional Technology Alliance, and the University of California at Davis are examples of using regional networking to advance the clean economy.

Challenges for Workforce Development

While much of this economic growth is creating demand for workers in existing occupations, it is also driving the need for enhanced work skills and training for emerging jobs such as PV/solar thermal installers and solar and wind operations and maintenance technicians. The need for a coordinated approach to workforce training that is closely aligned with labor demand will grow as investment in the clean energy economy continues to expand.

The current recession has caused difficulty in creating a steady bridge between workforce training programs and actual employment. Employers are hesitant to take on more employees in the fragile economy, which has resulted in low placement rates for some of the programs. This issue can be addressed by solidifying the hiring bridge with short-term on-the-job training (OJT) with employers throughout the state. Providing funding for the first three to six months of employment, while the employee has an opportunity to apply classroom learning and gain practical experience, can drastically improve the hiring and placement of trainees. Many employers are open to OJT and are willing to make the commitment of continued employment after the OJT ends.

Some workers who have received training funded by the American Recovery and Reinvestment Act (ARRA) in clean energy fields have reported difficulty finding employment. Rooftop solar and other renewable energy investments are not accessible to most low-income people, leaving communities with a mismatch of trained workers but little demand. A challenge in the deployment of DG is to channel investment into disadvantaged communities so that they may enjoy both the environmental and job creation benefits. This will require strategies to incentivize installation of small-scale renewables in renter and owner-occupied residential

buildings as well as commercial buildings, parking lots, and ground-mounted locations. In addition, with the delay and ultimate elimination of programs such as HomeStar and PACE, and due to the costs for rooftop solar and small-scale renewables still being prohibitive for many consumers, trainees are finding jobs hard to come by.

A large portion of the available government funding for workforce development is tied to ARRA with expiration dates ranging from 2011 to 2013.[617] As a result, community colleges, trade associations, and other training providers may have difficulty continuing their clean energy training into the future.

Efforts to Address Workforce Development Challenges

In 2010, the Center for Energy Efficiency and Renewable Technologies (CEERT) surveyed 14 clean energy developers in Southern California to better understand their workforce needs. The survey provided a sample of the type of jobs being created by large-scale renewable energy facilities in the area, such as welders, pipefitters, millwrights, laborers, ironworkers, engineers, and electricians, to name a few. The survey indicated that thousands of workers will be needed between 2010 and 2015 to build the power plants being proposed in Southern California, with hundreds of operations and maintenance jobs needed for the next 20 to 30 years.

For DG projects, CEERT estimates that construction jobs to build 2,000 PV projects totaling 6,000 MW over a 10-year period would create a monthly average of 10,400 jobs in trades similar to those identified for utility-scale renewables.[618] The "National Solar Jobs Census 2010" by the Solar Foundation notes that, nationally, solar companies expect to add jobs at a much faster pace than the general economy.[619] This trend is important for California since more than 30 percent of the estimated solar jobs in the United States in 2010 were in the state.[620] A 2010 labor market analysis by SolarTech notes that in 2010, California was home to 1,072 solar firms with an estimated 36,000 employees. Because a large number of workforce programs are already servicing the solar PV installer occupation, the SolarTech study suggests a need to focus on training qualified solar PV system sales and system design engineers. SolarTech estimates that there will be 650 to 1,300 new PV sales jobs in California in 2011.

California is already at the forefront of workforce training efforts for the green economy. Using federal stimulus funding, the Energy Commission worked with the California Employment

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617 For more information about ARRA funded workforce development programs, see California Energy Commission, *2010 Integrated Energy Policy Report Update*, January 2011, http://www.energy.ca.gov/2010publications/CEC-100-2010-001/CEC-100-2010-001-CMF.PDF.

618 Center for Energy Efficiency and Renewable Technologies, presentation to Inter-Solar North America, July 12, 2011, http://www.ceert.org/PDFs/reports/110712_DG-Jobs_CEERT_InterSolar-NA.pdf.

619 The Solar Foundation, *National Solar Jobs Census 2010*, October 2010, http://www.thesolarfoundation.org/sites/thesolarfoundation.org/files/Final%20TSF%20National%20Solar%20Jobs%20Census%202010%20Web%20Version.pdf.

620 SolarTech, *California Green Innovations Challenge: Renewable Energy Labor Market Study*, Report 1, 2010, http://www.solartech.org/index.php?option=com_st_document&view=general&Itemid=58.

Development Department (EDD) and the California Workforce Investment Board to establish the Clean Energy Workforce Training Program, the largest state-sponsored green jobs training program in the nation. Among other things, this program trains workers needed to operate large-scale renewable power plants and to install PV systems. This program also provides grants to establish community college and other training program curricula, which will provide the basis for long-lasting and sustainable changes in clean energy workforce training in California.

Several community colleges in the Clean Energy Workforce Training Program (CEWTP) have worked to make their programs sustainable by applying for accreditation for the coursework. For example, Imperial Valley College now has a certificate program in Energy Efficiency Technology. Other grantees have made their programs sustainable by training the staff in green and clean energy occupations or partnering with relevant organizations so they can better further occupational goals for trainees. Grossmont-Cuyamaca College, for example, has partnered with the California Center for Sustainable Energy on the delivery of its training program and coordination with Energy Upgrade California. Other grantees, such as the RichmondBUILD program, have found innovative ways to help trainees find employment. The city of Richmond has a local employment ordinance that requires employers to hire a certain percentage of city residents.[621]

One portion of the CEWTP is the roughly $24 million in ARRA State Energy Program and Workforce Investment Act funding that was awarded in October 2009 to 28 grantees as part of an interagency agreement with EDD. As of December 31, 2010, 55 percent of the funds awarded have been expended, and 70 percent of the total planned participants have been enrolled in the program. A total of 78 percent were enrolled in training, 15 percent have exited the program and 40 percent were placed in unsubsidized employment. The projects have partnered with education and industry and issued more than 2,400 certificates for various green occupations,[622] the bulk of which relate to energy efficiency occupations. At the end of the program, the grantees are expected to train nearly 5,000 trainees in areas such as energy fundamentals, general construction, solar electric installation and design principles, certified solar PV installation, and wind turbine technology.

Although the demand has come later than expected for many trainees, many of the CEWTP programs are working closely with the Energy Upgrade California program to ensure a smooth transition into jobs for their graduates. To spur investment and job growth in the clean energy economy, financing and incentive programs have assisted clean technology companies with financing. In October 2011, the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) started granting sales and use tax exemptions on manufacturing equipment purchased for clean energy manufacturing facilities and renewable energy generators. The exemption was authorized under Senate Bill 71, and as of July 2011, 30 companies had received sales and use tax exemptions for a total of $89 million in exemptions on

621 http://www.ci.richmond.ca.us/index.aspx?NID=1816.

622 Employment Development Department, *Clean Energy Workforce Training Program 2010 Annual Report*.

$963 million in qualified purchases. The total number of a jobs associated with the sales tax exemption program is estimated to be 6,386. The exemption is available to a wide range of qualified purchases for manufacturing equipment in the clean energy economy. About a third of the exemptions have been issued to PV manufacturers who have applied, but power plant operators who have decided to repower from fossil fuel to renewables have also taken advantage of the program. For example, a sales and use tax exemption was granted for $10 million in equipment purchases that will be used to convert a coal cogeneration plant at the Port of Stockton to a biomass facility, a project that will create 54 construction jobs and eight permanent jobs.

In addition, the Energy Commission's Clean Energy Business Finance Program provides low-interest revolving loans for clean energy manufacturing businesses in California, including six loans ranging from $2.7 million to $5 million to companies that produce PV panels. Together these companies are creating 640 jobs throughout the state.[623]

The CEWTP also has an interagency agreement with the Employment Training Panel, which provided $4.5 million in ARRA/State Energy Program funds to 14 grantees to perform career advancement training. These grantees train incumbent workers in clean energy skills while meeting a 90-day employment retention period after the training is completed. The program is set to train nearly 3,000 incumbent workers.

Kern Community College District has developed curricula for its PowerTech, SolarTech, and WindTech programs, which are targeted to entry level positions with utility companies and contractors, utility-scale solar thermal and PV companies, residential and commercial solar installers, and utility-scale wind and wind turbine companies. The district also has a pre-apprenticeship program to introduce women to the green jobs industry and provide a variety of apprenticeship trade opportunities like electrician, solar and wind technician, plumber and pipefitter, and sheet metal worker.

Another example is the College of the Desert in Palm Desert, California, which is working closely with solar developers like First Solar, Solar Millennium, Solar Reserve, and NextEra. First Solar has donated and installed two 40-foot arrays of thin film modules and rack-mounting equipment to train workers on a system that will be used in a 550 MW project planned for Desert Center. In addition, Gossamer Space Frames, an engineering design firm based in Huntington Beach, California, arranged for the donation of eight 8-meter parabolic trough frames, mirrors, and a tracking drive unit for training. Solar Millennium, Solar Reserve, First Solar, Schott Solar, and a host of other industry and labor partners have also provided support in the curriculum development and training.

Also as part of the CEWTP, the Energy Commission partnered with the Employment Training Panel to fund workforce training to advance green job skills in efficiency and renewable energy.

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623 For a description of the Clean Energy Business Finance Program, see California Energy Commission, *2010 Integrated Energy Policy Report Update*, January 2011, http://www.energy.ca.gov/2010publications/CEC-100-2010-001/CEC-100-2010-001-CMF.PDF.

This effort targets placement for unemployed workers and upgrading the skills of incumbent workers in jobs that reduce energy or water use in the building trades (for example, retrofitting, green plumbing, efficient lighting, and so on) or that produce or transmit renewable energy (such as solar panel manufacturing and smart grid installation).

Complementing the CEWTP is a workforce training grant program administered by the Labor and Workforce Development Agency and EDD to provide training for up to 3,000 workers in the clean energy economy. The $19 million Green Innovation Challenge Grant program helps community college students in the Bay Area learn the skills to perform after-market repairs and maintenance to electric and alternative fuel vehicles; helps the San Diego region develop college-level curriculum and certificates for workers in the biofuel industry; and helps train PV solar installers, system designers, and marketing professionals.

Vital to the success of the future clean energy workforce is career technical education at the high school level. Past efforts in this area include investment by the PIER Program of $12 million in the California Partnership Academies' Green/Clean Initiative to build clean energy career pathways for students in grades 10-12.[624] This effort funded about 60 programs through the California Department of Education that integrated academic and career technical education, business partnerships, mentoring, and internships with a focus on green careers such as green buildings, sustainable design, and green engineering.

To further expand the pipeline of students who want to pursue careers in renewable energy and other green industry sectors, Senate Bill X1 1 will provide $8 million in funding annually to the Superintendent of Public Instruction (SPI) to implement and administer a grant program to fund clean energy partnership academies in public schools for grades 9-12. The partnership academies, which serve primarily at-risk students, will focus on preparing students for careers in energy and water conservation, renewable energy, pollution reduction, and similar technologies. The Energy Commission is developing guidelines through a public process to ensure academy programs receiving grant funding from the SPI align themselves with current energy policies and priorities and provide skills and education linked to the current needs of the clean energy industries. Energy Commission staff held workshops in July and October 2011 to seek input on the guidelines, which under SB X1 1 must be adopted by February 2012.[625]

Other PIER Program efforts include providing cost-share funding to smart grid research projects that will create new jobs in the application of computers and computer-controlled equipment and the increased use of communications systems. With the increased integration of renewable resources into the grid, workers will be needed to support industries that sell and install small-scale renewable energy systems and to operate and maintain utility-scale generators. Other jobs will include energy engineers, who design the systems and write the specifications, as well as the technicians who install, program, and service the equipment. The PIER Program also provided cost-share funding that helped leverage ARRA funding for

624 Funding for this effort was appropriated by Assembly Bill 519 (Budget Committee, Chapter 757, Statutes of 2008).

625 For more information, see http://www.energy.ca.gov/cleanenergyacademies/documents/index.html.

California State University, Sacramento to develop a clean energy workforce curriculum targeted toward training needed for jobs being created in smart grid applications.

In addition, the PIER Program sponsored research on the need for a National Center for the Clean Energy Workforce (NCCEW) to serve as a clearinghouse for information on best practices and technical assistance. This led to the development of an unsolicited proposal for a national center, initially with a regional hub in California and one on the East Coast. At a March 14, 2011, IEPR workshop on the NCCEW, stakeholders noted the value of a national center in providing a central clearinghouse for information about the types of training and curricula available to workforce development agencies as well as certification standards for a variety of green jobs.[626] A central source of information reduces costs associated with workforce research, which can be very expensive, by having a single clearinghouse where people can take advantage of job surveys and other research done by other organizations.[627] A national center can also help align and integrate government goals for energy efficiency and renewables with industry job needs and standards.[628]

Cross-Cutting Issue 4: Public Sector Leadership

California has the potential to develop renewable energy systems on state-owned buildings, properties, and rights-of-way to help meet the state's renewable energy goals, and to create green jobs and reduce GHG emissions and other harmful air pollutants. Developing renewable generation on state properties can also reduce energy costs in state buildings and create new revenue for state government through the lease of vacant or unused land. State leadership will also demonstrate the benefits of renewable DG and help encourage larger-scale deployment throughout the state and nationwide.

In December 2010, the Energy Commission adopted a memorandum of understanding (MOU) with the Departments of General Services, Corrections and Rehabilitation, Transportation (Caltrans), Water Resources (DWR), and Fish and Game to help develop renewable energy projects on state buildings, properties, and rights-of-way. The California State Lands Commission and the University of California (UC) have since signed on to this effort, and the MOU includes an option for additional agencies to join in the future. The MOU commits agencies to collaboratively study, plan, and develop energy generating infrastructure, coordinate consistent procurement strategies and contract language in requests for proposals,

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626 *Transcript of the March 14, 2011 IEPR Workshop on the National Center for the Clean Energy Workforce,* comments by Benjamin Goldstein, http://www.energy.ca.gov/2011_energypolicy/documents/2011-03-14_workshop/2011-03-14_transcript.pdf, p. 38.

627 *Transcript of the March 14, 2011 IEPR Workshop on the National Center for the Clean Energy Workforce*, comments by Phil Jordan, http://www.energy.ca.gov/2011_energypolicy/documents/2011-03-14_workshop/2011-03-14_transcript.pdf, p.38.

628 *Transcript of the March 14, 2011 IEPR Workshop on the National Center for the Clean Energy Workforce*, comments by Tim Rainey, http://www.energy.ca.gov/2011_energypolicy/documents/2011-03-14_workshop/2011-03-14_transcript.pdf, p.38.

and develop one or more statewide solicitations to make state properties available to interested developers in the future.

As the first step to implementing the MOU, an Energy Commission staff report released in April 2011 discussed current development of renewable energy on state properties, barriers and solutions to future deployment, opportunities for further development, and recommended next steps, as summarized in the following.[629]

Inventory of Opportunities

In October 2010, Energy Commission staff began to identify and inventory state properties to understand potential opportunities for rapid deployment of renewable DG systems. The focus was on clusters of state buildings within seven load centers near existing distribution lines; buildings not in load centers with high onsite load, such as correctional facilities, state hospitals, and developmental centers, were also examined. Staff also collected annual and monthly metered load and utility billing data on many of these buildings and estimated the square feet of available roof and parking lot space.

Based on the inventory, staff recommended a target of 2,500 MW of new renewable generating capacity by 2020 (Table 24).

Table 24: Target for Renewable Development Allocated by Type of State Property

State Property Category	Potential Renewable Generation Capacity (MW)*
State Buildings in Load Centers	14 – 26
State Property With Potential for Wholesale Generation	54.5 – 195
Land Lease for Wholesale Generation	14,460 – 26,030
Total State Properties Renewables Target	**2,500**

* The MW ranges reflect staff's assumption that 1 MW of PV can be developed on 5 to 9 acres.

Source: California Energy Commission

Staff also developed interim targets that will be useful in monitoring progress toward the 2,500 MW goal. Although near-term opportunities are available to develop renewables on state buildings, the majority of the target will likely be met with projects developed on land leased for wholesale generation, including large-scale projects that take longer to deploy. Given deployment expectations, staff proposed the following interim targets: one-third by 2015 (833 MW); one-third by 2018 (1,666 MW, cumulative); and one-third by 2020 (2,500 MW, cumulative).

Challenges to Development of Renewables on State Properties

Barriers to the development of renewables on state properties are generally the same as those identified throughout this report and fall into four broad categories: economics, integration,

629 California Energy Commission, *Developing Renewable Generation on State Property*, staff report, April 2011, http://www.energy.ca.gov/2011publications/CEC-150-2011-001/CEC-150-2011-001.pdf.

interconnection, and permitting. Economic barriers include high upfront costs and the transaction costs associated with installing small-scale DG. Cost reduction strategies include the use of net energy metering, state and federal incentives and tax credits, feed-in tariffs, and streamlined contracting mechanisms such as the CPUC's Renewable Auction Mechanism.[630] Renewable Energy Credits can also offset capital costs.

Integration and interconnection challenges for renewables on state properties are the same as those discussed in Chapters 5 and 6. Installing renewables on state buildings will require interconnection studies to assure that they will not adversely affect the operation and safety of distribution or transmission systems. For small-scale systems, efforts to streamline and reform distribution system interconnection processes underway through the CPUC's Rule 21 process will ease interconnection of renewables on state properties.

Many of the renewable systems expected to be installed on state properties to meet the 2,500 MW target will be small-scale DG and therefore will not involve many of the environmental permitting challenges associated with developing large-scale facilities as discussed in Chapter 3. However, permitting of renewable projects on state properties is still subject to compliance with CEQA, although categorical exemptions may be appropriate for renewable projects located on state buildings. A negative declaration or mitigated negative declaration may also be appropriate for projects located on a state building, but an environmental impact report could also be required, depending on the nature and severity of potential impacts.

State agencies regulate the private use of state land and resources through permitting authority established by statute. Multiple agencies can be involved in the approval of renewable projects and in many cases individual agencies develop additional administrative rules and permitting requirements. Small-scale PV projects located on state-owned buildings would be permitted through the Department of General Services or those agencies with separate permitting authority that evaluate potential environmental issues, approve project plans, and perform inspections during and after project construction.

Larger renewable projects located on state-owned rights-of-way, aqueducts, or lands would be subject to review and approval, including CEQA evaluation, by the state agency with appropriate jurisdiction. Larger projects may also involve upgrades to the distribution or transmission system and will require evaluation by utilities or the California ISO, as well as greater coordination with local governments and affected stakeholders. These larger projects may not be developed as quickly as those on state buildings because they will require more in-depth environmental evaluation and have the potential for greater environmental impacts.

While local governments do not have permitting authority over renewable energy projects on government-owned (state, federal) buildings, rights-of-way, or properties, state agencies are often required to ensure that projects are consistent with local laws, ordinances, regulations, and standards. In addition, facilities related to the project, but not located on state property,

630 CPUC, *Decision Adopting the Renewable Auction Mechanism*, Decision 10-12-048, Rulemaking 08-08-009, December 16, 2010, http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/128432.pdf.

may require review and approval from the local jurisdiction (for example, a city or county planning agency). Local governments, the public, and other stakeholders will be encouraged to participate in the licensing and review of projects proposed on state property.

Current Efforts to Increase Renewables on State Properties

Many state agencies are already advancing deployment of renewable DG on state properties through a variety of efforts that will contribute toward these targets:[631]

- The Department of General Services (DGS) is tracking energy use at state buildings to measure progress toward reducing energy consumption 20 percent by 2020 as called for by Executive Order S-20-04. The database is a valuable tool to identify buildings that have undergone low-cost efficiency improvements and are thus best suited for DG. DGS also released 3 requests for proposals to develop PV on several state buildings and facilities, and 16 California State University campuses. The first solicitation resulted in the installation of 4.25 MW, the second awarded power purchase agreements for 21 MW, and the third solicitation is expected to result in about 30 MW, for a total of about 55 MW. The state purchases the electricity generated from the PV system for a price that is competitive with the site's electric utility tariff.
- Caltrans is pursuing the installation of PV along the California highway system consistent with Governor Brown's support of the California Solar Highway. One project in Santa Clara County is currently in development. Caltrans has also identified 70 state-owned structures for installation of PV panels; 55 of those facilities are generating energy with the remainder expected to be producing energy by the end of fiscal year 2011-2012.
- The Department of Water Resources (DWR) is analyzing several renewable energy projects, including development of additional small hydro generation within the State Water Project and assessing feasibility for a test project for in-aqueduct hydrokinetic generation. DWR is negotiating a Joint Development Agreement and other documents with the University of California on a photovoltaic demonstration project along the California aqueduct and an over 70 acre site next to one of its pumping plants. DWR is also negotiating a power purchase agreement for wind energy with an annual output of almost 144 GWh.
- California's fairgrounds have installed solar PV at 26 of the 74 state fairgrounds ranging in size from 41 kW to 1 MW, with a total installed capacity of 6.5 MW.
- The Department of Forestry and Fire Protection will continue to explore the feasibility of biomass facilities at conservation camps.
- The Department of Corrections and Rehabilitation (CDCR) has two operational 1 MW PV ground-mounted solar arrays at state prisons and has executed contracts to expand these systems to nearly 9 MW, which would offset almost all of the power requirements of both

631 For more detailed descriptions of agency efforts, please see California Energy Commission, *Developing Renewable Generation on State Property*, staff report, April 2011, http://www.energy.ca.gov/2011publications/CEC-150-2011-001/CEC-150-2011-001.pdf. The staff report is anticipated to be updated and released in December 2011.

facilities. CDCR also signed power purchase agreement contracts in May, 2011 for 3 additional sites, for a total of 21.5 MW at five sites. CDCR also sent out a request for proposals for an additional 14 locations and is in the process of reviewing the proposals. CDCR's next solar effort will include sites that can be considered for wholesale generation, combined with providing on-site power to the prisons for systems ranging from 1 to 20 MW. CDCR is also implementing roof-mounted PV for several new building construction projects as well as a request for information for wind resource opportunities.

- The State Lands Commission manages thousands of acres of "school lands" as a revenue source for the State Teachers' Retirement System. Unlike the other agencies, the State Lands Commission is focusing on utility-scale development rather than DG. It has approved leases for renewable energy projects on these lands and is considering applications for new projects.
- The University of California has embraced the goal of sustainability and is transforming its business practices to reduce its impact on the environment. As part of its effort to reduce greenhouse gas emission levels to year 2000 levels by 2014 and 1990 levels by 2020, the University of California has set aggressive energy efficiency targets, and has made substantial investments in combined heat and power plants. As of September 2011, the University of California had 8.4 MW of onsite PV installed or under construction, and an additional 6.2 MW of biogas-powered generation.

List of Acronyms

AB	–	Assembly Bill
AC	–	Alternating current
ACE	–	Area control error
AFC	–	Application for Certification
AGC	–	Automatic generation control
AIM	–	Alternative Investment Management
AMI	–	Automated Metering Infrastructure
ARB	–	California Air Resources Board
ARPA-E	–	Advanced Research Projects Agency-Energy
ARRA	–	American Recovery and Reinvestment Act of 2009
BAA	–	Balancing authority area
BESS	–	Battery energy storage systems
BLM	–	Bureau of Land Management
BPA	–	Bonneville Power Authority
CAEAFTA	–	California Alternative Energy and Advanced Transportation Financing Authority
CAES	–	Compressed air energy storage
California ISO	–	California Independent System Operator
CalPERS	–	California Public Employees Retirement System
CCPDA	–	California County Planning Directors Association
CEERT		Center for Energy Efficiency and Renewable Technologies
CEQA	–	California Environmental Quality Act
CERTS		Consortium for Electric Reliability Technology Solutions
CHP		Combined heat and power
CPUC	–	California Public Utilities Commission
CREB	–	Clean and Renewable Energy Bond
CREST	–	Cost of Renewable Energy Spreadsheet Tool
CREZ	–	Competitive Renewable Energy Zone
CSD		California Department of Community Services and Development
CSGI	–	Customer Self-Supply of Generation Imbalance
CSI	–	California Solar Initiative
CSP		Concentrating solar power
CSU		California State University
CTPG	–	California Transmission Planning Group
DC		Direct current
DFG	–	California Department of Fish and Game
DG	–	Distributed generation
DOE	–	U.S. Department of Energy
DR	–	Demand response

DRECP	–	Desert Renewable Energy Conservation Plan
DRRC		Demand Response Research Center
DTCR		Dynamic thermal circuit rating
EDD		Employment Development Department
EIR	–	Environmental impact report
EJ		Environmental justice
EPBB	–	Expected Performance Based Buydown
EPRI	–	Electric Power Research Institute
ERP	–	Emerging Renewables Program
FCC		Fault current controller
FERC	–	Federal Energy Regulatory Commission
FHFA	–	Federal Housing Finance Agency
FIT	–	Feed-in tariff
FWS	–	U.S. Fish and Wildlife Service
GHG	–	Greenhouse gas
GIP	–	Generator Interconnection Procedures
GRC	–	General Rate Case
GWh	–	Gigawatt hour
HAN		Home area networks
HCP	–	Habitat Conservation Plan
HTLS	–	High-temperature low-sag
HVDC		High-voltage direct current
iHub	–	Innovation Hub
IID	–	Imperial Irrigation District
IOU	–	Investor-owned utility
IRR		Integrating Renewable Resources Pilot Project
ITC	–	Investment Tax Credit
kW	–	Kilowatt
kWh	–	Kilowatt hour
LADWP	–	Los Angeles Department of Water and Power
LBNL	–	Lawrence Berkeley National Laboratory
LCOE	–	Levelized cost of energy
LGIP	–	Large Generator Interconnection Process
LGP	–	Loan guarantee program
LIHEAP		Low-Income Home Energy Assistance Program
LORS	–	Laws, Ordinances, Regulations, and Standards
LSE	–	Load-serving entity
LTPP	–	Long-term Procurement Plan
LVRT	–	Low-voltage ride through
MASH	–	Multifamily Affordable Solar Housing Program
MIC	–	Maximum import capability
MOU	–	Memorandum of understanding

MPR	–	Market Price Referent
MW	–	Megawatt
MWh	–	Megawatt hour
NCCEW		National Center for the Clean Energy Workforce
NCCP	–	Natural Community Conservation Plan
NEM	–	Net energy metering
NEPA	–	National Environmental Protection Act
NERC		North American Electric Reliability Corporation
NIST	–	National Institute of Standards and Technology
NPDES	–	National Pollutant Discharge Elimination System
NREL	–	National Renewable Energy Laboratory
NSHP	–	New Solar Homes Partnership
OII	–	Order Instituting Informational Proceeding
OIR	–	Order Instituting Rulemaking Proceeding
OpenADR		Open Automated Demand Response
OTC	–	Once-through cooling
PACE	–	Property Assessed Clean Energy Program
PBI	–	Performance-Based Incentive
PEIS	–	Programmatic environmental impact statement
PG&E	–	Pacific Gas and Electric
PIER	–	Public Interest Energy Research
PIRP	–	Participating Intermittent Resource Program
PPA	–	Power purchase agreement
PTC	–	Production Tax Credit
PURPA	–	Public Utility Regulatory Policies Act
PV	–	Photovoltaic
QECB	–	Qualified Energy Conservation bonds
R&D	–	Research and development
RA	–	Resource adequacy
RAM	–	Renewable Auction Mechanism
REAP	–	Rural Energy for America Program
REAT	–	Renewable Energy Action Team
Re-DEC	–	Renewable Distributed Energy Collaborative
REDS		Residential Energy Display Survey
REFTI	–	Renewable Energy Finance Tracking Initiative
REPI	–	Renewable Energy Production Incentive
RESCO		Renewable Energy Secure Communities
RETI	–	Renewable Energy Transmission Initiative
RFO	–	Request for offers
RPS	–	Renewables Portfolio Standard
RSC	–	Renewable Standard Contract
RTDMS	–	Real-Time Dynamic Measurement System

RTEP	–	Regional Transmission Expansion Planning Project
RUS	–	Rural Utilities Service Program
SA	–	Staff assessment
SANDAG		San Diego Association of Governments
SARTA	–	Sacramento Regional Technology Alliance
SASH	–	Single-family Affordable Solar Homes Program
SB	–	Senate Bill
SCADA	–	Supervisory control and data acquisition
SCE	–	Southern California Edison
SDG&E	–	San Diego Gas & Electric
SELP	–	Small-Scale Energy Loan Program
SEZ	–	Solar energy zone
SGIP	–	Small Generator Interconnection Procedure
SGIP	–	Self-Generation Incentive Program
SMUD	–	Sacramento Municipal Utility District
STIP	–	Strategic Transmission Investment Plan
SWRCB	–	State Water Resources Control Board
TELP	–	Tax Exempt Lease Program
TPP	–	Transmission planning process
TRECs	–	Tradable renewable energy certificates
TWh	–	Terawatt hour
UC		University of California
USEPA	–	U.S. Environmental Protection Agency
USFS	–	U.S. Forest Service
VAR	–	Volt-ampere reactive
VC	–	Venture capital
WAPA	–	Western Area Power Administration
WDAT	–	Wholesale Distribution Access Tariff
WECC		Western Electricity Coordinating Council

APPENDIX A: Renewable Generating Capacity in California

The following tables provide totals for different resource types by California county for utility-scale, wholesale distributed generation, and customer-side renewable distributed generation. Disaggregated data for wind capacity was unavailable at the time of publication of this report.

Table A-1: In-State Wholesale Renewable Distributed Generation Facilities (20 MW or less)

	Capacity (MW) (n/d indicates data unavailable)							Facilities						
County	Biomass	Geothermal	MSW-RPS	Small Hydro	Solar	Wind	Total	Biomass	Geothermal	MSW-RPS	Small Hydro	Solar	Wind	Total
Alameda	15	-	-	-	-	n/d	15	2	-	-	-	-	n/d	2
Alpine	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Amador	21	-	-	14	-	n/d	35	2	-	-	1	-	n/d	3
Butte	19	-	-	69	-	n/d	88	1	-	-	9	-	n/d	10
Calaveras	-	-	-	9	-	n/d	9	-	-	-	3	-	n/d	3
Colusa	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Contra Costa	3	-	-	-	-	n/d	3	1	-	-	-	-	n/d	1
Del Norte	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
El Dorado	-	-	-	41	-	n/d	41	-	-	-	5	-	n/d	5
Fresno	-	-	-	10	5	n/d	15	-	-	-	1	1	n/d	2
Glenn	-	-	-	5	-	n/d	5	-	-	-	1	-	n/d	1
Humboldt	29	-	-	-	-	n/d	29	2	-	-	-	-	n/d	2
Imperial	-	87	-	52	-	n/d	139	-	6	-	6	-	n/d	12
Inyo	-	-	-	43	-	n/d	43	-	-	-	10	-	n/d	10
Kern	-	-	-	50	-	n/d	50	-	-	-	4	-	n/d	4
Kings	-	-	-	-	39	n/d	39	-	-	-	-	2	n/d	2
Lake	-	-	-	6	-	n/d	6	-	-	-	2	-	n/d	2
Lassen	19	-	-	-	-	n/d	19	2	-	-	-	-	n/d	2
Los Angeles	68	-	-	90	8	n/d	165	7	-	-	15	1	n/d	23
Madera	13	-	-	29	-	n/d	41	1	-	-	4	-	n/d	5
Marin	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Mariposa	-	-	-	9	-	n/d	9	-	-	-	1	-	n/d	1
Mendocino	-	-	-	9	-	n/d	9	-	-	-	1	-	n/d	1

	Capacity (MW) (n/d indicates data unavailable)							Facilities						
County	Biomass	Geothermal	MSW-RPS	Small Hydro	Solar	Wind	Total	Biomass	Geothermal	MSW-RPS	Small Hydro	Solar	Wind	Total
Merced	13	-	-	13	-	n/d	25	1	-	-	2	-	n/d	3
Modoc	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Mono	-	40	-	21	-	n/d	61	-	3	-	3	-	n/d	6
Monterey	7	-	-	-	-	n/d	7	2	-	-	-	-	n/d	2
Napa	2	-	-	-	-	n/d	2	1	-	-	-	-	n/d	1
Nevada	-	-	-	55	-	n/d	55	-	-	-	9	-	n/d	9
Orange	49	-	-	12	-	n/d	61	5	-	-	3	-	n/d	8
Placer	19	-	-	67	-	n/d	87	1	-	-	8	-	n/d	9
Plumas	12	-	-	6	-	n/d	18	1	-	-	2	-	n/d	3
Riverside	5	-	-	20	-	n/d	25	2	-	-	5	-	n/d	7
Sacramento	9	-	-	14	8	n/d	31	1	-	-	1	4	n/d	6
San Benito	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
San Bernardino	6	-	-	11	17	n/d	35	3	-	-	9	3	n/d	15
San Diego	29	-	-	12	1	n/d	42	7	-	-	3	1	n/d	11
San Francisco	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
San Joaquin	14	-	-	11	-	n/d	25	1	-	-	1	-	n/d	2
San Luis Obispo	-	-	-	4	-	n/d	4	-	-	-	1	-	n/d	1
San Mateo	2	-	-	-	-	n/d	2	2	-	-	-	-	n/d	2
Santa Barbara	3	-	-	-	-	n/d	3	1	-	-	-	-	n/d	1
Santa Clara	10	-	-	-	-	n/d	10	4	-	-	-	-	n/d	4
Santa Cruz	2	-	-	-	-	n/d	2	1	-	-	-	-	n/d	1
Shasta	35	-	-	86	-	n/d	121	3	-	-	20	-	n/d	23
Sierra	20	-	-	14	-	n/d	34	1	-	-	2	-	n/d	3
Siskiyou	-	-	-	45	-	n/d	45	-	-	-	4	-	n/d	4
Solano	-	-	-	-	3	n/d	3	-	-	-	-	1	n/d	1
Sonoma	8	-	-	3	-	n/d	11	3	-	-	1	-	n/d	4
Stanislaus	-	-	-	18	1	n/d	19	-	-	-	5	1	n/d	6
Sutter	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Tehama	-	-	-	21	-	n/d	21	-	-	-	3	-	n/d	3
Trinity	-	-	-	9	-	n/d	9	-	-	-	4	-	n/d	4

	Capacity (MW) (n/d indicates data unavailable)							Facilities						
County	**Biomass**	**Geothermal**	**MSW-RPS**	**Small Hydro**	**Solar**	**Wind**	**Total**	**Biomass**	**Geothermal**	**MSW-RPS**	**Small Hydro**	**Solar**	**Wind**	**Total**
Tulare	13	-	-	38	-	n/d	51	2	-	-	7	-	n/d	9
Tuolumne	8	-	-	61	-	n/d	69	1	-	-	7	-	n/d	8
Ventura	3	-	-	2	-	n/d	5	1	-	-	2	-	n/d	3
Yolo	4	-	-	12	-	n/d	15	1	-	-	1	-	n/d	2
Yuba	-	-	-	0	-	n/d	0	-	-	-	1	-	n/d	1
Total	458	127	-	989	82	n/d	1,656	63	9	-	167	14	n/d	253

Source: California Energy Commission's "CEC-1304 QFER Database ." http://energyalmanac.ca.gov/electricity/web_qfer/ .

Table A-2: In-State Utility-Scale Renewable Facilities (> 20 MW)

	Capacity (MW) (n/d indicates data unavailable)							Facilities						
County	**Biomass**	**Geothermal**	**MSW-RPS**	**Small Hydro**	**Solar**	**Wind**	**Total**	**Biomass**	**Geothermal**	**MSW-RPS**	**Small Hydro**	**Solar**	**Wind**	**Total**
Alameda	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Alpine	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Amador	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Butte	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Calaveras	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Colusa	29	-	-	-	-	n/d	29	1	-	-	-	-	n/d	1
Contra Costa	12	-	-	-	-	n/d	12	2	-	-	-	-	n/d	2
Del Norte	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
El Dorado	-	-	-	26	-	n/d	26	-	-	-	1	-	n/d	1
Fresno	56	-	-	-	-	n/d	56	2	-	-	-	-	n/d	2
Glenn	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Humboldt	38	-	-	-	-	n/d	38	2	-	-	-	-	n/d	2
Imperial	-	563	-	-	-	n/d	563	-	13	-	-	-	n/d	13
Inyo	-	302	-	-	-	n/d	302	-	3	-	-	-	n/d	3
Kern	98	-	-	25	-	n/d	122	3	-	-	1	-	n/d	4
Kings	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Lake	-	55	-	-	-	n/d	55	-	1	-	-	-	n/d	1
Lassen	36	-	-	30	-	n/d	65	1	-	-	1	-	n/d	2
Los Angeles	427	-	-	-	-	n/d	427	8	-	-	-	-	n/d	8
Madera	25	-	-	31	-	n/d	56	1	-	-	1	-	n/d	2
Marin	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Mariposa	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Mendocino	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Merced	-	-	-	25	-	n/d	25	-	-	-	1	-	n/d	1
Modoc	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Mono	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Monterey	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Napa	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-

	Capacity (MW) (n/d indicates data unavailable)							Facilities						
County	**Biomass**	**Geothermal**	**MSW-RPS**	**Small Hydro**	**Solar**	**Wind**	**Total**	**Biomass**	**Geothermal**	**MSW-RPS**	**Small Hydro**	**Solar**	**Wind**	**Total**
Nevada	-	-	-	27	-	n/d	27	-	-	-	1	-	n/d	1
Orange	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Placer	28	-	-	22	-	n/d	50	1	-	-	1	-	n/d	2
Plumas	28	-	-	46	-	n/d	74	1	-	-	2	-	n/d	3
Riverside	61	-	-	30	21	n/d	112	2	-	-	1	1	n/d	4
Sacramento	43	-	-	-	-	n/d	43	1	-	-	-	-	n/d	1
San Benito	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
San Bernardino	-	-	-	24	387	n/d	411	-	-	-	1	8	n/d	9
San Diego	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
San Francisco	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
San Joaquin	23	-	-	-	-	n/d	23	1	-	-	-	-	n/d	1
San Luis Obispo	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
San Mateo	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Santa Barbara	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Santa Clara	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Santa Cruz	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Shasta	94	-	-	-	-	n/d	94	2	-	-	-	-	n/d	2
Sierra	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Siskiyou	-	-	-	27	-	n/d	27	-	-	-	1	-	n/d	1
Solano	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Sonoma	-	1,601	-	-	-	n/d	1,601	-	17	-	-	-	n/d	17
Stanislaus	-	-	24	3	-	n/d	27	-	-	1	1	-	n/d	2
Sutter	1	-	-	-	-	n/d	1	1	-	-	-	-	n/d	1
Tehama	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Trinity	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Tulare	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
Tuolumne	22	-	-	-	-	n/d	22	1	-	-	-	-	n/d	1
Ventura	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-

	Capacity (MW) (n/d indicates data unavailable)							Facilities						
County	**Biomass**	**Geothermal**	**MSW-RPS**	**Small Hydro**	**Solar**	**Wind**	**Total**	**Biomass**	**Geothermal**	**MSW-RPS**	**Small Hydro**	**Solar**	**Wind**	**Total**
Yolo	28	-	-	-	-	n/d	28	1	-	-	-	-	n/d	1
Yuba	-	-	-	-	-	n/d	-	-	-	-	-	-	n/d	-
TOTAL	1,046	2,521	24	315	408	n/d	4,313	31	34	1	13	9	n/d	88

Source: California Energy Commission's "CEC-1304 QFER Database." http://energyalmanac.ca.gov/electricity/web_qfer/.

Table A-3: In-State Facilities – Customer-Side Distributed Generation Facilities

	Capacity (kW)				Facilities			
County	Biomass	Solar	Wind	Total	Biomass	Solar	Wind	Total
Alameda	2,000	37,154	20	39,174	3	3,809	4	3,816
Alpine	0	0	9	9	0	0	1	1
Amador	0	1,105	11	1,117	0	190	5	195
Butte	1,070	13,824	188	15,082	2	826	18	846
Calaveras	0	1,864	16	1,880	0	321	3	324
Colusa	0	1,313	3	1,316	0	49	1	50
Contra Costa	480	26,917	35	27,431	2	3,386	6	3,394
Del Norte	0	0	1	1	0	0	1	1
El Dorado	0	6,884	4	6,888	0	1,241	2	1,243
Fresno	670	31,190	12	31,873	2	3,140	3	3,145
Glenn	0	837	129	967	0	97	10	107
Humboldt	0	1,234	48	1,282	0	448	7	455
Imperial	0	8	0	8	0	2	0	2
Inyo	0	1,136	0	1,136	0	44	0	44
Kern	453	21,162	404	22,018	2	1,559	64	1,625
Kings	0	4,869	0	4,869	0	260	0	260
Lake	0	5,246	23	5,270	0	372	8	380
Lassen	0	195	0	195	0	13	0	13
Los Angeles	4,730	62,296	1,083	68,110	9	5,543	30	5,582
Madera	0	4,250	4	4,254	0	476	2	478
Marin	27	12,891	3	12,920	1	2,020	4	2,025
Mariposa	0	433	0	433	0	76	0	76
Mendocino	0	3,577	14	3,592	0	555	5	560
Merced	700	5,766	2	6,467	2	272	2	276
Modoc	0	0	0	0	0	0	0	0
Mono	0	617	0	617	0	76	0	76
Monterey	0	5,725	0	5,725	0	710	0	710
Napa	210	15,138	1	15,349	1	843	1	845
Nevada	0	3,452	4	3,456	0	846	3	849
Orange	320	31,789	1	32,110	2	4,093	1	4,096
Placer	0	15,727	8	15,735	0	2,081	5	2,086
Plumas	0	1,077	0	1,077	0	80	0	80

	Capacity (kW)				Facilities			
County	**Biomass**	**Solar**	**Wind**	**Total**	**Biomass**	**Solar**	**Wind**	**Total**
Riverside	1,700	41,495	67	43,261	2	3,644	11	3,657
Sacramento	0	2,170	3	2,173	0	144	2	146
San Benito	0	643	9	652	0	102	1	103
San Bernardino	500	37,607	2,769	40,876	1	2,189	214	2,404
San Diego	3,220	69,349	76	72,645	6	9,399	29	9,434
San Francisco	250	10,185	3	10,438	1	2,044	2	2,047
San Joaquin	290	11,335	24	11,649	2	1,073	7	1,082
San Luis Obispo	240	12,097	36	12,374	1	1,501	7	1,509
San Mateo	660	14,082	8	14,750	2	2,214	4	2,220
Santa Barbara	1,870	8,902	10	10,783	4	1,134	2	1,140
Santa Clara	4,250	53,128	16	57,393	8	5,490	9	5,507
Santa Cruz	0	8,645	11	8,655	0	1,917	3	1,920
Shasta	0	4,396	104	4,500	0	409	13	422
Sierra	0	10	0	10	0	3	0	3
Siskiyou	0	0	9	9	0	0	1	1
Solano	0	12,868	387	13,255	0	729	22	751
Sonoma	36	31,402	280	31,718	1	3,594	14	3,609
Stanislaus	0	6,040	0	6,040	0	230	0	230
Sutter	300	3,103	50	3,453	1	270	3	274
Tehama	0	1,277	82	1,358	0	141	14	155
Trinity	0	24	0	24	0	4	0	4
Tulare	1,400	13,319	3	14,722	2	898	2	902
Tuolumne	0	1,251	0	1,251	0	211	0	211
Ventura	670	17,119	5	17,794	2	1,771	2	1,775
Yolo	0	12,038	19	12,058	0	1,112	7	1,119
Yuba	0	990	28	1,018	0	219	9	228

Source: Nonconfidential information from the California Energy Commission's Emerging Renewables Program and the New Solar Homes Partnership, the California Solar Initiative, http://www.californiasolarstatistics.ca.gov/current_data_files/, and the Self Generation Incentive Program, https://energycenter.org/index.php/incentive-programs/self-generation-incentive-program/sgip-documents/sgip-documents.

APPENDIX B: Additional Data on Renewable Percentages

Calculations of the percentage of renewable generation in California may vary depending on the source of data used, as shown in Table B-1.

Table B-1: Renewable Percentages Using Different Data Sources

Data Source	In-state Renewables (GWh)	In-state Renewables Percentage to In-state Generation***	Total Renewables (GWh)	Renewables Percentage to 2010 Retail Sales**
CPUC RPS Compliance Filings*	No Data	No Data	41,790	16.5%
Energy Commission RPS Tracking *	No Data	No Data	38,194	15.1%
Total System Power	30,005	14.6%	39,796	15.7%
Power Source Disclosure Program	31,054	15.1%	40,846	16.2%

Source: California Energy Commission
* Includes estimated 2010 POU deliveries of 8,822 GWh based on public records of signed contracts assumed eligible for the RPS.
** California's RPS targets are based on renewable procurement as a percentage of retail sales (excluding water pumping load). In 2010, California retail sales were 252,746 GWh.
*** Total In-state generation from the Total System Power was 205,018 GWh in 2010.

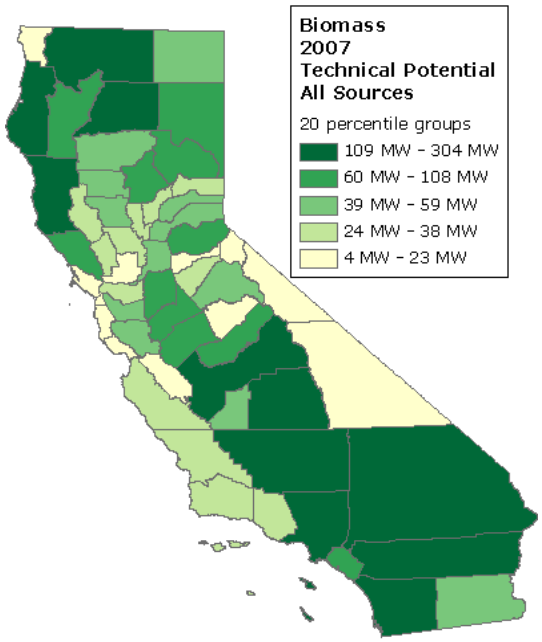
APPENDIX C: Renewable Technical Potential in California

Chapter 2 of this report discussed the high level of technical potential for renewable electricity generating technologies in California. This appendix provides additional information about that potential by technology and identifies some of the issues that will affect how much of that technical potential could ultimately be developed.

Biomass

Biomass generation currently represents nearly 20 percent of generation from in-state renewable resources,[632] but additional potential may be limited because of cost, air quality issues, and regulatory barriers. Existing biomass power generation capacity in the state totals 1,767 MW, which includes capacity from solid-fueled combustion power plants and engines, boilers, and turbines operating on landfill gas; sewage digester gas; and biogas from animal manures. In 2007, an assessment of biomass estimated technical potential for additional biomass development to be 3,820 MW; the assessment also suggested that by 2020 technical potential could reach 6,800 MWs as a result of resource growth and improvements in conversion efficiencies.

Figure C-1: Biomass Technical Potential by California County



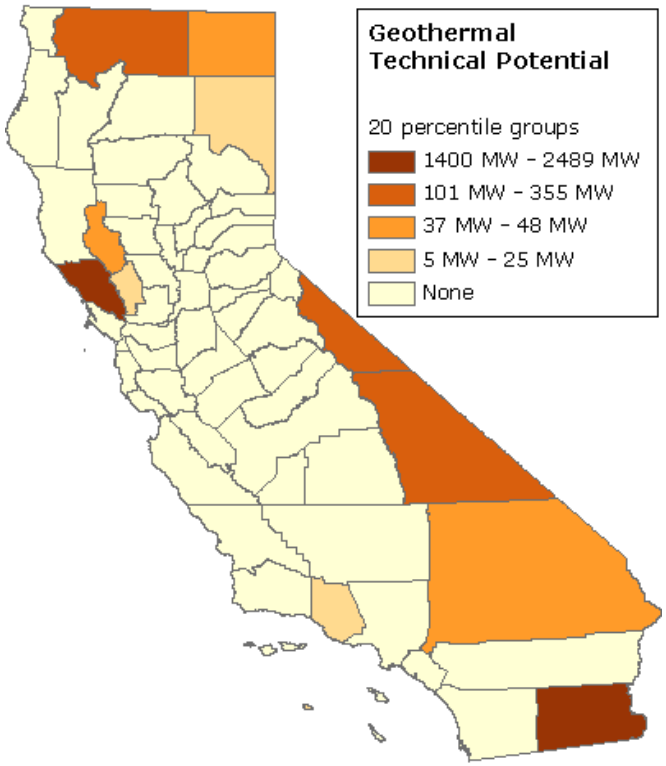
Source: California Renewable Resource Portal, Hhttps://calrenewableresource.llnl.govH.

Factors that could affect the amount of this technical potential ultimately developed include varying electricity prices and difficulty securing long-term contracts; permitting and utility interconnection challenges; fuels issues like feedstock prices, rules, and collection and delivery costs, as well as competition with the transportation sector for feedstocks; ability to meet local air quality regulations; issues with gas quality standards for biogas injected into utility pipelines; the ineligibility of some biomass systems for net metering programs; and lack of demonstrated commercial success for new technologies.

632 California Energy Commission, 2010 total system power, http://energyalmanac.ca.gov/electricity/total_system_power.html.

Key support programs for biomass technologies include the Energy Commission's Existing Renewables Program, which provides production incentives for solid fuel biomass facilities;[633] the CPUC's Renewable Auction Mechanism, a streamlined procurement process for renewable DG projects 20 MW or less in size;[634] state goals for meeting 20 percent of RPS targets using biomass resources;[635] the federal Investment Tax Credit and Production Tax Credit; and the *Bioenergy Action Plan*, which identifies strategies to address barriers to development of bioenergy in California.[636]

Figure C-2: Geothermal Technical Potential by California County



Source: California Renewable Resource Portal, Hhttps://calrenewableresource.llnl.govH.

Geothermal

Geothermal is a mature industry. There have also been many technology improvements and innovations over the past few years that have made geothermal energy one of the most cost-competitive renewable energy resources on a levelized cost basis.

Geothermal power plants provide 42 percent of in-state renewable generation. There are more than 40 geothermal power plants in California's geothermal resource areas with installed generating capacity of 2,574 MW. An additional 2,096 MW of capacity is in various stages of development.[637] California also imports geothermal power from the Southwest.[638]

633 The Existing Renewables Program is scheduled to expire at the end of 2011 unless the Public Goods Charge is reauthorized by the California Legislature.

634 California Public Utilities Commission, Renewable Auction Mechanism, http://www.cpuc.ca.gov/PUC/energy/Renewables/hot/Renewable+Auction+Mechanism.htm.

635 Executive Order S-06-06 commits California to a target of generating 20 percent of the state'srenewable energy from biomass by 2010 and maintaining this ratio through 2020.

636 California Energy Commission, *2011 Bioenergy Action Plan*, http://www.energy.ca.gov/2011publications/CEC-300-2011-001/CEC-300-2011-001-CTF.PDF.

637 Geothermal Energy Association, 2011. Stages of geothermal development include resource procurement and identification, resource exploration confirmation, permitting and initial development, and resource production and

Although the total geothermal resource base that could potentially support power generation is uncertain, the most recent estimate by the U.S. Geological Survey suggests that the additional, readily accessible resource in California is between 800 MW and 4,600 MW. Resources that are likely to exist, but which have yet to be discovered, could provide an additional ~3,200 MW to ~25,000 MW.

Geothermal steam resources can be depleted over time, leading to a reduction in electricity generation.[639] Another challenge facing geothermal development was the scheduled expiration of federal production tax credits in 2010, which discouraged investments in geothermal from 2005 onward.[640] Also, geothermal companies are forced to compete for access to drilling rigs and pipe with oil and gas companies, which typically have a larger market presence and incentives. Geothermal exploration is time-consuming because of the difficulty in establishing what, exactly, is in the subsurface. Other challenges include resource characterization (including steam quality and drilling depth), which could be addressed by technologies such as aerial or underground imaging for geothermal exploration. Particularly important and costly are studies required to define geothermal reservoir properties, volume, and geometry. Although there have been recent articles in the media regarding seismicity issues with geothermal projects, extractive industries such as geothermal, oil, gas, and mining have dealt with seismic activity for many years and have substantial experience in this area.[641] Areas of geothermal development are also areas of seismic activity, so it can be difficult to ascertain whether a particular seismic event is related to the geothermal activity or is naturally occurring. While geothermal activities can result in "micro-seismic activity" (in the range of 1-3 on the Richter scale), these events are not perceptible to humans and not considered a safety issue for plant operation.[642]

Support programs for geothermal resources include the RPS program; the federal Investment Tax Credit and Production Tax Credit; and the Energy Commission's Geothermal Program, which was established in 1981 and has cost-shared in research, development, and

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power plant construction. Seven of these projects are "unconfirmed;" the Geothermal Energy Association based information on these projects on publicly available information but did not confirm with respective developers.

638 California Energy Commission, 2010 total system power, http://energyalmanac.ca.gov/electricity/total_system_power.html.

639 See Chapter 9 for descriptions of PIER-funded projects to inject wastewater into geothermal wells for more effective energy production and to prolong the life of geothermal resources.

640 The American Recovery and Reinvestment Act of 2009 extended the production tax credit for certain renewable energy sources, including geothermal. See http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F.

641 See http://www.geo-energy.org/pdf/Geothermal_Energy_and_Induced_Seismicity_Issue_Brief.pdf, http://esd.lbl.gov/research/projects/induced_seismicity/references.html, and http://www.geothermal.org/GRCEGSBio.pdf.

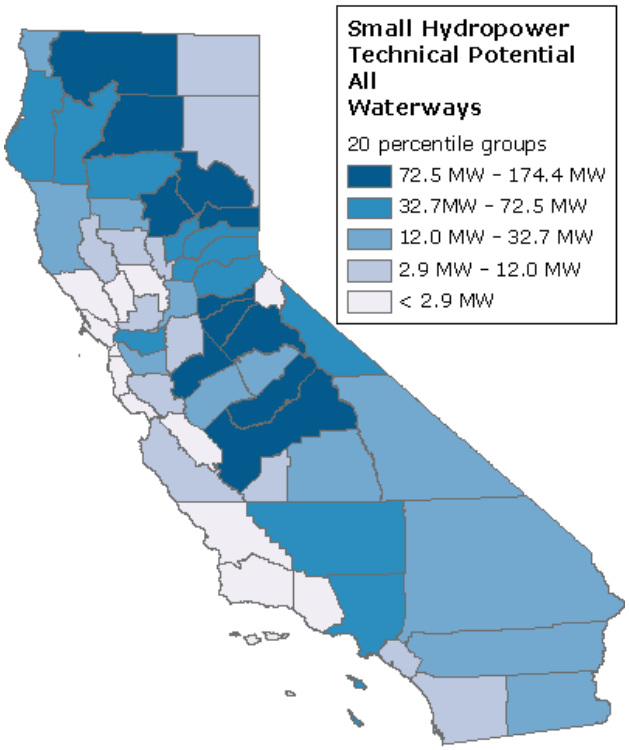
642 http://www.darlenecypser.com/induceq/induceq.html.

demonstration partnerships with more than 170 public and private entities through the Geothermal Resources Development Account.[643]

Small Hydroelectric

Small hydroelectric power, defined as systems 30 MW or less in capacity, represents 15 percent of in-state renewable generation.[644] Hydropower is considered to be a mature technology, and hydro projects with storage capability have some of the best operating characteristics of any renewable technology including dispatch predictability, ability to ramp up and down quickly, voltage control, high availability and reliability, and reactive power control for grid support when synchronous machines are used.

Figure C-3: Small Hydroelectric Potential by California County



Source: California Renewable Resource Portal, Hhttps://calrenewableresource.llnl.govH.

The amount of energy available from small hydro systems depends largely on snow and rainfall, so the amount of hydroelectricity produced varies significantly from year to year. Small hydroelectric power is typically highest in July and August and lowest in December and January. California has 1,386 MW of existing small hydro capacity, with an additional 7,011 GWh of potential capacity from man-made conduits and impoundments and natural waterways. Furthermore, some additional potential comes from increasing generation through retrofitting existing hydropower plants, adding turbines to existing dams lacking generation capacity, and undeveloped sites. Although hydropower energy is available in 52 of California's 58 counties, the counties with the highest potential lie in mountain ranges to the north and east of the Central Valley.

643 California Energy Commission, Geothermal Resources Development Account, http://www.energy.ca.gov/geothermal/grda.html.

644 California Energy Commission, 2010 total system power, http://energyalmanac.ca.gov/electricity/total_system_power.html.

Table C-1: California Small Hydropower

Resource Type	Capacity MW	Generation GW-h/year
Impoundments & Natural Waterways	1,927	5,880
Man-made Conduits	255	1,131

Source: California Energy Commission, *California Small Hydropower and Ocean Wave Energy Resources*, April 2005, CEC-500-2005-074. Capacity and annual energy production potential. Assumes that no site exceeds 30 MW combined existing and potential generation.

A variety of equipment options and plant configurations exist that can accommodate nearly every site condition. The equipment also has the added benefit of a long life of up to 50 years. Manufacturers continue to make mechanical and economic improvements to the equipment so that "water-to-wire" units will have reduced upfront costs of design and installation and are sized to fit the site. In addition many power facilities have been reconfigured, or their operations have been altered, to address adverse effects on stream flows and migrating fish.

Less than 10 percent of the hydropower units within the state are 30 MW or smaller. Units located in natural waterways may be operated as run-of-the river where the amount of energy produced at any one time is determined by the current flow in the river. The vast majority of run-of-the-river facilities within the state have a small generating capacity—usually less than one megawatt. Other facilities are associated with a dam that allows water to be retained in a reservoir and controls the amount and timing of generation. Downstream discharges from such facilities are controlled by a variety of factors, including retaining water for municipal and agricultural water supply, flood control, recreation, and environmental concerns. The Federal Energy Regulatory Commission (FERC), which permits all small nonfederal hydropower projects within the state, provides exemptions for small conduit projects (usually less than 15 MW) and for projects 5 MW or smaller. All other projects require a license from FERC. Challenges facing small hydropower development within California are often exacerbated by their remote location and include interconnection requirements and suitable market and permitting requirements.

Solar

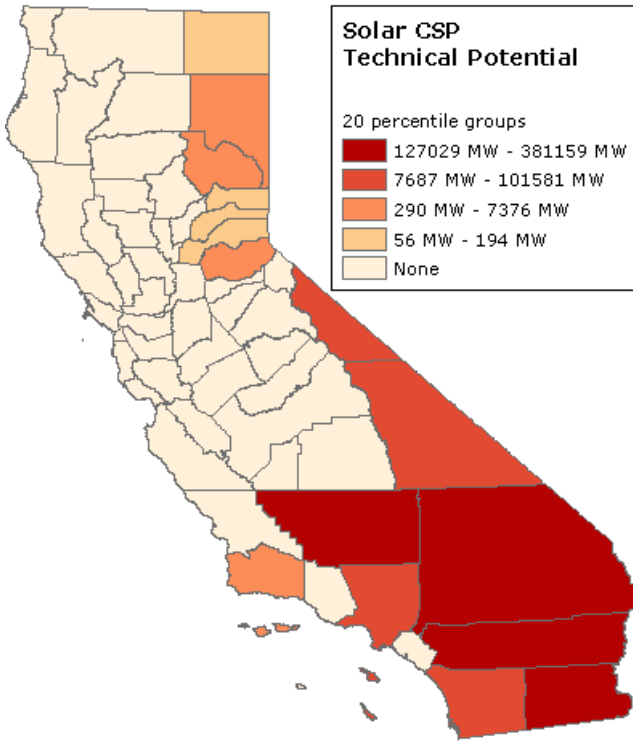
Generation from solar resources in California totals about 3 percent of in-state renewable generation.[645] Solar technologies in California include concentrating solar power (CSP) and photovoltaics (PV). Fundamental challenges in solar generation being addressed with active support from the U.S. Department of Energy and the solar industry include reducing overall cost, improving efficiency, and integration with energy storage technologies.

645 California Energy Commission, 2010 total system power, http://energyalmanac.ca.gov/electricity/total_system_power.html.

Concentrating Solar Power

Current installed capacity of CSP in California is less than 400 MW with an additional 2,473 MW characterized as "in development" as of June 2011.[646] In 2010, the Energy Commission approved licenses for nine CSP plants totaling 4,124 MW, a portion of which is included in the "in development" total. Three of these plants totaling 1,620 MW of capacity have begun construction.[647] Technical potential for CSP has been estimated to be as much as 1 million MW.[648]

Figure C-4: Concentrating Solar Power Technical Potential by California County



Source: California Renewable Resource Portal, Hhttps://calrenewableresource.llnl.govH.

CSP requires direct sunlight, and is only cost competitive when located in arid and semi-arid areas at low latitudes due to greater sunlight availability in these areas. This can be challenging since these areas are usually located far from existing transmission lines. Also, utility-scale solar developments require large tracts of land, roughly eight acres per MW; the nine solar projects approved by the Energy Commission are expected to require 44,937 acres or more than 70 square miles in California's desert. This significant land requirement can have impacts on species habitats, agricultural or recreational use, and cultural resources like Native American historical or ancestral sites. When CSP is combined with thermal storage, these plants can generate dispatchable electricity depending on daily resource constraints. Recent trends include a renewed interest in power towers that are capable of attaining higher operating temperatures than trough systems, and incorporating thermal storage to enable dispatchable generation and higher capacity factors.

Key support programs for solar thermal projects include the RPS program; federal loan guarantees and tax credits under the American Recovery and Reinvestment Act of 2009; and the federal Investment Tax Credit and Production Tax Credit.

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646 California Public Utilities Commission, "RPS Project Status Table – June," http://www.cpuc.ca.gov/PUC/energy/Renewables/index.htm.

647 See Chapter 3, Table 9: Status of Large-Scale Renewable Projects Under Energy Commission Jurisdiction.

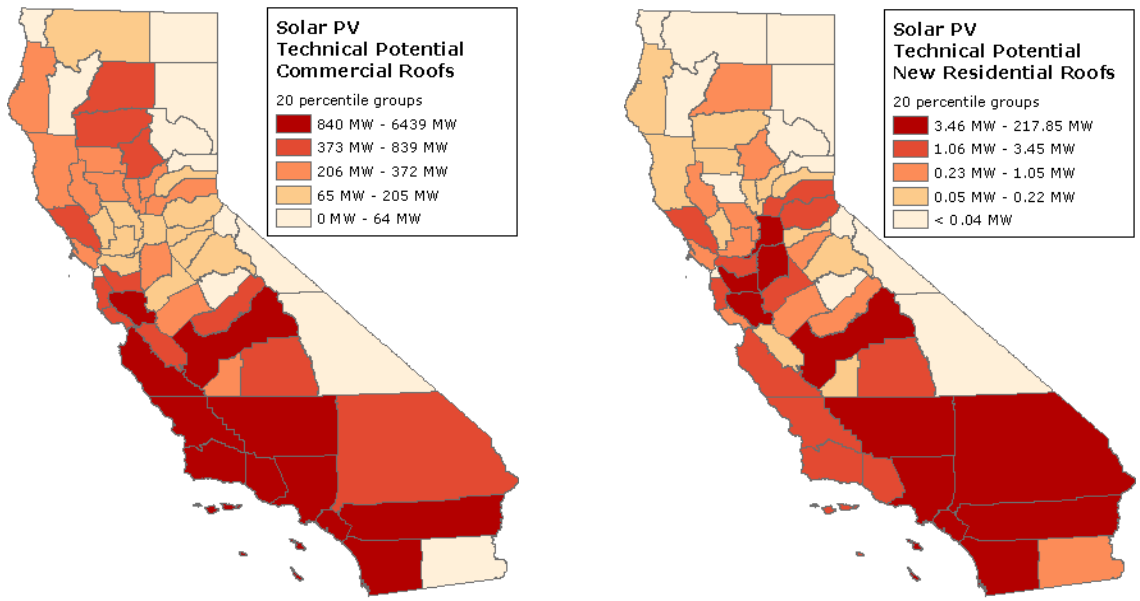
648 http://www.energy.ca.gov/2005publications/CEC-500-2005-072/CEC-500-2005-072-D.PDF.

Solar Photovoltaics

Installation of distributed solar generation continues to increase in California, with current installed capacity approaching 1 GW. Technical potential for PV, ignoring economic constraints and including both utility-scale and DG, has been estimated to be as much as 17 million MW.[649]

PV technologies can be installed at the distribution level, generating power at a home or business. PV can also be installed as a utility application, either near load centers to produce power for municipalities or in large remote installations, and connected to high voltage transmission resources. PV price and performance have improved consistently over the past several decades through technical innovation, and over the past few years costs have declined rapidly (see Chapter 8). Further cost-reduction efforts include the Department of Energy's SunShot Initiative, which has a goal of reducing the cost of solar energy systems by 75 percent before 2020 and bringing total installed cost for utility-scale solar to 6 cents/kWh without subsidies. However, PV still faces challenges since these technologies generate electricity only when sunlight is present and not on command and are therefore not dispatchable. In addition, like any intermittent resource, integration can be a challenge, as discussed in more detail in Chapter 5.

Figure C-5: PV Technical Potential for New Residential and Commercial Roofs by California County



Source: California Renewable Resource Portal, Hhttps://calrenewableresource.llnl.govH.

649 http://www.energy.ca.gov/2005publications/CEC-500-2005-072/CEC-500-2005-072-D.PDF.

Some CSP power plant project developers are converting their plants to use PV. There are several reasons for this switch including financing issues, the market crisis, the state of each technology, and reduced environmental review. In recent years there was a significant demand for PV, and development of this technology occurred at a highly rapid rate, resulting in significant cost reduction. In addition, compared to CSP, PV requires less initial capital investment.

There are a number of programs in California supporting DG PV, including the CPUC's California Solar Initiative, renewable feed-in tariff, and Renewable Auction Mechanism; utility PV programs; and the Energy Commission's New Solar Homes Partnership Program.

Wind

Wind resources provide 21 percent of California's in-state renewable generation. Wind is considered a mature technology but continues to face challenges due to intermittency of the resource, lack of transmission access in remote areas, and environmental issues. As of the end of 2010, there was 3,177 MW of on-shore wind generation installed capacity in California, with the American Wind Energy Association (AWEA) reporting an additional 594 MW under construction.[650] The majority of onshore wind development is concentrated in four regions of the state: Tehachapi, San Gorgonio Pass, Altamont Pass, and Solano-Montezuma Hills (Figure C-6). The Energy Commission's *Intermittency Analysis Project* conducted in 2007 indicated that there is 34,000 MW of economic potential for new wind development in California.[651]

Land-based wind turbines are commercially available from many companies and are cost-competitive with some conventional energy technologies both on an installed-capacity basis and on a cost-of-energy basis. Small, incremental improvements over the next few decades are expected to improve cost effectiveness by 30-40 percent through a combination of decreased capital cost and improved turbine performance. Areas of improvement include turbine components (rotors, gearboxes, and towers), power electronics and controls, and manufacturing.

Wind faces challenges because it is a variable resource, with average capacity factors ranging from about 20 to 40 percent, and cannot be dispatched at will, so it needs backup from other generation or storage. Abrupt changes in wind speed can also cause large and rapid changes in wind power output, which adds difficulty for system operators who plan for and mitigate these severe ramping events.[652] During low-load periods (for example at night), wind generation has the potential to overload the system with excess capacity and may need to be curtailed in

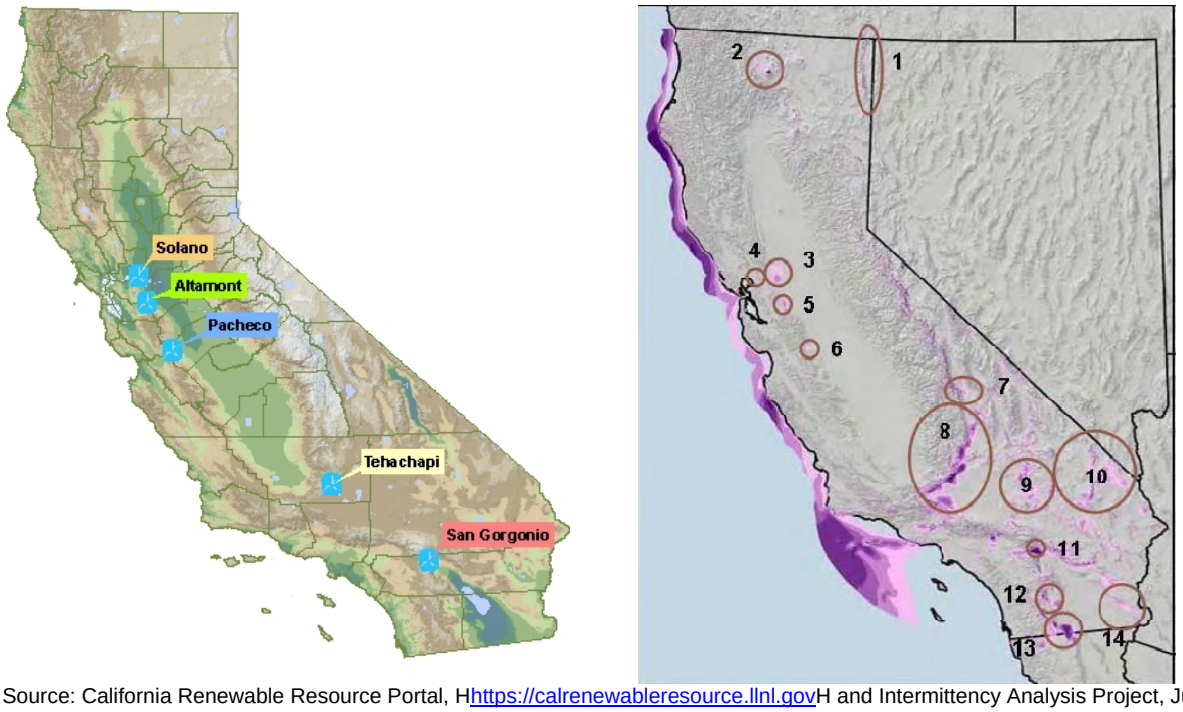
650 This total differs from the wind capacity shown in Table 4,:Installed In-State Renewable Capacity Providing Electricity to California Customers, due to the addition of a 150 MW wind project that came on-line at the end of 2010.

651 *Intermittency Analysis Project*, July 2007, CEC-500-2007-081.

652 Please see Chapter 5 for charts showing wind and solar variability.

absence of effective storage.[653] Regardless, utilities must continue to purchase the curtailed "generation" at agreed-to rates. If storage is not available, utilities may even have to pay other utilities to take this excess wind production in overgeneration periods.[654] On the other hand, if a utility can refuse to accept wind power whenever there are overgeneration conditions, it will not be financeable.[655] Wind is also a widely disbursed resource with many of the best resources occurring in remote areas with insufficient or no transmission. Existing transmission assets may need to be upgraded to accommodate additional wind resources.

Figure C-6: Wind Resource Areas in California and Locations for Additional Economic Potential



Source: California Renewable Resource Portal, Hhttps://calrenewableresource.llnl.govH and Intermittency Analysis Project, July 2007, CEC-500-2007-081

Wind also faces environmental challenges that include potential impacts on bird and bat populations from collisions with turbine blades, although siting guide development[656] and

653 *Transcript for the April 28, 2011 Integrated Energy Policy Report Committee Workshop on Energy Storage for Renewable Integration*, presentation by Mark Rothleder of the California ISO, http://www.energy.ca.gov/2011_energypolicy/documents/2011-04-28_workshop/2011-04-28_Transcript.pdf, page 45.

654 Ibid, page 57.

655 Ibid, presentation by Mark Irwin of Southern California Edison, pp. 191-193.

656 California Energy Commission, *California Guidelines for Reducing Impacts to Birds and Bats From Wind Energy Development*, October 2007, http://www.energy.ca.gov/2007publications/CEC-700-2007-008/CEC-700-2007-008-CMF.PDF.

ongoing research to help solve avian and bat mortality have lessened this to some degree.[657] These and other environmental issues associated with wind development are discussed in more detail in Chapter 3.

Support programs for wind development include the RPS Program and the federal Investment Tax Credit and Production Tax Credit. Programs targeted toward small wind systems include the CPUC's Self-Generation Incentive Program and Renewable Auction Mechanism; net metering; and the Energy Commission's Emerging Renewables Program.

Offshore Wind

Shallow water offshore wind technology has been commercialized in Europe but has not yet been deployed in the United States. However, there are 9 offshore wind projects totaling 2,322 MW of capacity proposed to be located along the Northeastern and Mid-Atlantic coastlines that are in the permitting and development process. Additional projects have also been proposed for the Great Lakes and Gulf of Mexico.[658] All of these projects are in shallow water and are accessible with existing technology. To date, there are no offshore wind projects being proposed off California, and the shallow water opportunities may be limited since only a very small portion of California coastal waters are 20 meters or less.

To date, no offshore wind projects have been installed in the United States and the development of an offshore wind power market still faces challenges. Nonetheless, significant offshore wind capacity exists off California's coast, mainly in deep waters. According to a Stanford University study, there is large potential for offshore wind along California's coast.[659] Potential was based on acceptable depths for three categories of offshore wind farms: 20 meter depth for monopile turbine foundations, 50 meter depth for multileg turbine foundations, and 200 meter depth for deep water floating turbines. Estimated potential from these three categories was 1.4–2.2 GW for deep-water monopile turbine foundations, or floating platforms, 4.4–8.3 GW for multileg turbine foundations, and 52.8–64.9 GW from floating turbine.[660]

Deep-water offshore wind is an emerging technology that is only now undergoing full-scale demonstration in Europe. Challenges facing development of offshore wind in California's deeper coastal waters include high cost, permitting and siting uncertainties, and technological limitations. Despite potential benefits offshore wind can provide the state, including superior capacity factors and proximity to load centers compared to onshore wind, until development of suitable (and affordable) deep water structures and floating platforms, significant offshore wind development will not occur off California's coast.

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657 See Chapter 9 and Appendix H for a description of ongoing research on bird and bat mortality.

658 Musial, Walter, and Bonnie Ram, *Large-Scale Offshore Wind Power in the United States: Assessment of Opportunities and Barriers*, September 2010, NREL/TP-500-40745, http://www.nrel.gov/wind/pdfs/40745.pdf.

659 Dvorak, Michael J., Cristina L. Archer, Mark Z. Jacobson. 2009. "California offshore wind energy potential."

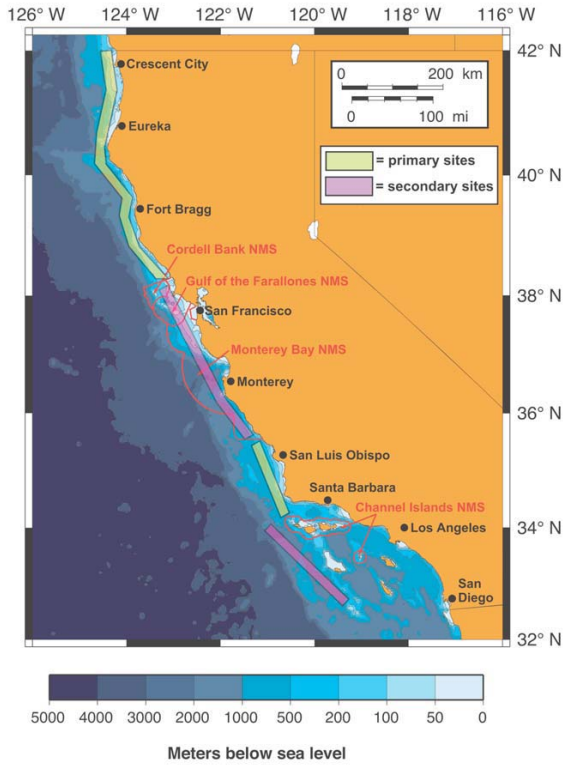
660 Ibid.

Potential environmental concerns with offshore wind turbines include interference and/or exclusion of other offshore activities like fishing or shipping, aesthetic impacts on scenic coastal viewsheds, seabird and bat interaction with turbines, disruption of marine mammal migration patterns, sea floor disturbance from anchors or power cables, and mooring line impacts on sea life such as whales.

Wave and Tidal Energy

Traditional tidal electricity generation involves building a barrage across an estuary to block the incoming and outgoing tide.[661] Newer technologies rely on free flowing kinetic power resulting in turbines that do not need dams or sluices. Golden Gate Energy Company has applied for permits for a project located in San Francisco Bay using free-flowing tidal energy devices.

Figure C-7: Wave Energy Potential in California



Source: California Ocean Wave Energy Assessment, CEC-500-206-119-D, May 2007

Wave energy technologies rely on the up-and-down motion of ocean waves produced by wind to generate electricity. Although ocean wave energy is still in its infancy, there appears to be significant wave resource potential offshore in the northern and central parts of the state.

While there is some potential in Southern California, those resources are located seaward of the Channel Islands, well offshore the Los Angeles and San Diego areas, and onshore transmission infrastructure. California has the potential to support wave energy due to large population centers in San Francisco and the Central Coast, high-energy wave climate, and deep water close to shore. A study funded by the Energy Commission indicated that California has 32,763 MW of ocean wave capacity available for development,[662] but this capacity is unlikely to be developed in the near future since technologies are not yet ready for commercial use. Some technologies are close to commercialization, while others are emerging. Recent experience with several projects

661 http://www.oceanenergycouncil.com/index.php/Tidal-Energy/Tidal-Energy.html.

662 *California Small Hydropower and Ocean Wave Energy Resources*, April 2005, CEC-500-2005-074, pg. 1.

proposed offshore California demonstrate that complex permitting issues, stakeholder skepticism, and high cost preclude wave energy as a near-term option in helping the state meet its renewable energy goals. Agency efforts to address regulatory challenges and projects such as the Reedsport OPT Wave Park in Oregon may help advance technologies and provide a roadmap for addressing other issues.[663]

663 The Reedsport project is likely to receive its construction/operation license by the end of 2011.

APPENDIX D: Renewable Net Short Input Variables

This appendix details the assumptions and method used to calculate the renewable net short estimates presented in Chapter 2. A standardized approach and set of assumptions to estimate the renewable net short will improve the ability to understand the context for studies and to transfer findings from one research area to another. This will also promote consistency and establish an analytical link between the different infrastructure studies, leading to better informed policy development. The proposed equation for calculating the renewable net short is as follows:

> *Renewable Net Short (TWh) = ((Projected Retail Electricity Sales – Energy Efficiency Programs – Combined Heat & Power Customer Services – Self-Generation Additions – Other Demand Reduction Programs) x Policy Goal Percent) – Generation From Existing Eligible Renewable Facilities*

The assumptions used for the renewable net short calculation are based on the most current electricity system assessments and projections. These inputs and assumptions are not static. They are constantly being revised and updated as new information becomes available. There are numerous studies and proceedings underway that will ultimately update some of the key input assumptions. The Energy Commission will update these variables each year to revise the renewable net short estimates.

Key Assumptions and Uncertainties That Affect the Renewable Net Short

Anything that reduces electricity retail sales – changes to the economy, energy efficiency program savings, rooftop solar photovoltaic additions, and other customer-side-of-the-meter distributed generation – will reduce the renewable net short. The need for additional renewable generation to meet policy goals also depends on how much renewable power is already flowing into the system. Estimates of the renewable net short will also change over time as forecasts of electricity demand change. These changes have been particularly noticeable in the last several years due to the effects of the economic downturn and the possible timing of a rebound. Similarly, uncertainties about meeting state goals for energy efficiency, CHP, and rooftop solar will affect the amount of renewable energy ultimately needed. The wide variation between estimates illustrates the need for common assumptions and counting conventions so that the public can be confident in both the goals and reported progress.

Prudent consideration of these kinds of uncertainties should be applied to renewable net short calculations and infrastructure studies. The use of a single-point forecast will not reveal potential economic and system reliability risks of an infrastructure investment decision.

Each of the elements of the renewable net short calculation has contributing sources and uncertainty factors included in this appendix and are organized as follows:

- Projected Retail Electricity Sales

- Retail Sales From California Energy Demand Forecast
  - Treatment of Transmission and Distribution Losses
- Demand Reduction Programs
  - Energy Efficiency Impacts
  - Incremental Self-Generation Goals
  - Incremental Combined Heat and Power
- Generation From Existing Eligible Renewable Facilities
  - Estimating Existing Renewable Generation

Projected Retail Electricity Sales

Projected retail sales are the foundation for the calculation of renewable goals and renewable net short. As part of the biennial *Integrated Energy Policy Report*, Energy Commission staff develops a full statewide energy and peak demand electricity forecast, the *California Energy Demand Forecast (CED),* which is the appropriate starting point for calculating the renewable net short.

The key drivers for the electricity retail sales forecast are population, household, and economic growth. Electricity retail sales forecasts also include assumptions for electrifying transportation sector, such as the Governor's 1 million electric vehicles goal. Economic growth remains highly uncertain, and conditions could change markedly within the next few years. The most current *CED* was prepared for the *2009 IEPR* and was recently updated to incorporate the latest economic assessments. The updated *2009 CED* electricity retail sales projection for the California load serving entities is 297.9 TWh by 2020. Staff also developed alternative retail electricity sales forecasts using more optimistic and pessimistic economic projections than used in the base case forecast, escalating the projection by 2.3 percent for a high case and -1.9 percent for the low end of the range.[664] The resulting retail electricity sales range is 292.5 TWh to 305.3 TWh for 2020. These statewide retail sales projections include water delivery agency electricity demand of 13.6 TWh, which must be subtracted for the renewable net short calculation.

There are other demand reduction policy goals and an expectation that some progress toward those goals will likely occur. These additional programs are not included in the *CED* forecast and must be considered as an adjustment to the electricity retail sales estimate for the renewable net short calculation. Other programs to consider include uncommitted energy efficiency programs, self-generation additions, and CHP policy goals.

Energy Efficiency Impacts

The Energy Commission's retail electricity sales forecast does not include all load reductions expected to occur or required by policy. The *2009 CED* incorporated committed utility efficiency

664 California Energy Commission, *California Energy Demand 2010-2020, Adopted Demand Forecast*, CEC-200-2009-012-CMF, p. 6.

programs[665] through 2012 (the end of the current three-year CPUC program cycle) for the investor-owned utilities and through 2009 for publicly owned utilities, along with efficiency codes and standards implemented through 2005.

Beginning with the *2009 CED*, staff also estimates potential uncommitted efficiency impacts[666] that are in addition to committed impacts. Forecasts of uncommitted energy efficiency impacts are subject to a great deal of uncertainty, given lack of firm funding. Estimates of committed utility program net impacts, both historical and projected, are also fairly uncertain. For example, efficiency measures might be purchased but not installed, or may not perform as expected. The most recent CPUC Evaluation Measurement &Verification study[667] for 2006–2008 IOU programs found utility-reported savings to be overstated. Staff therefore included an adjustment to the *2009 CED* forecast to reflect the lower percentages estimated in the CPUC study during the forecast period. The amounts of uncommitted efficiency for 2020 range between 15.2 TWh and 19.9 TWh, which are applied to the renewable net short calculations.

Incremental Distributed Generation Goals

Forecasted retail sales are calculated by subtracting projected private electricity supply consumed on-site (self-generation) from projected consumption. In general, projected self-generation is developed by trend analysis and then included in the IEPR demand forecast. Including the value of distributed generation (DG) in the renewable net short calculation is done if it is prudent to plan on more distributed generation than is already included in the IEPR demand forecast.

DG can be categorized two ways, self-generation and wholesale distributed generation. Self-generation is produced on site by consumers for their own use, while wholesale DG is a small generating station meant to serve electrical load elsewhere on the system. New self-generation from a DG project affects the calculation of renewable net short differently than wholesale DG. New self-generation DG will reduce projected retail sales by the amount of generation. Wholesale DG is sold into the electricity market instead of being used to serve the on-site electricity needs. The primary self-generation DG supply considered for the renewable net short calculation is the amount of electricity expected from small scale rooftop photovoltaic (PV) systems.

Assumptions about various DG policy goals affect the net short calculation in different ways. Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006) requires the California Air Resources Board (ARB) to develop regulations and market mechanisms that will reduce California's

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665 These include utility and public agency programs, codes and standards, and legislation and ordinances that have final authorization, firm funding, and a design that can be readily translated into characteristics that can be evaluated and used to estimate future impacts.

666 Uncommitted impacts include future initiatives that are less firm than committed yet reasonably likely to occur. Examples include utility efficiency programs beyond 2012 and Assembly Bill 1109 (Huffman, Chapter 534, Statutes of 2007).

667 http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/2006-2008+Energy+Efficiency+Evaluation+Report.htm.

greenhouse gas (GHG) emissions to 1990 levels by 2020. The ARB's *Climate Change Scoping Plan* for the implementation of AB 32 calls for 3,000 MW [668] (4.5 TWh of electricity) of additional self-generation rooftop PV beyond what was identified in the *2007 IEPR CED* forecast. New rooftop PV has been built since 2007 and must be adjusted in the *2009 IEPR CED* demand forecast.

In 2010, the *California Clean Energy Future,* a multiagency effort among state energy and environmental agencies and the California Independent System Operator to expand collaboration on state energy policies, set a new goal of 5,000 MW by 2020 for renewable distributed generation.[669] Work is underway to revise the Clean Energy Future goals to reflect the Governor's 12,000 MW goal. If fully subscribed, existing programs for renewable distributed generation would meet or exceed 5,000 MW by 2020:

- 3,000 MW of self-generation DG PV through the programs associated with Senate Bill 1 (Murray, Chapter 132, Statutes of 2006).
- 500 MW of wholesale generation DG PV through PG&E (half of the MW will be utility-owned; half will be provided by independent energy producers).
- 500 MW of wholesale generation DG PV through SCE (half of the MW will be utility-owned; half will be provided by independent energy producers).
- 100 MW of proposed wholesale generation DG PV through SDG&E (26 MW will be utility-owned; 74 MW will be provided by independent energy producers).
- 750 MW of wholesale generation (including non-PV DG, per SB 32) from existing feed-in tariff; plus an additional 66.5 MW contracted by SMUD.[670]
- 1,000 MW of wholesale generation (including non-PV DG) for the Renewable Auction Mechanism (RAM) decision that was adopted by the CPUC.[671]

Given the combined *AB 32 Scoping Plan* and California Clean Energy Future goals, increased PV additions are assumed to range between 2.3 TWh and 4.1 TWh for the renewable net short calculations.

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668 *Climate Change Proposed Scoping Plan Appendices*, Volume I: Supporting Documents and Measure Detail, Page C-121.

669 *California's Clean Energy Future - An Overview on Meeting California's Energy and Environmental Goals in the Electric Power Sector in 2020 and Beyond*, http://www.cacleanenergyfuture.org/2821/282190a82f940.pdf.

670 SMUD developed a feed-in tariff program for up to 100 MW. Part of the program was in response to Senate Bill 32, which increased the current feed-in tariff project capacity from 1.5 MW to 3 MW and also included an obligation for POUs. SMUD calculated that their portion of the 750 MW would be 33.5 MW and so designed their feed-in tariff to have two buckets. 33.5 MW for projects 3 MW and below and an additional 66.5 MW for projects 5 MW and below. Therefore, the 66.5 MW is above what would be required under Senate Bill 32.

671 For more information, please see:
http://www.cpuc.ca.gov/PUC/energy/Renewables/hot/Renewable+Auction+Mechanism.htm.

Incremental Combined Heat and Power

CHP projects are a specific type of distributed generation project that combines elements of both self-generation and wholesale DG. CHP reduces the need for an industrial customer to purchase electricity, thereby affecting the retail electricity sales forecast. Any number selected for use in a renewable net short calculation will be in addition to the amount already embedded in the *2009 CED*.

Staff included a range of possible CHP additions for the renewable net short calculation based in part on the AB 32 *Climate Change Scoping Order* and the 2009 *Combined Heat and Power Market Assessment.*[672] The *ARB Scoping Plan* set a goal of 4,000 MW of installed CHP capacity by 2020 that would displace about 30 TWh of demand from other generation sources.[673] The ARB also assumed that a substantial portion of existing CHP projects will continue to operate. The 2009 market assessment includes a range of incremental CHP capacity from 2,259 MW to 5,532 MW, with the amount serving the customer side of the meter ranging up to 90 percent, which would affect the renewable net short.

Based on these factors, the range of incremental CHP energy to be included in the preliminary renewable net short calculation is between 0 TWh and 16.2 TWh. The lower bound represents the possibility that all of the CHP generation will be sold to the grid or replacing existing facilities and will not affect the renewable net short. The higher bound captures the possibility of greater CHP development levels and increasing amounts of the generation serving owner loads to reduce overall retail electricity sales in California.

Estimating Existing Eligible Renewable Generation

To estimate the renewable net short, staff must consider renewable generation currently in place and expected to be operational for California retail electricity sales in the target year, both in-state and out-of-state. New generation is added each year or procured under contract, and the amount also fluctuates depending on weather conditions that affect the amounts of electricity produced by wind or solar.

The Energy Commission uses a combination of reported energy and capacity data to estimate the existing renewable generation for renewable net short calculations. The most current full year of generation data that has been submitted to the Energy Commission is 2010. For subsequent years, staff used an annual generation value for nonintermittent renewable projects that are operating in California. Small hydroelectric generation is averaged over five years to account for annual hydropower availability. For intermittent wind and solar, the reported installed capacity is used with an average capacity factor to estimate the amount of electricity that can be generated under normal weather conditions. Capacity factors are also applied to plants currently under construction that have power purchase agreements and are expected to

672 ICF International, Inc., prepared the Public Interest Energy Research (PIER) final project report *Combined Heat and Power Market Assessment*, CEC-500-2009-094, in October 2009.

673 California Air Resources Board *Climate Change Scoping Plan*, pp. 42-43.

be operational by the end of each update calendar year. (Capacity factors currently represent facilities anticipated to be on-line by December 31, 2011.)

Out-of-state renewable electricity generation delivered to California is based on the most recent set of Power Source Disclosure Program filings to the Energy Commission. Only imports associated with long-term contracts are applied to the imports estimate, since there is a degree of uncertainty about whether short-term transactions will continue to occur at current observed levels. Similar to the in-state small hydro generation estimates, an average of historical year generation is used to normalize water variations in out-of-state hydropower.

The total amount of existing renewable generation used for the renewable net short calculation is 34.3 TWh. The amount of electricity imports from renewable generation under long-term contract is 9.2 TWh.

APPENDIX E: Method for Setting Regional and Interim Targets for 12,000 MW of DG by 2020

Background

Staff presented a previous iteration of these regional targets at the Energy Commission's May 9, 2011 Integrated Energy Policy Report (IEPR) Committee Workshop titled "Distributed Generation – Getting to 12,000 MW by 2020." The current analysis is modified to reflect public comments from the workshop and continued staff analysis.[674] Changes from the May 2011 analysis include:

- More emphasis on development in low-income areas.
- An estimate of the potential capacity to interconnect on local distribution lines.
- A broader mix of technologies.
- A category of "undefined mix" instead of allocating all capacity as either behind the meter or wholesale. In this sense, the current analysis is less prescriptive and more open to future market developments.
- Targets allocated by region instead of county.

More information about the preliminary method that staff presented on May 9 is available at: http://www.energy.ca.gov/2011_energypolicy/documents/index.html#05092011

Overview

For this analysis, staff defines localized generation as renewable distributed generation projects 20 MW and smaller that are interconnected to the distribution or transmission grid. The scope includes both behind the meter installations to serve on-site load and projects that produce excess energy for wholesale. The analysis is intended to be technology neutral and includes solar, biomass, geothermal, wind, fuel cells using renewable fuel, and small hydro. Staff's analysis includes data from the beginning of the California Solar Initiative in 2007 and extends projections to 2020. The analysis is organized into three components:

- Behind the Meter – Staff assumes that past market trends are a proxy for the resource availability, interconnection availability, and local policies going forward. By 2020, staff assumes development of 3,300 MW on existing residential, commercial buildings; 564 MW of localized generation in low-income communities; 150 MW on new homes such that the SB 1 goal of building 50 percent of all new homes with solar power is achieved; and 700 MW in publicly owned utility service territories to meet their SB 1 goal. Staff also included

674 Staff's presentation and public comments from the workshop are available at: http://www.energy.ca.gov/2011_energypolicy/documents/index.html#05092011 A total of 31 parties representing utilities, environmental groups, developers, environmental justice advocates, and local government provided written comments to the Energy Commission.

estimates of the potential for wind and biomass development behind the meter, 200 MW and 275 MW, respectively. For the Self Generation Incentive Program and Emerging Renewables Program, staff assumes a combined total of about 24 MW will be developed. In total, staff estimates about 5,210 MW of behind-the-meter development.

- Wholesale Generation – Staff also estimates regional development of wholesale distributed generation. Staff assumes that proposed, wholesale distributed generation facilities 20 MW and smaller that are under contract or are going through the environmental review process would be developed. Staff recognizes that some portion of projects will fail, but assumes that projects under contract or in environmental review show a level of investment at specific sites that may be indicative of future market interest. Staff also assumes that 700 MW would be developed as a result of feed in tariff programs in Los Angeles (600 MW) and in the Sacramento Municipal Utility District (100 MW) service territory. Staff identifies about 3,420 MW of wholesale generation.
- Distribution Grid Interconnection Capacity – Staff estimated available capacity to install generation on the distribution system to verify the feasibility of further regional goals. Staff identifies roughly 11,000 MW of technical potential capacity to interconnect in the investor-owned utilities' (IOUs) service territories. This category is not defined as wholesale or behind the meter, but rather could be any mix of the two applications. Also, this category is not technology specific and could include solar, wind, biomass, fuel cells fueled by renewable resources, and perhaps small hydro. Staff combined the region-specific wholesale data and behind the meter data for a total of 8,630 MW. Staff assumed that the remaining 3,370 MW needed to meet the 12,000 MW goal would be developed to meet the Governor's policy goals, keeping in mind the constraint of available capacity on the distribution grid. Staff is assuming that the remaining 3,370 could be either behind the meter or wholesale and could be any number of technologies.

Staff compiled the data into targets for 13 geographic regions based on the following county groupings:

- Inland Empire: San Bernardino, Riverside
- Central Valley: Kern, Kings, Tulare, Fresno, Madera, Merced, Stanislaus
- Sacramento Region: San Joaquin, Solano, Sacramento, El Dorado, Placer, Nevada, Yuba, Sutter, Yolo
- East Bay: Contra Costa, Alameda
- Central Coast: Santa Cruz, San Benito, Monterey, San Luis Obispo, Santa Barbara, Ventura
- Los Angeles (both city and county)
- Orange County
- San Diego County
- Imperial

- SF Peninsula: San Francisco, San Mateo, Santa Clara
- North Bay: Sonoma, Napa, Marin
- Sierras: Amador, Calaveras, Alpine, Tuolumne, Mariposa, Mono, Inyo
- North Valley: Lake, Colusa, Glenn, Butte, Sierra, Plumas, Mendocino, Tehama, Lassen, Shasta, Trinity, Humboldt, Del Norte, Siskiyou, Modoc

Table E-1 shows staff's estimates by region for development of behind the meter, wholesale, and an undefined mix of behind the meter and wholesale projects.

Table E-1: Summary of Proposed Regional Targets by 2020

Region	Behind the Meter (all technologies)	Wholesale	Undefined Mix (behind the meter and wholesale)	Total
Central Coast	280	90	0	370
Central Valley	830	1590	0	2420
East Bay	420	30	0	450
Imperial	50	90	0	140
Inland Empire	480	430	0	910
Los Angeles*	970	860	2,170	4,000
North Bay	220	0	0	220
North Valley	120	50	0	170
Sacramento Region	410	170	220	800
San Diego	500	50	630	1,180
SF Peninsula	480	10	310	800
Sierras	30	40	0	70
Orange	420	10	40	470
Total	**5,210**	**3,420**	**3,370**	**12,000**

*city and county of Los Angeles

Source: Energy Commission Staff

Behind the Meter

Staff assumed that the state's SB 1 goals will be met through the continuation of current market trends. Described below is the method for developing regional targets for the California Solar

Initiative, Multifamily Affordable Solar Housing program, Single-family Affordable Solar Homes program, New Solar Homes Partnership, Self Generation Incentive Program and Emerging Renewables Program, and Publicly Owned Utility SB 1 programs. To include nonsolar technologies behind the meter, staff also estimated potential wind and biomass development by region.

California Solar Initiative

Data source for PV installation: http://www.californiasolarstatistics.org/current_data_files/

The California Solar Initiative (CSI) program provides two data sets to the public, a working data set and a raw data set. Staff used the working data set because applications with data errors were removed from it. Staff included projects that were installed, received funding, or for which funding was reserved between January 1, 2007, and June 15, 2011.[675] The total allocation of solar PV for the California Solar Initiative is 3,300 MW.

Staff categorized projects by year based on the "First Reservation Request Review Date." Staff used this filter because it was identified for all projects regardless. Staff made the following assumptions:

- There were a few projects that had a "First Reservation Request Review Date" from the end of 2006. These projects were added to the 2007 category.
- Due to budgetary constraints, the CSI program is not currently issuing reservations but is still accepting applications. These applications are added to a waitlist and will be processed as funding becomes available. Staff assumed that additional funding for the CSI program would become available in 2012, and so all waitlisted projects were added to the 2012 category.
- Because the data points were kilowatts (kW) reserved annually, and the CSI program is not currently issuing reservations, staff assumed that the capacity reserved to date in 2011 would be the total capacity reserved for the entire year.[676] Staff then used project location information to categorize each project by the 13 regions used in this analysis.
- Staff identified the number of MW reserved per region and assumed the same trends would continue until the goals of the CSI were met. The data from 2007 to 2011 were plotted and the best fitting trend line was selected to come up with regional projections through 2020.

675 Staff included all projects that had a current status of "reservation" or a stage beyond that. Staff included projects that had a status of "Pending RFP-Reservation Reserved," "Pending Payment" and "System Removed." Staff did not include projects that had a current status of "Cancelled" or "Withdrawn."

676 Using the reservations that had occurred so far for 2011 to represent the reservations for all of 2011 would have affected the trends for some regions more than others, especially those areas that had seen a high number of reservations in the previous year or two, and then showed a large drop in 2011 due to only having a half year of reservations.

Multifamily Affordable Solar Housing

The California Public Utilities Commission (CPUC) implements the Multifamily Affordable Solar Housing (MASH) program to provide incentives for PV development on existing, low-income multifamily residences. The MASH program is one of the CSI's two low-income programs. The MASH program is structured to offer incentives under two "tracks." Although Track 1 is now closed, it provided upfront incentives for eligible photovoltaic (PV) installations on low-income residential units or common areas. Track 2 is still open and provides incentives through a bid process. Staff used program data for Track 1 incentives for Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E). Staff chose not to use Track 2 data because there is an inconsistent correlation between project size and rebate level, which made it problematic to extrapolate trends.

To estimate how much solar could have been installed if MASH continued through 2020, staff first identified the duration of the Track 1 program for each utility. PG&E's, SCE's, and SDG&E's programs lasted 9, 12, and 17 months, respectively.[677]

Staff extrapolated program activity to the end of 2020, assuming that it would have remained constant over time. For each utility, staff divided the amount of time from the end of the program to 2020 by the program duration. This resulted in a factor of 15 for PG&E, 11.25 for SCE, and 8 for SDG&E. Staff multiplied these factors by the number of MW installed in each county at the close of Track 1. The result was 244 MW of potential PV installation in multifamily low-income housing.

Single-Family Affordable Solar Homes

The CPUC also oversees the Single-Family Affordable Solar Homes (SASH) program, which provides incentives for PV installations on eligible, existing, low-income homes. The SASH program is also under the CSI. The SASH PV-solar incentive is available to qualifying low-income homeowners in the PG&E, SCE, and SDG&E service territories.[678]

The CPUC contracted with Navigant to do a market assessment of the SASH program. Navigant concluded that there are 128,000 SASH-eligible households in Enterprise Zones (EZs) in the IOU service territories.[679] With an average system size of 2.5 kW in the SASH program,[680] single-family low income homes represent a market potential of 320 MW.

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677 http://www.cpuc.ca.gov/NR/rdonlyres/C0EEF9DF-1EF4-4C9A-965D-683205D59293/0/MASHSemiAnnualProgressReport_July2010.pdf, page 14.

678678 California Public Utilities Commission, *Single-family Affordable Solar Homes (SASH) Program Q1 2011 Program Status Report*, April 2011, www.cpuc.ca.gov/NR/rdonlyres/BE2A2B11-A16A-4687-A556-39E337E9F1E4/0/2011Q1SASHREPORT.pdf.

679 Page 27: http://www.cpuc.ca.gov/NR/rdonlyres/EB601615-61B3-43B2-B034-EEC95AF46708/0/CSISASHandMASHMarketAssessmentReport.pdf.

680 Page 8, http://www.cpuc.ca.gov/NR/rdonlyres/BE2A2B11-A16A-4687-A556-39E337E9F1E4/0/2011Q1SASHREPORT.pdf.

Staff uses data on SASH installations to estimate the regional distribution of the potential identified by Navigant, assuming that all 128,000 eligible households identified will install PV. Staff first identifies the county and then EZ for systems installed in a county with an EZ. Although there are 42 EZs statewide, the SASH data covers only the IOU service territories. Also, not all EZs in the IOU service territories have participated in SASH. To estimate distribution, staff calculates the percentage of PV installed in each EZ relative to all PV installations in EZs and then multiplies this percentage by the 128,000 household potential. Staff then multiplies the number of homes in each county by the average 2.5 kW project size to estimate SASH development per region.

New Solar Homes Partnership (NSHP)

The NSHP is administered by the Energy Commission and provide rebates for PV installations at newly constructed homes. Staff accounted for projects approved for reservation from January 1, 2007 – July 7, 2011 by county. This totals about 31.5 MW. Staff assumed that the 400 MW NSHP program target would not be met due to the following reasons:

- The depressed housing market
- The NSHP program is for new residential construction. Projects reserved for this program may not be realized for one to three years, and the PV installation is dependent upon the builder obtaining and maintaining financing for the construction of the new home(s).
- The incentive for the PV system is tied to the new home achieving specified energy efficiency levels. Even with decreasing equipment costs, builders may not be able to afford the costs associated with achieving the required energy efficiency levels.

Staff assumed a slower growth trajectory for the new homes market, returning to the 150,000 new unit level of the early 2000s, but not the highs of 2004 to 2006.[681] Staff assumes that the program will be successful in achieving its goal of placing PV systems on 50 percent of new homes by the end of the program. Staff's analysis of the NSHP installations shows that the average size for all installed or reserved systems is 2.63 kW. Excluding installations and reservations for common areas, the system size decreases to 2.38 kW. Staff assumed an average system size of 2 kW in part to reflect a market trend toward smaller systems[682]. Also, the assumption that system sizes will continue to get smaller reflects the NSHP program emphasis on properly sized systems. As the energy efficiency requirements increase, the systems should be smaller. Based on the assumed level of housing starts and applying an estimated average system size of 2 kW, staff estimated that 150 MW would be installed through NSHP.

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681 http://www.cbia.org/go/cbia/?LinkServID=FE5ED931-F09E-44C7-96836630388F21F7&showMeta=0.

682 http://www.cbia.org/go/cbia/government-affairs/cbia-reports1/june-18-2010/square-footage-shrinking-in-new-american-homes/?keywords=new http://www.nahb.org/news_details.aspx?newsID=11485&fromGSA=1 .

Staff categorized systems by year of their payment approval date. In the NSHP program, developers apply for funds and then make a payment claim after the project is complete. Staff assumes that all NSHP applications would result in completed projects within the time frames required by the program as follows:

- Staff assumed that systems reserved in 2007 that have not yet received an incentive payment would be completed in 2011, systems reserved in 2008 would be completed in 2012, and systems reserved in 2009 would be completed in 2013. These completion dates correspond to the latest possible date before the project application expires.
- Staff assumed that systems reserved in 2010 that have not yet received an incentive payment would be completed in 2012, and unpaid systems reserved in 2011 would be completed in 2013. Staff assumed these systems would be completed and would receive payment in two years instead of three years due to changes to the NSHP program that allow housing developments to be split up into multiple applications. This allows applicants to apply for funds in time frames that better match their build-out schedules.
- Since available 2011 payment data accounts only for half of the year, staff assumed an equal capacity of systems would be paid in the second half of the year.

Staff then calculated the installed capacity from 2007 to 2011 per region and the percentage of capacity per region. The percentage for each region was then multiplied by 150 MW to estimate the MW per region in 2020.

Publicly Owned Utilities (POUs)

Staff assumes that the POUs will meet their SB 1 targets. Collectively, the target for all POUs is 700 MW. The City of Lompoc and Plumas-Sierra Electric Cooperative did not provide the Energy Commission with their SB 1 megawatt goals. To determine their MW projections, staff developed a trend line with the existing data from 2007 to 2010, and the projections for 2011 through 2016 are based on the extension of the trend line.

Self-Generation Incentive Program and Emerging Renewables Program

Staff identified DG installations under the CPUC's Self-Generation Incentive Program (from 2007 to present) and all non-PV installations under the Energy Commission's Emerging Renewables Program from 2007 to April 28, 2011.

The data for the Self-Generation Incentive Program is available at: https://energycenter.org/index.php/incentive-programs/self-generation-incentive-program/sgip-documents/sgip-documents. Staff first categorized the projects by year based on their payment date. They were further categorized by county and then region. The statewide total is 22 MW.

The data for the Emerging Renewables Program is available online at: http://www.energy.ca.gov/renewables/emerging_renewables/index.html. Staff first categorized the projects by year based on their payment date, then by county and region. The regional totals added up to 1.92 MW.

Estimate of Biomass and Wind Potential

Staff made a rough estimate of biomass potential from dairy cattle populations. Preliminary work from Central Valley dairies indicates that every 6,000 cattle can produce 1 MW of electricity production from manure.[683] Staff selected counties with dairy cattle populations greater than 6,000 and concluded that the potential from manure is about 275 MW.

To estimate wind potential, staff used an estimate from Foundation Windpower, which identified about 100 MW of projects in various stages of construction, permitting, development, negotiation, or proposal.[684] Foundation Windpower representatives also stated that they believe there is at least an additional 100 MW of potential projects in California. Table C-26 shows the estimates of wind potential by region.[685]

Table E-2: Allocation of Small Wind Potential by Region

Region	MW
Central Valley	30
North Bay	10
Los Angeles	10
East Bay	20
Central Coast	50
Inland Empire	50
Imperial	10
Orange County	10
San Diego County	10
TOTAL	**200**

Wholesale Distributed Generation

Energy Commission staff is maintaining a list of renewable energy projects sized 20 MW and smaller that are under environmental review or permitted at the state or local level in California in 2010, 2011, and 2012.[686] The Energy Commission also maintains databases for renewable facilities under contract to the investor-owned utilities (IOUs) and the publicly owned utilities.[687]

683 Personal correspondence with Paul Fukumoto of Flex Energy on July 6, 2011.

684 Personal correspondence with John Pimentel of Foundation Windpower on July 13, 2011.

685 Foundation Windpower suggested 20 MW wind in Orange and San Diego Counties combined. For the purpose of this regional analysis, staff assumed 10 MW in each county.

686 The data on environmental reviews used for this analysis was last updated on June 14, 2011.

687 For this analysis, staff used the database on IOU-RPS contracts that was last updated in April, 2011 and the POU database was last updated November 17, 2010.

The IOU contract database is available at: http://www.energy.ca.gov/portfolio/IOU_Contract_Database.xlsx.

The publicly owned utility contract database is available at: http://www.energy.ca.gov/2008publications/CEC-300-2008-005/CEC-300-2008-005_rev.xls.

Staff carefully reviewed the Energy Commission's IOU and publicly owned utility contract databases and the environmental review project database to remove projects that were on-line before 2007, located out of state, were behind the meter, or exceed 20 MW, including project expansions that increased the overall project size to a capacity of more than 20 MW. Staff also removed projects that were determined likely to fail, such as a tidal generation project. However, staff does not have detailed information on all the projects to make these determinations, and as a result there may be minimal double counting or inclusion of projects that serve on-site load. Staff identified 645 MW under contract and 2,320 MW going through environmental review at the local level, and about 197 MW both under contract and environmental review.

Staff intended to identify projects under contract or in environmental review that were also in the distribution and transmission interconnection queues, but were only able to obtain the necessary data to identify the projects located in the California Independent System Operator's (California ISO) generation interconnection procedure (GIP) queue. Staff did this analysis through a review of confidential data received from the California ISO from a quarterly subpoena. To date, staff has been unable to determine the WDAT queue status of the projects due to Federal Energy Regulatory Commission restrictions on data confidentiality.

Next, staff assigned regions to the wholesale projects by the county in which the project is located. Staff used Microsoft Excel®'s pivot table function to divide the projects into the categories shown below, also by region and technology.

- Wholesale projects that are on-line, 50 MW.
- Wholesale projects in the environmental review database, the IOU or POU contracts database, and the GIP interconnection queue, 20 MW.
- Wholesale projects in the IOU or POU contracts database and the environmental review database, 197 MW.
- Wholesale projects in the IOU or POU contracts database and the GIP interconnection queue, 0 MW. (One project would qualify for inclusion in this category, but because it is also under environmental review, the project is included under the second bullet.)
- Wholesale projects in the GIP interconnection queue and the environmental review database, 169 MW.

Estimated Potential for Interconnection at the Distribution Level

For the final piece of analysis, Energy Commission staff investigated California's distribution infrastructure, hoping to gain visibility into which geographic areas had capacity to

interconnect distributed generation projects without requiring extensive upgrades. Following the California Public Utilities Commission's (CPUC) Rule 21 guidelines, staff estimated total distributed generation interconnection capacity by first applying a screen based on "15 percent of the distribution line section annual peak load,"[688] commonly referred to as "excess capacity." Next, staff estimated region's total available capacity by adding in its queued and waitlisted CSI and NSHP capacity, and its previously calculated wholesale capacity. This final number, a region's total capacity available for localized generation, estimates a cap on feasible interconnections on current infrastructure. Staff assumes that projects developed in areas with available capacity will have low interconnection costs. However, staff recognizes that application of the 15% screen does not guarantee that project development will not require costly circuit upgrades to accommodate interconnection. Also, staff recognizes that although a line may have interconnection capacity, there may not be adequate space available to develop a project, or there may be other site constraints that preclude development.

Staff generated estimates for 9 of its 13 identified regions. For this effort, the Energy Commission requested substation capacity information calculated under the CPUC's Renewable Auction Mechanism procurement program from the state's three largest investor-owned utilities. The utilities made this data available to the public in a limited fashion through the Renewable Auction Mechanism maps, which are accessible through each utility's website. Considerable heterogeneity exists between different utilities' data, which constrained staff's ability to conduct the analysis. PG&E provided geographic data for all of its substations; SCE and SDG&E did not. For this reason, staff made the simplifying assumption that all of SDG&E's substations were in San Diego County, despite the fact that SDG&E's territory extends into southern Orange County. The Energy Commission staff did not obtain data from publicly owned utilities or smaller investor-owned utilities, and therefore does not have excess capacity numbers for Imperial County, Los Angeles, Orange County, or the Inland Empire. The numbers provided for Central Coast, Central Valley, East Bay, North Bay, North Valley, SACOG, SF Peninsula, and Sierras only reflect capacity on the PG&E distribution grid.

SCE provided interconnection potentials that were originally calculated for their Solar Photovoltaic Program (SPVP). This program sought to encourage the installation of 1 to 2 MW rooftop solar PV systems. SCE capped each line's interconnection potential at 2 MVA, following the Merchant Plant interconnection under the federal WDAT application. This cap remained in place for the numbers provided for staff's analysis, making it unclear just how reflective the provided capacities are of SCE's true interconnection potential. Instead, staff attempted to use public information from SCE's RAM program.[689] Unfortunately, SCE's RAM maps identify only preferred geographic areas for interconnection, without including any indication of an area's interconnection potential. Nevertheless, SCE has stated that their RAM program target is 500 MW; looking at the maps provided, Energy Commission staff estimate that at least one tenth of

688 California ISO's Small Generator Interconnection Procedures: http://www.caiso.com/27c3/27c3ecd2556e0.pdf.

689 The maps are available at: http://www.sce.com/EnergyProcurement/renewables/renewable-auction-mechanism.htm.

this appears to be along the Central Coast. Based on these basic parameters, staff added 50 MW of excess capacity to the Central Coast region.[690]

Staff used the calculated available capacity for each region as a ceiling for a region's capacity to accommodate relatively inexpensive interconnection, seeking to ground a region's total goal in feasible possibilities for future project development. Ultimately, however, these regional goals reflect policy decisions. Therefore, staff used regional targets set by the Governor's Office,[691] which took economic development and resource potential[692] into account, in addition to other considerations, to set their overall distribution. Staff's analysis and projections for wholesale and behind-the-meter installations resulted in some areas exceeding these regional targets. This meant that the Governor's Office goals were used as a guideline for the final capacity allocation, but staff's final projections do not perfectly match these original allocations.

The results of this analysis are a rough cut for development potential. As California strives to integrate more distributed generation into the grid, the shortcomings of Rule 21 and its underlying screen have become more apparent. Stakeholders and utilities have convened workshops to revise these guidelines, recognizing that technology, existing distribution and substation infrastructure, and facility characteristics are also important in determining grid impacts.

The resulting goals distribute local generation across the state, focusing on urban centers like Los Angeles and San Diego that have relatively good climate and available space relative to the San Francisco Peninsula and East Bay regions, and areas of high resource potential, like the Central Valley. Staff's final distribution places 571 MW on the Central Coast, 2054 MW in the Central Valley, 682 MW in the East Bay, 147 MW in Imperial County, 1000 MW in the Inland Empire, 3842 MW in Los Angeles, 223 MW in the North Bay, 316 MW in the North Valley, 740 MW in SACOG, 1091 MW in San Diego, 770 MW on the San Francisco Peninsula, 66 MW in the Sierras, and 500 MW in Orange County.

Challenges

Staff recognizes that there are several challenges with this method. One challenge is developing a common definition of a renewable localized generation facility to clarify discussion and planning related to achieving the Governor's goal for 12,000 MW of renewable localized generation by 2020.

Staff recognizes that achieving the assumption for aggressive development in low income housing areas totaling 564 MW will be challenging. The analysis assumes that installations

690 Ventura County and parts of Santa Barbara are in SCE's territory, while PG&E serves the rest of the Central Coast region.

691Presentation by Michael Picker at the May 6, 2011, Integrated Energy Policy Report workshop, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-09_workshop/presentations/02b_Off_of_Gov_Picker_Background.pdf.

692 The estimate of technical potential was based on a NREL/Lawrence Livermore study available at the California Renewable Resource Portal, January 28, 2010. www.calrenewableresource.llnl.gov/solar/potential-by-county.php.

under the MASH program's Track 1 continue on the initial program activity trajectory, despite the closure of the rebate due to lack of funding. According to the MASH semiannual progress report, there has been 2.031 MW installed through Track 1.[693] There is no data on installation for Track 2, but so far only 1.327 MW has been reserved. Staff estimates that if MASH had continued on its current trajectory through 2020, there would be 244 MW installed on multifamily low-income housing. Clearly, there is a large disconnect between program progress to date and the policy direction pursued through these regional targets.

For the SASH program, the method assumes buildout of the technical potential in the Enterprise Zones of PG&E, SCE, and SDG&E service territories, totaling about 320 MW. The SASH Program budget is $108.34 million, with $92 million allocated to incentives. As of the first quarter of 2011, 992 homes requested $17 million in incentives, for 2 MW of solar.[694] If SASH continues on its current trajectory, an estimated 5,700 solar homes would be incentivized by the end of the program, for roughly 14.5 MW. Achieving the targets proposed in this paper for low income housing will be extremely challenging.

Another challenge is that some of the most promising, and possibly least-cost, resource areas are in the Central Valley where load is relatively low. Wide-scale development of distributed generation in the Central Valley may not be "localized" resources and may not create as many jobs in low-income areas, but may be a lower-cost course of development in a time when the state is undergoing a financial crisis.

Also, this method largely builds off market trends as a proxy for future development. This approach does not account for new developments that are not yet considered in the market. Further, staff is reviewing comments from the Governor's Conference on Local Renewable Energy Resources and the May 9, 2011, workshop to further refine these targets and explore other options beyond a market-based approach.

693 ftp://ftp.cpuc.ca.gov/gopher-data/energy_division/CSI/MASHSemi-AnnualProgressReport_Feb 2011.pdf.

694 http://www.cpuc.ca.gov/NR/rdonlyres/BE2A2B11-A16A-4687-A556-39E337E9F1E4/0/2011Q1SASHREPORT.pdf.

APPENDIX F: Description of Transmission Projects Needed to Support California Renewable Energy Mandates

Sunrise Powerlink Transmission Project

The San Diego Gas & Electric Company's (SDG&E) 117-mile Sunrise Powerlink is under construction and is expected to be in service by 2012.[695] The project will increase the import capability into San Diego from the renewable energy rich Imperial Valley by an additional 1,000 MW for a total of 1,700 MW. As of May 24, 2011, the California Independent System Operator (California ISO) Interconnection Queue included more than 7,600 MW of renewable generation in Imperial County that could use the Sunrise Powerlink to provide power to SDG&E and the rest of California.[696] There are also another 3,000 MW of renewable generation in the Imperial Irrigation District (IID) Interconnection Queue that could make use of the Sunrise Powerlink.[697]

Tehachapi Renewable Transmission Project

Southern California Edison's (SCE's) Tehachapi Renewable Transmission Project (TRTP) will provide the electrical facilities necessary to integrate new wind generation – up to about 4,500 MW – in the Tehachapi Wind Resource Area and accommodate solar and geothermal projects either planned or expected in the future. As of May 24, 2011, the California ISO interconnection queue had 13,774 MW of renewable generation in Kern County and 2,390 MW in Los Angeles County that could use transmission capacity provided by the TRTP.[698]

The TRTP addresses reliability needs of the California ISO-controlled grid due to projected load growth in the Antelope Valley and the South of Lugo transmission constraints in Hesperia, California. The project includes more than 300 miles of new and upgraded high-voltage electric transmission lines and substations to deliver electricity from new wind farms planned by independent power producers in eastern Kern County to the Los Angeles Basin. A new major substation component of the TRTP, SCE's Whirlwind facility, is under construction and is expected to be completed in 2113.[699] The entire project is expected to be completed by 2015.[700]

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695 http://www.sdge.com/sunrisepowerlink/.

696 California ISO Controlled Grid Generation Queue and Map, Docketed 5-24-11.

697 Keene, Stephen, Imperial Irrigation District, *Transcript of the May 17, 2011 IEPR Committee Workshop on Transmission Needed to Meet State Renewable Policy Mandates and Goals*, p. 71, California Energy Commission, Sacramento, California, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/2011-05-17_Transcript.pdf , accessed June 9, 2011.

698 California ISO, Renewable Generation in the ISO Queue as of 5/24/11, Docket Nos. 11-IEP-1E and 11-IEP-1G, May 24, 2011, http://www.energy.ca.gov/2011_energypolicy/documents/2011-05-17_workshop/comments/CAISO_Controlled_Grid_Generation_Queue_and_Map_TN-60916.pdf, posted June 3, 2011, accessed June 9, 2011.

699 SCE Petition for Declaratory Rate Treatment, December 2010, Exhibit E, Page 9.

Colorado River – Valley 500 kV Project (and Red Bluff Substation)

SCE's Colorado River – Valley 500 kV transmission project includes the Colorado River to Devers project (which has also been called the California-only portion of the Palo Verde – Devers #2 project). With the West of Devers upgrade (discussed below), this project would allow for delivery of about 4,700 MW from Riverside County. In 2007, SCE received a Certificate of Public Convenience and Necessity (CPCN) from the California Public Utilities Commission (CPUC) for the Palo Verde – Devers #2 line, and in 2009 SCE was issued a modified decision that allowed the termination of the project at the proposed Colorado River Substation in California rather than the Palo Verde (Harquahala) Substation in Arizona.[701]

The Colorado River – Valley 500 kV Project will consist of the following main components:

- A new 500/220 kilovolt Colorado River Substation near Blythe.
- A new 111-mile 500 kilovolt transmission line between SCE's Devers Substation near Palm Springs and the new Colorado River Substation that would parallel the existing Devers-Palo Verde transmission line.
- A new 42-mile 500 kilovolt transmission line between Devers Substation and SCE's Valley Substation in Menifee that would parallel the existing Devers-Valley transmission line.[702]

In Riverside County, there are more than 8,700 MW of renewable generation in the California ISO Generator Interconnection Queue. This project would allow generators in eastern Riverside County to connect with the Devers Substation in Southern California. SCE expects to begin construction on the project in 2011. SCE applied for the Permit to Construct (PTC) for the expanded Colorado River Substation in November 2010.[703] The CPUC granted the PTC for the Colorado River Substation on July 14, 2011. Also on July 14, 2011, the BLM issued its Record of Decision for the Devers – Palo Verde No. 2 Transmission Project[704] (now called the Colorado River – Valley project.)

If the required federal permits for the 220 kV bus expansion are issued by late 2011, the interconnecting bus for generators could be completed by summer 2013. SCE has also proposed to build the 220/500 kV Red Bluff Substation as a second interconnection point for generators in Riverside County. The would tie into the SCE transmission network by looping in the Colorado River – Valley 500 kV line and the existing Devers – Palo Verde 500 kV line while providing another interconnection point for generators near Desert Center, California. SCE applied for a

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700 (http://www.sce.com/PowerandEnvironment/Transmission/ProjectsByCounty/Multi-CountyProjects/TRTP1-3/default.htm), and http://www.sce.com/PowerandEnvironment/Transmission/ProjectsByCounty/Multi-CountyProjects/TRTP4-11/tehachapi-4-11.htm.

701 http://docs.cpuc.ca.gov/published/FINAL_DECISION/110360.htm.

702 http://www.sce.com/PowerandEnvironment/Transmission/ProjectsByCounty/RiversideCounty/DPV/default.htm.

703 http://docs.cpuc.ca.gov/efile/A/126246.pdf.

704 See: http://www.blm.gov/ca/st/en/prog/energy/fasttrack/devers.html.

PTC from the CPUC in November 2010. The CPUC granted the PTC for the Red Bluff Substation on July 14, 2011. SCE plans to begin construction as soon as the project receives all federal approvals and could complete construction as early as the summer of 2013.[705]

Eldorado to Ivanpah Transmission Project

The final environmental impact report/environmental impact statement (EIR/EIS) for SCE's El Dorado – Ivanpah Transmission Project was published November 9, 2010, and the CPCN was granted December 16, 2010.[706] The proposed project will provide the electrical facilities necessary to integrate more than 1,400 MW of new solar energy generation in the Ivanpah Dry Lake area. The project's major components include: (1) construction of a new Ivanpah Substation in San Bernardino County; (2) removal of roughly 35 miles of existing 115 kV transmission line and replacement with a new double-circuit 220 kV transmission line between the new Ivanpah Substation and the existing Eldorado Substation in Clark County, Nevada; and (3) installation of associated telecommunication infrastructure. The El Dorado – Ivanpah Project is expected to be on-line in 2013.

Borden – Gregg 230 kV Reconductoring Project

Pacific Gas and Electric Company's (PG&E's) Borden – Gregg 230 kV project would allow for the delivery of 800 MW of new solar generation proposed in the Fresno area, specifically the Westlands area.[707]

South of Contra Costa Reconductoring Project

Pacific Gas and Electric's (PG&E) South of Contra Costa Reconductoring project has the potential to deliver 535 MW of new wind generation in the Solano Competitive Renewable Energy Zone (CREZ). Without reconductoring the lines south of the Contra Costa Substation, none of the renewable generation proposed in the Solano area would be considered deliverable.[708]

Pisgah – Lugo Renewable Transmission Corridor Project

SCE's Lugo – Pisgah Renewable Transmission Corridor Project is needed to interconnect and deliver power generated by the Calico Solar Project and other generators near Newberry Springs in the Mojave Desert. The project consists of nearly 67 miles of new 500 kV transmission line from the new Pisgah substation to the Lugo Substation. The majority of the project, 51 miles, would replace the existing Lugo – Pisgah No. 2 220 kV line and use the existing transmission corridor. The remaining 16 miles, between the Lucerne Valley and the Lugo Substation, would require a new corridor because the existing corridor is not wide enough for a

705 http://docs.cpuc.ca.gov/efile/A/126666.pdf.

706 http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/128873.htm.

707 California Independent System Operator 2010/2011 Transmission Plan, page 341.

708 California Independent System Operator 2010/2011 Transmission Plan, page 255.

500 kV line.[709] According to the *California ISO 2010-2011 Transmission Plan*, the Lugo – Pisgah Project would provide access to about 1,750 MW of renewable capacity in the Mojave Desert.[710] SCE anticipates submitting permit applications to the CPUC and the BLM in early 2012 and having the project operational by 2017.

West of Devers Transmission Upgrades

SCE's West of Devers transmission upgrades have been identified as network delivery upgrades in the California ISO's Generator Interconnection process. The West of Devers upgrades consist of the relocation and upgrade of the four 230 kV circuits heading west from the Devers Substation, two circuits to the San Bernardino Substation and two to the Vista Substation. SCE has approval from the Federal Energy Regulatory Commission (FERC) and the California ISO through acceptance of the nonconforming Large Generator Interconnection Agreement (LGIA) for the Blythe, Genesis, and Palen solar generating projects in Riverside County.[711] SCE is beginning to develop routes and gather the environmental information required to apply for required state and federal permits. Without the West of Devers upgrades, most of the renewable generation proposed in eastern Riverside County will be unable to meet the deliverability requirements in their power purchase agreements. The current expectation is that unless there are unforeseen licensing issues, the West of Devers upgrades could be completed by 2017.

The California ISO identified an interim solution that would allow much of the generation proposed in eastern Riverside County and the Imperial Valley to meet deliverability requirements until the West of Devers upgrades are operational. The interim solution, which would cost less than $50 million, consists of series reactors on existing lines and a special protection scheme to trip generation and/or load under various contingencies. These upgrades would not require environmental licensing; however, they would not have any value once the West of Devers Upgrade was operational.[712]

Carrizo – Midway 230 kV Reconductoring Project

On May 5, 2011, PG&E submitted a Notice of Construction to the CPUC for transmission facilities that would connect renewable generators in the Carrizo Plain to the PG&E grid. The proposed project consists of two new PG&E switching stations associated with two solar PV projects and reconductoring about 35 miles of the existing Morro Bay – Midway 230 kV transmission line. Permits for the switching stations were issued by San Luis Obispo County as

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709 Southern California Edison, http://www.sce.com/PowerandEnvironment/Transmission/ProjectsByCounty/SanBernardinoCounty/LugoPisgah/lugopisgah.htm.

710 *California Independent System Operator 2010/2011 Transmission Plan*, Table 4-2.1 page 222.

711 http://www.caiso.com/2b28/2b28811743ed0.pdf, http://www.caiso.com/2b1b/2b1bbe5734440.pdf, http://www.caiso.com/2875/2875ed9e5d360.pdf, and http://www.caiso.com/2867/2867bfb23c1b0.pdf.

712 *California ISO 2010/2011 Transmission Plan*, page 289.

part of the conditional use permits granted for two PV projects: the California Valley Solar Ranch Project and the Topaz Solar Farm Project. PG&E planned to begin construction in July 2011 with the project completed and able to deliver up to 900 MW of new solar generation by the end of 2012.[713]

Coolwater – Jasper – Lugo Transmission Project

SCE's Coolwater – Jasper – Lugo transmission project is a network delivery transmission upgrade identified through the Large Generator Interconnection Procedures for the Abengoa Mojave Solar Project. The project would promote solar development in the Kramer area, San Bernardino-Lucerne Valley, Inyokern, and Owens Valley, as well as geothermal development in Nevada that interconnects near Mono Lake. The project consists of substation upgrades at SCE's existing Coolwater and Lugo Substations, a new Jasper Switching Station, and 63 miles of new transmission facilities between the Coolwater and Lugo Substations. Forty-seven miles of the project would be new 220 kV facilities, and the remaining 16 miles would be built as 500 kV towers with the line energized at 220 kV.[714] The majority of the transmission line will likely require a new corridor. The project will allow for the delivery of up to 700 MW of new generation to California load centers.[715] The project could be on-line by 2018.

In addition, the project would increase deliverability for generation in the Western Mojave area, one of the most promising areas for solar development in California with some of the highest solar insolation in the world. This area also has a high concentration of disturbed land, including former and marginal agricultural land, which generally has little value as habitat for endangered species and can therefore be developed with minimal adverse impacts to biological and cultural resources.[716]

California ISO/IID Joint Path 42 Upgrades

The joint SCE/IID upgrade of the path is critical for delivery of renewable generation in the IID area into the California ISO. Upgrading Path 42 requires improvements to facilities under the control of SCE and the California ISO as well as facilities under IID control. The IID upgrades consist of replacing the 220 kV circuits between the Coachella Valley Substation and the Mirage Substation with bundled circuits, two conductors per circuit. The IID portion of the upgrades would increase the capacity of IID's portion of the path by around 800 MW and could be completed by the end of 2011. The SCE portion of the upgrade received California ISO Board of Governors approval upon adoption of the *2010-2011 Transmission Plan*. SCE is studying ways to upgrade the existing Mirage – Devers 220 kV line without replacing the transmission poles to

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713 Advice 3842-E, Notice of Construction for the Carrizo – Midway Reconductoring Project, PG&E May 5, 2011, http://www.pge.com/nots/rates/tariffs/tm2/pdf/ELEC_3842-E.pdf.

714 SCE Petition for Declaratory Rate Treatment, December 2010.

715 *California ISO 2010-2011 Transmission Plan*, p. 222.

716 http://www.caiso.com/Documents/CaliforniaEnergyComments_RenewablePortfolioAssumptions_2011-2012TransmissionPlanningProcess.pdf.

reduce the licensing/permitting time. The total renewable potential for the California ISO/IID Path 42 upgrades is about 1,400 MW.

Imperial Irrigation District Upgrades

IID has promoted renewable energy in the Imperial Valley for many years. Nearly 20 years ago, IID upgraded its transmission system by building a 230 kV collector system to accommodate the interconnection of new geothermal generation and export of this renewable energy to the California ISO balancing authority area. Currently, IID wheels about 550 MW of geothermal energy from Imperial Valley into the California ISO.[717]

IID has developed a detailed long-term transmission plan (10 years plus time frame) to define the transmission improvements necessary to continue meeting its load service requirements in future years as well as allowing for the export of renewable resources from the Imperial Valley area. The plan has primarily focused on the upgrade of certain sections of IID's 161 kV transmission system to 230 kV to integrate the existing 230 kV collector system and create a 230 kV transmission loop that will cover most of IID service area to allow for the export of renewable generation to the north, south and east of IID's service area. The individual projects were described in detail in Appendix C of the Energy Commissions' *2009 Strategic Transmission Investment Plan*.

Licensing and construction of transmission upgrades by IID could be completed for generators in their transition cluster by December 2013 but require the execution of LGIAs. One key component of these upgrades is the Path 42 Upgrade, which would increase the export capability from IID to SCE by about 855 MW but requires line upgrades on the IID and SCE parts of the path from the Mirage Substation to the Devers Substation.[718] The IID portion consists of upgrading the existing double-circuit line from the Coachella Valley Substation to Mirage, and IID estimates that it could complete this upgrade by the end of 2011.[719]

Barren Ridge Renewable Transmission Project

The Los Angeles Department of Water and Power's (LADWP) Barren Ridge Renewable Transmission Project consists of a new 61-mile double-circuit 230 kV transmission line between the Barren Ridge Switching Station and a new Haskell Canyon Switching Station. The Barren Ridge Switching Station is a newly constructed facility along the existing Inyo to Rinaldi line, approximately 20 miles north of the city of Mojave. The project also includes reconductoring of the existing line from Barren Ridge to Haskell Canyon. The construction of the new line and the reconductoring will provide access to 1,000 MW of wind, solar, and other renewable resources.[720] The project is in the environmental analysis process with the final EIR/EIS

717 *RETI Draft Phase 2A Report*, Appendix G, pp. 13-18.

718 Transcripts from May 17, 2011, workshop, Keene page 74.

719 Source: IID Transmission F&I response, page 7.

720 Source: LADWP March 28, 2008 Fact Sheet for the Barren Ridge Renewable Transmission Project, available at: http://www.ladwp.com/ladwp/cms/ladwp009509.pdf

expected in mid-2012 and the Notice of Decision/ Record of Decision issued in late summer 2012. The project could be on-line in early 2016.[721]

721 Source: http://www.ladwp.com/ladwp/cms/ladwp009508.jsp

APPENDIX G: Additional Information Resources for Renewable Distributed Generation Planning and Permitting Assistance

National

- **American Planning Association (APA)**
  "Wind Energy Planning: Results of the American Planning Association Survey", July 2010 (DG)
  This ongoing survey assesses the current state of wind energy planning in communities across the country. It also inquires about challenges that planners are facing in the process of planning, regulating and implementing wind energy facilities.
  For more information,
  visit: www.planning.org/research/wind/surveyreport.htm

- **American Wind Energy Association (AWEA)**
  "Permitting Small Wind Turbines: A Handbook", September 2003. (small-scale DG)
  This is an informative guide to assist public officials and property owners in understanding the permitting process for small wind systems; it includes best practices for siting.
  For more information,
  visit: www.consumerenergycenter.org/erprebate/documents/awea_permitting_small_wind.pdf

- **U.S. Department of Energy (DOE)**
  Solar America Cities / Solar America Communities (Community-scale DG)
  The Solar America Cities program provided awards and funding for special projects to cities throughout the United States that demonstrated a strong effort to promote solar power and streamlined interaction between local government and residents.
  For more information, visit: www.solaramericacommunities.energy.gov/home.aspx

  SunShot Initiative (DG)
  The SunShot Initiative focuses on increasing the efficiency of equipment in the solar market, and on reducing the cost of installation and permitting for solar systems. Recently, $27 million has been made available for grants intended to assist in decreasing nonhardware costs of solar energy systems, specifically focusing on rooftop, distributed generation solar systems.
  For more information, visit: http://www1.eere.energy.gov/solar/sunshot/index.html

  Solar America Board for Codes and Standards (Solar ABC's) – "Expedited Permit Process for PV Systems," October 2009 (Small-scale DG)
  This report presents industry and local officials with a standardized process for reviewing and issuing permits for solar PV systems. These standards have been adopted by several building departments nationwide.

For more information, visit: www.solarabcs.org/about/publications/reports/expedited-permit/pdfs/Expermitprocess.pdf

"Solar Educational Resources for Code Officials" (Small and community-scale DG)
This site offers a portal to a variety of technical documents aimed at assisting code officials with planning, monitoring, and overseeing PV markets locally.
For more information,
visit: http://www1.eere.energy.gov/solar/code_official_resources.html

"Solar Powering Your Community: A Guide for Local Governments", January 2011. *(Community-scale DG)*
This guide was created for local government and stakeholder use in developing and implementing a strategic local solar plan.
For more information, visit: www.solaramericacommunities.energy.gov/pdfs/Solar-Powering-Your-Community-Guide-For-Local-Governments.pdf

Wind Powering America – "Siting Wind Turbines" (DG)
This Web portal provides important information and links to other resources on siting and permitting practices for distributed generation wind systems.
For more information, visit: http://www.windpoweringamerica.gov/siting.asp

- **National Renewable Energy Laboratory (NREL)**
  "Analysis of the Status and Impact of Clean Energy Policies at the Local Level," 2010 (DG and Utility Scale)
  This report provides a background on the role of local government, an overview of the current status of local clean energy policy, a summary of results from a questionnaire of local government officials, and advice for further local government research. The report highlights that there is little diffusion of clean energy policies across local governments.
  For more information,
  visit: www.nrel.gov/applying_technologies/state_local_activities/pdfs/49720.pdf

- **National Wind Coordinating Collaborative (NWCC)**
  "Permitting of Wind Energy Facilities: A Handbook," 2002
  This document presents suggestions for permitting officials to improve the efficiency and flow of the permitting process. The publication applies to both small-scale and utility-scale wind and points out the differences between distributed generation and wind farms, as applicable to specific difficulties in permitting that arise in each venue.
  For more information,
  visit: http://www.nationalwind.org/assets/publications/permitting2002.pdf

- **SolarTech**
  SolarTech Permitting Committee Initiative, "Online Permit Application Interoperability Standard," November 11, 2009 (DG)

This document represents Phase 1 of the Online Permit Application process interoperability standards and describes a general approach to automating the building permit process and its interfaces to various stakeholders.
For more information, visit:
www.solartech.org/index.php?option=com_st_document&view=documentdetail&id=14&Itemid=58

- **SunRun**
  "The Impact of Local Permitting on the Cost of Solar Power," January 2011 (DG)
  This report includes a detailed breakdown of the permitting and inspection costs and a series of practical recommendations the federal government should encourage to improve the onerous requirements and processes.
  For more information, visit:
  www.sunrunhome.com/cost-of-solar/solar-panels/local-permitting

- **The Energy Foundation**
  "Community Wind 101: A Primer for Policy Makers," September 2008 (DG and Utility Scale)
  This report lays out a set of public policies designed to increase local wind investment and ownership.
  For more information, visit:
  www.ef.org/docs/CommWind_web.pdf

- **The Vote Solar Initiative**
  This website provides users with a map comparing current permitting costs and processing times for cities throughout the United States. It also includes a toolkit for local governments, including a list of best practices for permitting.
  For more information, visit:
  www.votesolar.org/city-initiatives/project-permit/.

California

- **California Air Resources Board**
  "Guidance Resources for Power Plants," Updated 2008 (community-scale DG and utility-scale)
  This website compiles short descriptions and links to various documents that discuss best practices for siting and permitting power
  plants. http://www.arb.ca.gov/energy/powerpl/powerpl.htm

  "Air Quality Guidance for Siting Biorefineries in California," DRAFT, October 2010 (community-scale DG and utility-scale)
  This document provides guidance on best practices for siting biofuel production facilities in California. Technologies covered by this document can also be used for siting biomass to electricity conversion facilities under 50 MW.
  For more information, visit:

http://www.arb.ca.gov/fuels/lcfs/101110_DRAFT_Air_Quality_Guidance_for_Siting_Biorefineries.pdf

- **California Energy Commission**
  "Solar Electric Photovoltaic/Solar Thermal Hot Water Systems Survey Report," (small-scale, residential DG)
  This report is in the process of being developed and examines trends in permitting fees and processing times for solar electric photovoltaic and solar thermal hot water systems on new and existing residences throughout California. Survey data for the report was collected in 2007, 2009, and 2010.
  For more information, visit: contact the Renewable Energy Office at renewable@energy.state.ca.us

  "Energy Aware Planning Guide," February 2011 (DG and Utility Scale)
  This guide is a comprehensive resource for local governments seeking to reduce energy use, improve energy efficiency, and increase usage of renewable energy across all sectors.
  For more information, visit: www.energy.ca.gov/energy_aware_guide/index.html

  "Energy Aware Facility Siting and Permitting Guide, Consultant Report," December 2010 (DG and Utility Scale)
  This guide helps local governments develop general plan energy and transmission elements and provides guidance on electricity generation, transmission, and permitting.
  For more information, visit: www.energy.ca.gov/energy_aware_guide/siting.html

  "Distributed Generation: CEQA Review and Permit Streamlining," 2000 (DG)
  This report summarizes the results of a stakeholder workshop and surveys with local government planning directors and building officials that focus on the CEQA review process, issuance of permits, and technical assistance needed to establish a regulatory framework for processing DG projects.
  For more information, visit: www.energy.ca.gov/reports/2000-12-21_700-00-019.PDF

  "The Role of Land Use in Meeting California's Energy and Climate Change Goals," August 2007 (DG and Utility Scale)
  Chapter 7 of this staff report is helpful for local jurisdictions that seek guidance on including utility planning with land use planning.
  For more information, visit: www.energy.ca.gov/2007publications/CEC-600-2007-008/CEC-600-2007-008-SF.PDF

  "Solar PV Permitting Study, Study and Recommendations for Residential Permitting," June 2010 (prepared for the Energy Commission (PIER) Program (small scale, residential DG)
  This study provides recommendations, based on the results of a survey of 33 San Francisco Bay Area cities, for standardizing the permitting process of solar photovoltaic technologies. A copy of this report is available to Energy Commission staff at no cost; cost for nonmembers is $45.
  For more information, visit:
  www.solartech.org/index.php?option=com_st_document&view=general&Itemid=143

California Guidelines for Reducing Impacts to Birds and Bats From Wind Development, 2007,
These voluntary guidelines provide information to help reduce impacts to birds and bats from new development or repowering of wind energy projects in California. They include recommendations on preliminary screening of proposed wind energy project sites; prepermitting study design and methods; assessing direct, indirect, and cumulative impacts to birds and bats in accordance with state and federal laws; developing avoidance and minimization measures; establishing appropriate compensatory mitigation; and postconstruction operations monitoring, analysis, and reporting methods.
For more information, visit: http://www.energy.ca.gov/2007publications/CEC-700-2007-008/CEC-700-2007-008-CMF.PDF

"Developing Renewable Generation on State Property," 2011
This report focuses on the potential for developing renewable distributed generation – onsite or small energy systems located close to where energy is consumed – on state-owned properties to contribute toward the goal of installing 20,000 megawatts of renewable generation by 2020. In addition to distributed generation, the report explores the potential for developing utility-scale renewables on state properties as well. Making state properties available to renewable developers could reduce energy costs in state buildings, create new sources of revenue by leasing vacant or unused lands and highway rights-of-way, and provide cost savings to the state through reduced land maintenance costs that would be assumed by renewable developers who use those lands.
For more information, visit: http://www.energy.ca.gov/2011publications/CEC-150-2011-001/CEC-150-2011-001.pdf

- **Climate Change, Land Use, and Infrastructure Web Portal, 2011 (CCLU-In) (DG and Utility Scale)**
  This Web portal allows local governments to access existing state programs, projects, guidance and resources related to land use and sustainable community planning.
  For more information, visit: www.climatechange.ca.gov/action/cclu/index.php

- **Sierra Club, Loma Prieta Chapter**
  "Reducing Local Barriers to the Installation of Solar Power Systems", Last updated 2011 (residential DG). This chapter of the Sierra Club surveyed the costs of permitting and permit processing times for solar photovoltaic systems in various jurisdictions throughout California.
  For more information, visit: http://lomaprietaglobalwarming.sierraclub.org/solar.php

APPENDIX H:
PIER Project Details

This appendix provides more details on the projects summarized in Chapter 9. It also describes energy storage technology progress.

Research to Address Environmental and Permitting Challenges

Past Research

- A life cycle assessment to identify and evaluate the environmental impacts of emissions, resource consumption, and energy use associated with the production of electricity by existing and emerging distributed generation (DG) technologies.[722]
- An assessment of current knowledge about potential environmental impacts of increased use of forest biomass for energy production with suggested areas for future research that regulators can use to develop guidelines for using woody biomass for energy production.[723]
- Multiple studies on reducing the impacts of wind energy development on birds and bats as well as reducing bird deaths from electrocution and collision with power lines.[724]
- Research to improve forecasting of hydroelectric reservoir inflow and provide reservoir managers with tools to facilitate choices between competing demands like flood control, water supply, environmental protection, and electricity generation.[725]
- A study on the efficiency and effectiveness of environmental flow evaluations conducted during the Federal Energy Regulatory Commission's hydropower relicensing process, one of the most contentious issues during relicensing.[726] About 4,000 MW of in-state hydropower capacity is up for relicensing in the near future; because these licenses are for 30 to 50 years, it is critical that the best science is used in the relicensing process.

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722 National Renewable Energy Laboratory, *Life Cycle Assessment of Existing and Emerging Distributed Generation Technologies in California*, July 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-001/CEC-500-2011-001.pdf.

723 William Stewart et al, *Potential Positive and Negative Environmental Impacts of Increased Woody Biomass Use for California*, July 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-036/CEC-500-2011-036.pdf.

724 See http://www.energy.ca.gov/research/environmental/reports.html for a list of reports on PIER projects addressing this topic.

725 *Hydrologic Research Center, Integrated Forecast and Reservoir Management (INFORM) for Northern California: System Development and Initial Demonstration*. March 2007, http://www.energy.ca.gov/pier/project_reports/CEC-500-2006-109.html.

726 Peter Moyle et al., *Improving Environmental Flow Methodologies Used in California FERC Relicensing*, August 2011, http://www.energy.ca.gov/pier/project_reports/CEC-500-2006-109.html.

Future Research

- Six ongoing PIER-funded environmental research projects are addressing the major siting issues facing utility-scale solar energy development in the desert. These research projects are focused on biological issues that caused uncertainty and delay in the permitting of solar thermal generating projects in 2010. The intent is to improve the scientific basis for management decisions to promote resource conservation, resolve biological issues, and ensure environmental protection while also facilitating permitting. Current projects include evaluation of rare plant transplanting success[727] and tools to enhance the survival of desert tortoises affected by solar energy development.[728, 729,]
- Research to identify the lowest-risk sites for wind turbines and improve the accuracy and cost-effectiveness of bird and bat surveying and monitoring methods, such as the use of radar, to reduce bird and bat deaths.[730]

Research to Address Transmission Challenges

Past Research

- Development of a prototype Real-Time Dynamic Measurement System (RTDMS) installed at the California ISO for monitoring and testing.[731] The RTDMS, like other synchrophasor-based tools,[732] allows greater awareness of impending problems, increased grid capacity, and improved reliability of the grid. In 2009, the California ISO decided to bring the system into its mainstream operation. This system is now in Version 8 release and is commercially available from the manufacturer
- Wide-Area Energy Storage and Management System to Balance Intermittent (Renewable) Resources in the California ISO: [733] This project showed that sharing power system regulation services between two control areas (California ISO and the Bonneville Power

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727 California Energy Commission, *Plant Population Viability and Restoration Potential for Rare Plants Near Solar Installations Fact Sheet*, March 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-FS/CEC-500-2011-FS-014.pdf.

728 California Energy Commission, *Decision Support Tool for Desert Tortoises Near Solar Installations Fact Sheet*, April 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-FS/CEC-500-2011-FS-007.pdf.

729 California Energy Commission, *Minimizing Conflicts between Desert Tortoises and Energy Development Projects in the Mojave Desert Fact Sheet*, January 2011, http://www.energy.ca.gov/2010publications/CEC-500-2010-FS/CEC-500-2010-FS-015.PDF.

730 California Energy Commission, *Assessing Bat and Bird Movements and Mortality Relative to Wind Turbines Fact Sheet*, March 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-FS/CEC-500-2011-FS-013.pdf.

731 http://www.phasor-rtdms.com/

732 Synchrophasors provide better information to grid operators about real-time grid conditions by collecting and reporting information 30 times per second.

733 Pacific Northwest National Laboratory, *Wide-Area Energy Storage and Management System Phase 2*, August 2010, http://uc-ciee.org/images/downloadable_content/electric_grid/Final_WAEMS_Report_CIEE.pdf

Administration in the Northwest) using two types of energy storage (flywheels in the California ISO for fast regulation and hydro in the Northwest for smooth/slow regulation) would provide fast, cost-effective, and efficient ancillary services for balancing renewable generation in the power grid. The study projected a savings of 30 percent in additional reserve resource requirements with substantial dollar savings.

- Western Electricity Coordinating Council Wind Generator (Model) Development: [734] California transmission operators and planners rely on models for how various types of electric generators behave during sudden changes in the power grid and the effects of that behavior on reliability throughout the Western grid. This project, cofunded by the PIER Program and the U.S. Department of Energy (DOE), developed and validated models for four types of wind generators. These models are now included in standard model libraries used by transmission operators and planners in the western United States.

- Developing Tools for On-line Analysis and Visualization of Operational Impacts of Wind and Solar Generation: [735] This project is developing forecasting tools for wind and solar generation to allow the California ISO to better manage the California electric grid. One of these, a "ramping tool," predicts the system ancillary resources – conventional generators, energy storage or demand response – needed to handle ramping up or down caused by intermittent renewables for 24 hours ahead. Another tool, the "transmission planning" tool, forecasts possible power flow congestion issues. A prototype of the ramping tool has been operating at the California ISO and successfully predicted a significant shortfall of balancing reserve that led to a spike in pricing to $1,000/MWh for purchasing "backup" power. Because of this success, the California ISO plans to use both of these tools in its control room display screen.

- Real-Time Grid Reliability Management: [736] The PIER Program has funded a series of projects using synchrophasor measurements for real-time situational awareness, diagnostics, and control of the entire electric grid by transmission system operators. This new measurement technology gives operators an unprecedented ability to know what is happening throughout the system and provides "over the horizon" early warnings of developing problems in real time. As these measurement devices are being deployed in the electric grid, PIER funding is helping to develop applications for using the data to improve grid operating reliability and economic efficiencies, especially under high penetrations of renewable generation. This particular research effort has been developing a "platform" for

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734 National Renewable Energy Laboratory, *WECC Wind Generator Development*, March 2010, http://uc-ciee.org/downloads/WGM_Final_Report.pdf.

735 The project fact sheet can be found at: http://uc-ciee.org/images/downloadable_content/electric_grid/OT_FactSheet.pdf.

736 Lawrence Berkeley National Laboratory, *Real-Time Grid Reliability Management 2005*, February 2007, http://uc-ciee.org/images/downloadable_content/electric_grid/RTGRM2005_FactSheet.pdf andReal-Time Grid Reliability Management, December 2008, http://www.energy.ca.gov/2008publications/CEC-500-2008-049/CEC-500-2008-049.PDF.

using these applications, with an early generation prototype in use by the California ISO and utilities.

- Oscillation Rapid Detection and Mitigation Analysis: [737] PIER funded a series of research projects targeted at reducing instabilities in the western electric transmission system that can cause large, expensive blackouts, such as the 1996 West Coast blackout that affected more than 7.5 million people. As a precaution against instabilities, some transmission connections for California are being operated thousands of MW below maximum capacity. Tools are being developed that use synchrophasor measurements to help transmission operators rapidly detect oscillations and advise the operator on what actions to take to mitigate these threats to reliability. Early generations of these tools are already in use at the California ISO. The goal is to eventually control these oscillations so that transmission capacity can be used at full capacity and transmit additional power.
- Application of Advanced Wide Area Early Warning Systems with Adaptive Protection:[738] The PIER Program has funded a series of projects for improving the reliability of systems that protect grid equipment and people from excess power flows. Analyses of large blackouts in the past have shown that some conventional protection systems actually made the blackouts worse.[739] The modern grid needs smarter protection systems, particularly given expected high penetration of renewable resources. PIER has developed a number of tools, using synchrophasor measurements, that can adapt protection relays for different situations encountered on the grid at various times. PIER is now cofunding with the federal government demonstrations of two of these new tools in the PG&E and SCE transmission systems.
- Development of Fault Current Controller Technology Phase I: [740] Due to ever-increasing load on the electric system, fault currents are increasing beyond the ability of circuit breakers to safely interrupt the fault currents and protect vulnerable substation equipment. PIER funded a successful field demonstration of a prototype fault current controller, a new grid device that can limit maximum current flows, at the 15 kilovolt (kV) level at SCE that provided valuable learning experience for how to deploy these devices and make next generation with improvements, such as the ability to withstand higher voltages.

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737 Pacific Northwest National Laboratory, *Oscillation Detection and Analysis*, August, 2010, http://uc-ciee.org/images/downloadable_content/electric_grid/ODA_Final_Report.pdf.

738 Stuart Consulting, *Multi-Area Real-Time Transmission Line Rating Study*, October 2007, http://uc-ciee.org/images/downloadable_content/electric_grid/IGPS_Final_Report.pdf.

739 Hazel R. O'Leary, Secretary of Energy, *The Electric Power Outages in the Western United States*, July 2-3, 1996; Report to the President, August 2, 1996.

740 http://www.energy.ca.gov/pier/portfolio/Content/ar07/Development%20of%20Fault%20Current.htm.

- The California Field Test of the 3M High-Temperature Low-Sag (HTLS) Conductor: [741] Ordinary transmission cables made with a steel core wire wrapped with aluminum conductors can carry only so much power before the heat produces temperatures that cause too much sag or damage in the line. New core materials allow replacement lines to be operated at much higher temperatures, allowing more power to be transferred over the same towers in the right of way. PIER cofunded a demonstration of 3M's version of a HTLS conductor at SDG&E that demonstrated that the line behaved as designed, and showed that special handling techniques could accommodate new physical properties of these emerging types of conductors.
- Extreme Events:[742] A wide-area blackout is a typical example of an extreme event in the transmission system that can be initiated by an earthquake, a power plant tripping offline, or even a line sagging into a tree. However, analyzing and predicting extreme events are very difficult. This PIER project used modeling and stochastic analysis techniques that were new to the electric grid community to develop and test a small-scale network model and the science and conceptual framework and advanced mathematical techniques needed for the complexity of multiple component and system failures in a transmission system. The methods were then applied to realistic network models to test their practicality.
- SCE, working with Waukesha Electric Systems, Inc., will design, develop, fabricate, and install a smart-grid compatible fault current limiting superconducting transformer on SCE's utility host site.[743] The 28 MVA, three-phase, medium power utility fault current limiting transformers will be placed within SCE's MacArthur Substation, located in Newport Beach, and within the project area of SCE's Irvine Smart Grid Demonstration Project. By incorporating fault current limiting capability, the transformer is better able to handle fault currents and represents a cost- and space-efficient means to bring fault current limiting capability into the substation without adding a separate device, and ultimately improves the grid performance and reliability.

Future Research

- New grid operating tools for accommodating solar and wind generation's unique characteristics with increasingly higher levels of penetrations.
- Solar generator modeling: As the amount of both utility- and distributed-scale solar generators grows, dynamic stability models, similar to the Wind Generator Models developed with PIER and DOE funding, are needed.

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741 http://www.energy.ca.gov/pier/portfolio/Content/06/ESI/High%20Temperature%20Low%20Sag%20Conductor2.htm.

742 The Extreme Event Research project fact sheet can be found at http://uc-ciee.org/images/downloadable_content/electric_grid/EE_FactSheet.pdf.

743 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf

- Solar and wind forecasting: The ability to forecast solar and wind resources expected in minutes to many hours ahead at given generator locations is important for the reliable, economic, and efficient operation of the electric grid. Existing technologies need improved accuracy and precision.
- Dynamic Thermal Circuit Rating (DTCR): DTCR can provide transmission congestion relief and improve grid reliability while providing increased transmission line capacity in real time. This technology also allows faster integration of wind energy.[744] Transmission lines have limitations on the amount of power they can carry, determined by the performance of the line conductors at high temperatures. System design engineers and planners establish limits (ratings) on the capacity of the individual lines so that under high loading and extreme weather conditions when the lines typically sag or might be damaged, the operator will be assured that the lines will safely and securely maintain the minimum ground clearances.[745] However, actual transmission line capacity changes constantly as a result of variations in wind, solar radiation, ambient temperature and other weather conditions in combination with line loading, and at most times the real-time line rating can be significantly higher than the static line rating. Real-time line rating systems such as DTCR include monitors that communicate data on the real-time line conditions, allowing the system operator to load existing transmission lines more closely to their "full" capacity, reducing the need for new transmission.[746,747] Use-case studies of DTCR and diagnostic, forecasting, and visualization tools are needed to enhance adoption rates by utilities and enhance the benefits of DTCR
- Voltage-source converter high-voltage direct current cables: Conventional high-voltage direct current (HVDC) cables are used for bulk transmission lines over long distances. They require extremely costly converter stations at each end of the cable to convert voltage between direct current (DC) and alternating current (AC), and typically carry from 300 to 3,000 MW of power. Newer voltage-source converter technology, such as ABB's HVDC Light® and Siemens's HVDC Plus, can carry lower capacity amounts in the range of 50 to 1,200 MW at bulk transmission voltages, can be run underground, and are particularly useful for interconnecting wind and offshore power sources.[748,749]

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744 Aivaliotis, Sandy K., "Dynamic Line Ratings for a Reliable and Optimized Smart Transmission," PowerPoint presentation at the Seventh Annual Carnegie Mellon Conference on the Electricity Industry 2011, May 8-9, 2011.

745 California Energy Commission, *Development of a Real-Time Monitoring/Dynamic Rating System for Overhead Lines* by EDM International Inc., Publication No. 500-003, December 2003, ES-1.

746 *Demonstration of Advanced Conductors for Overhead Transmission Lines*, 1017448, EPRI, July 2008, p. 6-1.

747 *Dynamic Circuit Thermal Line Rating*, California Energy Commission Publication P600-00-036, October 1999. http://www.energy.ca.gov/reports/2002-01-10_600-00-036.PDF, ES-2.

748www.abb.com/industries/us/9AAC30300394.aspx.

749 http://www.energy.siemens.com/us/en/power-transmission/hvdc/hvdc-plus/.

- High capacity cables: Advanced HTLS conductors are designed to improve performance by being capable of continuous operation at high temperatures without losing tensile strength and also sag less with temperature than normal. The same size of HTLS conductor can carry multiple times the current than a conventional conductor can. There is a need to track experiences in the field as these conductors begin to be deployed throughout the world to examine possible premature failure mechanisms and installation issues.
- Fault current controllers: Utilities increasingly have a critical need for a highly efficient fault current controller (FCC) technology. Traditional methods of limiting fault currents include the use of circuit breakers that may not be economical or efficient. Developments in superconductivity and power electronics are resulting in a number of different innovative designs for fault current controllers. While PIER has funded the successful demonstration of one concept, other promising concepts need to be tested, especially for the ability to handle higher voltages.
- Power flow control devices: With today's technology, the grid operator has little control of how power flows through the transmission network. This limits the ability to avoid congestion, overload lines, increase the power flow into some locations, and make optimum use of existing grid infrastructure. Largely due to developments in power electronics, new devices are being developed to provide additional ability to control power flows that could also complement power flow control of energy storage, leading to even greater efficiency in the use of grid infrastructure.

Research to Address Integration Challenges

Transmission-Level Integration – Smart Grid

Past Research

- California Utility Vision and Roadmap for the Smart Grid of Year 2020: [750] This project collected information from the state's three largest utilities to develop a common California smart grid vision and roadmap. This vision and roadmap would direct a comprehensive R&D plan supporting smart grid deployment by 2020. The final project report details findings in six domains of technical expertise: Communications Infrastructure and Architecture; Customer Systems; Grid Operations and Control; Renewable and DER Integration; Grid Planning and Asset Efficiency; and Workforce Effectiveness. These domains define a structure of technical areas under which the project provides further findings on vision, baseline, technology readiness roadmaps, gaps, and recommendations. This project also addressed the CPUC's Order Instituting Rulemaking (OIR) #R.08-12-009 to "Consider Smart Grid Technologies Pursuant to Federal Legislation and on the Commission's own Motion to Actively Guide Policy in California's Development of a Smart Grid System." Additionally, this research will help the Energy Commission develop information for the requirements defined under SB 17.

750 Electric Power Research Institute, *California Utility Vision and Roadmap for the Smart Grid of 2020,* July 2011, http://www.energy.ca.gov/2011publications/CEC-500-2011-034/CEC-500-2011-034.pdf.

- Performance Testing Protocols and a Database for Distributed Generation:[751] This project, completed in 2010, promoted the adoption of DG and combined heat and power (CHP) units by providing performance data comparisons for power generating systems. Systems included microturbine generators, engine generator sets, small turbines, and fuel cells. The database will encourage appropriate DG and CHP applications that provide real benefits to system owners. The project facilitated adoption by providing globally accessible information of CHP systems via the Internet.
- Storage Viability and Optimization Tool: [752] This research project helps end users determine if energy storage and photovoltaics (PV) together are appropriate for their facility. The technology is available for public use on the Lawrence Berkeley National Laboratory website. Users include universities, private companies, and utilities.
- Modeling Validation Benefits of Distributed Energy Resources to Power Grid:[753] This project demonstrated tools that can be used by a utility to identify the best sites for distributed energy resources. These tools can identify beneficial projects and quantify their benefits for California. The key feature of the Energynet® method is the simulation of the power system in full detail, with all distribution and transmission equipment integrated into a single model, to allow the direct observation of the grid impacts of individual distribution-connected generation and storage.

Current Research

- Smart Grid Demonstration Project: [754] The Los Angeles Department of Water & Power (LADWP) will develop and demonstrate a network of smart grid technologies which also involves battery energy storage systems for electric vehicles. The project goal is to facilitate the establishment of protocols and standards in the Smart Grid Demonstration Project that allow for the measurement and validation of energy savings and fossil fuel emissions reductions associated with an electric vehicle program by specifying, acquiring, and installing a sufficiently sized electric vehicle demonstration network.

Future Research

- Hardware and software to enable demand response, including home area networks (HAN).

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751 The final report can be found at http://www.energy.ca.gov/2010publications/CEC-500-2010-017/CEC-500-2010-017.PDF. The database can be found at http://www.dgdata.org.

752 Ernest Orlando Lawrence Berkeley National Laboratory, *Storage Viability and Optimization Web Service* : http://der.lbl.gov/sites/der.lbl.gov/files/LBNL-4014E_approved_0.pdf. The Storage Viability and Optimization Tool can be downloaded from: http://der.lbl.gov/microgrids-lbnl/current-project-storage-viability-website.

753 New Power Technologies, *Verification of Energynet® Methodology*, December 2010, http://www.energy.ca.gov/2010publications/CEC-500-2010-021/CEC-500-2010-021.PDF.

754 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf.

- Interfaces for the above, where applicable, for transmission and distribution operators.

Several of the items listed above are particularly urgent because advancements in these areas are needed to promote the integration of renewable resources as mandated by state policy:

- Intermittent Resource Forecasting: Grid operators will need practical, real-time tools to better anticipate rapid changes and ramp rates due to variable generation, with increased resolution in time and space. Better knowledge of variability will enable more economic use of firming resources.
- Generator Modeling and Control: Generator modeling focuses on the electrical behavior of wind and solar power relative to the grid. Of particular concern are switch-controlled generators, which include the inverters used for solar PV as well as modern wind generators. Advances in these technologies allow them to provide electric output with desired characteristics (such as reactive power, voltage control, and dynamic response to help stabilize grid frequency). However, to be useful to the grid, these capabilities must be thoroughly understood by grid operators and proven to be dependable. Furthermore, algorithms must be developed along with the communications and control infrastructure that will enable grid operators to call upon these generators to provide the specific attributes that best support the grid.
- System of Systems: Grid operators, owners, and their engineers often model and analyze the performance of particular subsystems as part of the process of designing and deploying smart-grid technologies to manage a particular challenge. However, research is needed on how these subsystems work together from the standpoint of overall system performance and operating reliability. With advanced deployment of individual smart grid technologies, the problem of subsystem interaction merits increasing attention. Because of the depth, breadth, and difficulty of this problem, an initial scoping study and problem definition will need to be completed to outline a path for ongoing research in this area. Some specific research areas that follow the systemic approach include:
    - Systemwide Impacts of Variable Generation: This research would develop tools to predict and assess the impacts of large contributions from variable and switch-controlled generators on wide-area stability, for example inertia, and reliability on increasingly shorter time scales. This includes the impact of renewable generation on the dynamic response of the WECC system, notably low-frequency oscillations, as well as the system's resilience with respect to disturbances and extreme events.
    - Resource Coordination: This research area addresses the optimal coordination of a growing number of contributing resources, including variable renewable generation, storage, and demand response. Due to the many variables involved, it is difficult to determine the best implementation of such a diverse portfolio at any given instant. Work in this area would analyze the complementarities and optimal management of specific sets of resources – for example, geographically and technically diverse storage resources (building on previously Energy Commission-funded work on Wide-Area Energy

Storage and Management Systems). Further work would explore how the uncertainty in the availability or cost of resources can be most efficiently and economically addressed in managing highly diverse portfolios.

- Resource Aggregation: A related research area will need to focus on the aspect of information management, with ultimate implications for control architectures. As the grid draws upon many individual distributed resources, sometimes with information flow and control actions on short time scales, the volume of data to be processed increases exponentially. An overarching concern is how to group data effectively and preserve vital technical and economic information while lowering the transaction costs for system operators of managing a vast fleet of resources. Research in this area should investigate approaches and algorithms for information flow and control, focusing on ways in which resources might be most effectively bundled or coordinated so as to collectively provide services to the grid. Such aggregation might include local clusters of diverse resources, such as generation combined with storage and/or flexible demand, capable of operating with some degree of self-sufficiency (microgrids).

Transmission-Level Integration – Energy Storage

Pumped Hydro

Pumped hydro systems are the oldest energy storage systems. There are nine pumped hydro projects in California with a combined capacity of 3,758 MW.[755] Efforts are underway to extend the functionality of existing pumped hydro at the 1,200 MW Castaic facility in Los Angeles County and the 1,050 MW Helms facility in Fresno County. Besides providing ancillary services, pumped hydro can also firm up wind and solar resources and is especially well suited for storing hundreds of MW of energy over many hours. However, adding pumped storage requires finding environmentally acceptable sites close enough to transmission to be cost-effective. Closed-loop systems that use two captive reservoirs that do not interfere with recreational uses, aquatic life, flood control, or irrigation face fewer environmental barriers.

As of April 2011, 14 pumped storage projects with a combined capacity of 9,900 MW have applied for or have received permits from FERC (Table H-1). One example is the 1,300 MW Eagle Mountain project in Riverside County that is awaiting approval of its FERC license. The Eagle Crest project is also proposing variable speed pumps that make it suitable for meeting a wider range of ancillary services than other pumped storage projects. The project is projected to have a ramp rate of 10 MW per minute. Many new pumped hydro projects plan on using variable speed pumps, which provide greater control in pumping mode and can increase response time to compensate for power fluctuations and improve the stability of the power system.[756] Retrofitting existing pumped hydro plants with variable speed pumps could improve their ability to support intermittent renewable resources, but the cost of retrofitting is more

755 The number and capacity of California pumped hydro plants from the Hydropower Review March 2011.

756 *Variable Speed Pumped Storage Hydropower Plants for Integration of Wind Power in Isolated Power Systems*, published by InTech - Open Access Publisher, ISBN 978-953-7619-52-7.

prohibitive compared to installing these pumps at new plants, assuming that construction of a new plant is underway. The cost of retrofitting existing power plants is generally less expensive than breaking new ground and constructing a new plant.

Table H-1: Proposed Pumped Storage Projects in California

Applicant	Facility	Application Date	Status	Proposed Capacity (MW)
SMUD	Iowa Hill	March 2008	Applied for Permit	400
Nevada Hydro	Lake Elsinore	May 2008	Permit Received	500
Pacific Gas & Electric Co	Kings River	September 2008	Permit Received	350
Pacific Gas & Electric Co	Mokelumne	September 2008	Permit Received	380
San Diego County Water	San Vicente	September 2008	Permit Received	550
Eagle Crest Energy Co	Eagle Mountain	October 2008	Permit Received	1,300
Eldorado Pumped Storage, LLC	Eldorado	October 2010	Applied for Permit	400
Pajuela Peak	Pajuela Peak	November 2010	Permit Received	250
Turlock Modesto Irrigation	Red Mountain Bar	November 2010	Permit Received	900
Brookfield Generation	Mulqueeney Ranch	January 2011	Permit Received	280
Bison Peak LLC/Gridflex Energy, LLC	Bison Peak	April 2011	Applied for Permit	1,000
Storage Development Partners, LLC	Camp Pendleton Project	April 2011	Applied for Permit	1271
Storage Development Partners, LLC	Vandenberg #3 Project	April 2011	Applied for Permit	1,136
Storage Development Partners, LLC	Vandenberg #5 Project	April 2011	Applied for Permit	1,196
TOTAL				9,913

Source: Hydropower Society. Courtesy Steve Lowe Eagle Crest Mountain LLC.

Compressed Air Energy Storage

Compressed Air Energy Storage (CAES) technology can provide ancillary services and also help firm up wind and solar power and shape wind generation, which allows these resources to bid

for renewable contracts that seek firm capacity.[757] This technology can store hundreds of MW of energy over many hours but is limited by difficulty of finding suitable underground reservoirs for storing compressed air. The technology has been used in Alabama since 1991, and new projects are being built in Iowa and New York. Compressed air loses heat when it is compressed and requires a heat source to decompress it so that it can drive turbines. Commercial projects use natural gas to do so, but emissions are lower than emitted by a full natural gas unit. Future projects will reduce or eliminate emissions, but any compressed air installations over the next five years will not have that option. Technologies that eliminate emissions completely are still at the concept level and need to be more fully developed and demonstrated at a pilot scale before they are adopted for a full size plant. PG&E and other California utilities are actively exploring development of a full-scale demonstration project using ARRA funding. PG&E has also received ARRA/PIER cost-share for a 300 MW 10-hour CAES project, tentatively located in Kern County.

Batteries

Battery storage technology provides near-term availability for several applications that can help with renewable integration. Using batteries to provide distributed energy storage can also provide frequency control and reduce variations in the localized solar output on the distribution circuits, which in turn reduces the need for integration services on the transmission level. When properly sized, some battery types can provide adequate ramp rates to meet the load balancing and frequency regulation requirement, although ramp rates vary by battery technology and size.[758] Modularity and scalability of various battery types and many vendors of different battery chemistries provide the promise of drop in cost over next few years. However, the cost-effectiveness of each battery type must be evaluated in the context of its potential application. Capacity costs ($/kW), energy costs ($/kWh), the level to which a battery could be discharged, the number of charge-discharge cycles it can deliver, the duration for holding charge, and round-trip efficiency vary substantially based on battery type. The predominant battery types currently available are: lead- acid, lithium ion (Li-ion) batteries, nickel-metal hydrides, sodium sulfur (NaS), and flow batteries such as zinc-bromine or vanadium oxides.[759] Costs vary widely; for some recent stationary utility-grade applications, costs have been "upwards of $2000/kWh", but some li-ion batteries have been installed at $1000/kWh. For many grid connected applications, batteries must come down to a level of $500/kWh.[760] Factors such

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757 The longest running CAES plant is the Huntsdorf plant in Germany, which has been operating since 1979. A second plant in Alabama has been operating since 1989. The critical components for CAES technology such as turbines, compressors, and expanders are all considered commercially available as are the technologies for developing or assessing the underground reservoirs. Source: Communications with Robert Shainker, EPRI CAES Manager. June 2007.

758 Roy Kuga presentation at Integrated Energy Planning Annual Meeting, September 24, 2010.

759 National Renewable Energy Laboratory. http://www.nrel.gov/vehiclesandfuels/energystorage/battery_types.html. September 2009.

760 "Start-up Battery Could Provide Cheaper Grid Storage," *MIT Technology Review*, June 7th, 2011.quoting Haresh Kamath, Strategic Program Manager, EPRI, Palo Alto, California.

as improvement in battery performance due to advances in material sciences and also mass production would bring the cost down. Energy storage capacity of battery systems will need to be properly sized to match the load to avoid any additional backup systems needed as the batteries discharge.

Different battery chemistries, some driven by the promise of a large electric vehicle market, are now available. Many technologies are commercially[761] available, although their economic and technical viability must be matched to the specific energy and power needs of ancillary services. The cost per kWh is much higher than pumped hydro or compressed air storage, but their compact size make batteries better suited for integrating renewable resources at distributed locations, particularly for PV systems, and for reducing second-to-second fluctuations in output at wind farms. Batteries have a smaller footprint, are easy to site, are modular, and can be brought on-line fairly quickly. They can therefore match the rate of deployment with the anticipated pace of renewable distributed generation penetrating the grid.

Xtreme Power has several battery systems operating in Hawaii and Japan to assist renewable integration with the grid.[762] These battery systems are being used to manage wind intermittency, ramp rates, and provide frequency control. Batteries are also being used for frequency regulation in New York, and the same capability was demonstrated in Huntington Beach, California, by AES Energy Storage LLC until 2010. Lacking a suitable tariff for energy storage under existing market rules at that time, AES terminated the demonstration project and is bidding in other ISO territories for providing frequency regulations services.[763] The California ISO, however, developed a straw proposal to accommodate energy storage technologies, including batteries, to competitively provide some ancillary services support products to the grid.[764] Stakeholders, including many storage vendors, are providing comments, and the California ISO expects the process, including FERC filings and implementation, to conclude by 2014.

Several California utilities are deploying lithium-ion, sodium-sulfur and zinc-bromine battery chemistries. The battery sizes and associated power electronics are designed to match the

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761 A technology is deemed commercially available when it has a track record of proven performance and has at least one manufacturer who can supply or build it as standard equipment. Yet a new application of a commercially available technology could be considered as a demonstration. In 1988 Southern California Edison used commercially available lead-acid batteries (same technology as used in a car battery) for peak-shaving and load management but considered the project as a demonstration.

762 "Importance of Energy Storage to California's Renewables Future," Presentation by Amanda Stevenson, Xtreme Power Inc., Slide # 17 to 22 at the 2011 IEPR Workshop on Energy Storage, April 28, 2011, http://www.energy.ca.gov/2011_energypolicy/documents/2011-04-28_workshop/presentations/06_Xtreme_Stevenson_IEPR_Storage_Workshop.pdf.

763 Communications with Praveen Kathpal. Manager for Markets and Regulatory Affairs. AES Energy Storage LLC. August 4, 2011.

764 Renewable Integration Market Vision & Roadmap: Day-of Market Initial Straw Proposal. By California Independent System Operator, July 6, 2011.

functions served by these technologies. Smaller (25 kW up to 3-4 hours) are used for community-scale storage for distribution-level integration while larger (4 to 8 MW and for 4-8 hours) are being used to integrate large-scale PV and wind systems. The technologies are available and are being tested as part of "smart homes" by utilities. The batteries are typically sold in a basic module of certain kW capacity, and in some instances, such as a sodium-sulfur or lithium-ion battery, the power capacity (kW) and energy (kWh) are tied to the battery design. For flow-batteries, the membrane determines the power while the liquid electrolyte delivers the energy and allows for increasing the energy without altering power. Therefore, scale-up potential is a function of proposed application of the battery technology, with the ability to add more battery modules to scale up the storage system to the size required.

California utilities are cautiously optimistic about battery performance and treat these projects as demonstrations until battery efficiency, life, and reliability are established. Therefore, many of these projects are not financed through utility base rates but instead are being cofunded through ARRA and the PIER Program. The ultimate adoption of batteries as a standard equipment for managing renewable integration would depend on the economic viability. SCE has developed an elaborate framework to assess the economic viability and proposes to do so in the context of specific utility application and functions delivered by the energy storage technology.[765] Small-scale modular batteries can also provide home/small commercial-level energy storage that can promote demand response, which can then be bid in the ancillary services market by an aggregator.

Flywheels

Flywheels store energy from the momentum created by fast spinning cylinders driven by an electric motor. Electricity is retrieved by spinning the motor backward to act as an electric generator. More than one flywheel can be combined to increase stored electrical power. The use of this technology for frequency control was proven first in California, and Regional Transmission Operators in two Northeastern states are now using flywheels to provide frequency control service. Flywheels are modular and can be combined with wind systems to compensate for second-to-second variations and can also provide frequency regulation services. Flywheels also have some unique characteristics. For instance, unlike batteries, they are not affected by life-cycle limits or how deeply they are discharged. Also, ramp rates could be much higher and response to system operators requests much faster (less than 4 seconds) than the existing fleet of combustion turbines, or hydro plants in some instances, that provide frequency regulation services.[766] In addition to fast response, unlike combustion turbines flywheels can operate without fossil fuels and are capable of both up and down regulation. System operators in other regions have recognized this benefit of flywheels and have redesigned their product

765 *Moving Energy Storage from Concept to Reality: Southern California Edison's Approach to Evaluating Energy Storage*. May 2011. http://www.edison.com/files/WhitePaper_SCEsApproachtoEvaluatingEnergyStorage.pdf.

766 "Coordinated Multi-Objective Control of Regulating Resources in Multi-Area Power Systems with Large Penetration of Wind Power Generation" by Yuri Markow, Dave Hawkins et al. 7th International Workshop on Large Scale Integration of Wind Power and on Transmission Networks for Offshore Wind Farms. Madrid, Spain. May 2008.

requests to avoid discriminating against flywheels or any other technologies with similar capabilities. Following the lead of other independent system operators, the California ISO is redesigning its procurement specifications to accommodate this technology.

The PIER Program has played a critical role in making ISOs and other national stakeholders aware of the flywheel's ability to provide frequency controls and laid foundation for its subsequent commercialization. In 2004, PIER funded a demonstration of the Beacon flywheel at PG&E's San Ramon testing site to demonstrate a 15 kW/100 kWh bank of seven flywheels to show their ability to respond to the California ISO's Area Generation Control signal. PIER also funded research at Pacific Northwest Laboratories[767] to demonstrate flywheels' ability to react faster and with a higher ramp rates and consequently reduction in the MW needed to meet the frequency control and load following leads compared to other generation assets.

Thermal Energy Storage

Heat energy from large-scale concentrating solar plants can be stored directly or indirectly in a molten salt medium, and then released after sunset or to smooth out interruptions in the electric output that result when clouds pass over a solar field. Thermal storage can reduce the sudden ramping up or down of solar output, thereby reducing or eliminating the need for other balancing power. However, thermal energy storage is not as versatile in its ability to directly provide ancillary services compared to other electricity storage options.

Current Storage Research

- The Strategic Analysis of Energy Storage Technology Project will develop a strategic analysis of energy storage technologies and will provide a vision for energy storage in California by 2020.[768] Working interactively with utilities, the energy storage industry, and other stakeholders, this project will identify and define the necessary research on the energy storage technologies and applications for achieving greater penetration of renewable energy resources. Research projects will be developed from the resulting roadmap and include the development of technologies to integrate energy storage into the smart grid and have it interoperate with other grid assets.

- PG&E Sodium Sulfur Energy Storage Demonstration: [769] This is the first utility-scale demonstration of a sodium-sulfur battery energy storage system (BESS) in California. The sodium-sulfur BESS is one of the most advanced battery storage technologies on the market, with both fast discharge and slow energy release capabilities, a high efficiency of about 80 percent, and a long life span of 15 years. This specific installation will be a 4-megawatt system with a 28-megawatt-hour storage capacity. Once installed and operating, this system will be the largest battery storage system in California and will provide critical data on the

767 http://www.energy.ca.gov/2011_energypolicy/documents/2010-11-16_workshop/presentations/10_Dagle_How_to_Integrate_Energy_Storage_and_Demand_Response_Into_the_Wide-Area_Network_Control.pdf.

768 http://uc-ciee.org/images/downloadable_content/electric_grid/ESV2020_Factsheet.pdf.

769 http://www.next100.com/2010/02/pges-big-battery.php.

use of large-scale battery energy storage technologies to meet California's future renewable energy needs. Future research will investigate other applications of battery storage systems.

- As part of its Tehachapi Wind Energy Storage Project, SCE will design and build a 32 MWh lithium-ion battery system and smart inverter and connect it to its Monolith Substation near the Tehachapi Wind Resource Area.[770] This project will demonstrate the ability of the battery storage system to enhance grid operations and integrate intermittent wind power in a remote, transmission-constrained area. The installed system will help achieve utility load shifting, increased dispatchability of wind generation, and enhanced ramp rate control to minimize the need for fossil fuel-powered backup generator operation. The project will leverage the data and results of an ongoing PIER-funded study on the Antelope-Bailey 66 kV system. The ongoing study aims to determine the ways in which energy storage can address wind integration issues to help meet California's renewable energy goals. One of the key early findings of this study was that a 32 MWh energy storage device located at the Monolith Substation can prevent overloaded transmission lines.
- Primus Power Corporation will work with the United States Department of Energy, Sandia National Laboratory, Pacific Gas and Electric Company (PG&E), and Modesto Irrigation District to develop, field test, install, and evaluate a 25 MW/75 MWh grid-connected zinc-based flow battery energy storage system.[771]The project will provide a low-cost energy storage system with a footprint consistent with or smaller than other competing technologies and demonstrate primary and secondary applications including renewable firming, strategic local peak shaving, automated load shifting, and ancillary services.
- Under its Solid State Batteries for Grid-Scale Energy Storage project, Seeo Inc. (Seeo) will develop the first large-scale or grid-scale prototype of a new class of advanced lithium ion rechargeable batteries, with unprecedented safety, lifetime, energy density, and cost.[772] The primary focus of this project will be the development and deployment of a 25 kWh prototype battery system based on Seeo's proprietary nanostructured polymer electrolytes. This will validate the transformational performance advantages of this technology for use in grid-tied energy storage applications. In particular, Seeo seeks to address the utility market needs for clean energy systems, which envision small (<100 kW) distributed energy storage systems alongside pad-mounted and pole-mounted transformers, and grid-connected electric vehicle systems.
- In the Premium Power Distributed Energy Storage Systems Demonstration, the Sacramento Municipal Utility District (SMUD) will install and demonstrate a fleet of two Premium

770 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf.

771 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf.

772 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf.

Power Corporation's Zinc Bromine Flow Battery energy storage systems in Sacramento, one at the SMUD Headquarters (East City Substation) serving the SMUD campus microgrid, and one at a substation serving the nearby Anatolia III SolarSmart Homes community development.[773] The SMUD Headquarters storage system will explore its utility in improving microgrid operations; emergency operations, including campus islanding; and augmenting peak period campus operation with nonpeak generated electricity. The storage system at SMUD's Anatolia-Chrysanthy substation will be integrated with the Anatolia III SolarSmart Homes community, which will have 600 homes totaling 1.2 MW of PV generating capacity. The two storage systems will be controlled from a common control system at the SMUD headquarters site to demonstrate fleet control of multiple distributed storage devices. Over a four-year period, this project and the technology validation it supports will demonstrate competitively priced, multimegawatt, long-duration advanced batteries for utility grid applications. They will also validate the potential penetration of zinc bromine flow batteries, particularly in PV and microgrid applications, by demonstrating multiple use cases.

- Amber Kinetics, Inc., will demonstrate a prototype utility-scale flywheel energy storage system employing technology advances in composite flywheel rotor materials, magnetic bearing systems, and high efficiency motor-generators.[774] These new technologies, when integrated into a flywheel system, can prove that flywheel energy storage can be competitive with pumped hydro in terms of cost and efficiency. The goal of the project is to clearly demonstrate the economical and technical viability of bulk flywheel energy storage and renewable energy integration for the electric grid.
- Flow Battery Solution to Smart Grid Renewable Energy Applications: [775] EnerVault Corporation (EnerVault) will partner with Ktech Corporation to demonstrate the commercial viability of EnerVault's novel iron-chromium redox flow BESS. This demonstration consists of integrating EnerVault's Vault-20 BESS (250kW, 1MWh) with an intermittent renewable energy source – a dual-axis PV system. The 36-month project will culminate in the deployment of a Vault-20 Beta system in conjunction with a 150kW PV system at a site in California's Central Valley. Additionally, the operating results will be analyzed and compared to the baseline for final quantification of benefits and operating costs. The capital costs, operating costs, and benefits will be used to determine total cost of ownership.

773 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf.

774 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf.

775 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf.

- Advanced Underground Compressed Air Energy Storage Demonstration Project: [776] PG&E will design, build, and demonstrate the world's first advanced "second generation" CAES design system that requires less fuel, uses standardized less expensive turbo-machinery, and captures the waste heat from the compression cycle. This design uses readily available proven turbo-machinery that will result in lower capital and operating costs than first generation designs. The plant design will also include the option for future use of thermal storage to test the potential of adiabatic CAES, a "third generation" technology that would completely eliminate the use of fuel for a CAES plant.[777] The project will use depleted gas fields, located within PG&E's service territory, for compressed air energy storage.

Future Storage Research

- The Energy Commission's PIER Program needs to continue to support and sponsor field demonstration of new and commercially available energy storage technologies. For distribution level integration, energy storage projects in the 1 MW to 5 MW range are the highest priority for these demonstrations.[778]

- Research should be completed to better estimate the amount of energy storage and automated demand response necessary to meet the integration challenges of the RPS by 2020.[779]

- Research and workshops on financial models and tariffs need to address how a fee system can be developed to allow energy storage systems to be compensated for all the values they provide the grid such as reliability improvements, integration of renewables, ancillary services, power quality improvements, and others.[780]

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776 http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FINAL-REV_Combined_SGDP_Selections_2011_01_04.pdf.

777 An adiabatic process is one in which no heat is gained or lost by the system.

778 California Energy Commission, *Transcript of the November 16, 2010 Staff Workshop on Energy Storage and Automated Demand Response Technologies to Support Renewable Energy Integration*, comments of Janice Lin , California Energy Storage Alliance, http://www.energy.ca.gov/2011_energypolicy/documents/2010-11-16_workshop/2010-11-16_Transcript.pdf, page 111.

779 California Energy Commission, *Transcript of the November 16, 2010 Staff Workshop on Energy Storage and Automated Demand Response Technologies to Support Renewable Energy Integration*, comments of Albert Chui, PG&E, http://www.energy.ca.gov/2011_energypolicy/documents/2010-11-16_workshop/2010-11-16_Transcript.pdf, page 111.

780 California Energy Commission, *Transcript of the December 17, 2010 joint IEPR Committee/CPUC Workshop on Smart Grid Research Road Mapping Projects*, comments by David M. Tralli of JPL (page 96) and Chris Villareal of the CPUC (page 127), http://www.energy.ca.gov/2011_energypolicy/documents/2010-12-17_workshop/2010-12-17_Transcript.pdf.

- The results of the many ARRA and PIER funded energy storage and automated demand response demonstrations need to be made available as soon as possible so these results can be used in developing future demonstrations.[781]

Transmission-Level Integration – Demand Response

Past Research

- Industrial sector research conducted in 2008 by the PIER's Demand Response Research Center (DRRC) at Lawrence Berkeley National Lab (LBNL) looked at DR opportunities at industrial wastewater facilities. A scoping study was conducted that concluded that energy-intensive wastewater facilities with their high summer electrical loads are potential good candidates for DR[782]. The scoping study also acknowledged that these wastewater facilities have the necessary controls systems to allow integration of automated demand response strategies. The result of this scoping study lead to a pilot demonstration project at the San Luis Rey[783] Wastewater Treatment Plant in Oceanside to demonstrate and quantify demand response capability of a wastewater treatment plant.

- Past PIER research shows that giving end-use customers the ability to automate their response can provide the predictable and reliable load reductions to the grid. A standard open architecture protocol has been developed called Open Automated Demand Response (OpenADR).[784]The PIER Program has several years of experience in developing, evaluating, testing, and demonstrating OpenADR with commercial and industrial customers, and OpenADR is becoming the preferred protocol for these customers. Currently, several fully commercialized programs in California and other state utilities use OpenADR for their utility service territory.

- In 2009, three large commercial and industrial facilities with OpenADR-enabled energy management systems provided load reductions through PG&E's Participating Load Pilot. This pilot program successfully demonstrated using demand response as a nonspinning reserve product in the California ISO market.

- Research conducted in 2010 by the PIER Program's DRRC at Lawrence Berkeley National Lab (LBNL) to summarize the response time, duration, and market characteristics of building and process automation with the corresponding requirements of spin, nonspin and

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781 Compilation of various comments received at the November 16, 2010 Staff Workshop on Energy Storage and Automated Demand Response Technologies to Support Renewable Energy Integration; the December 17, 2010 joint IEPR Committee/CPUC Workshop on Smart Grid Research Road Mapping Projects; and April 28, 2011, IEPR Committee Workshop on Energy Storage for Renewable Integration, http://www.energy.ca.gov/2011_energypolicy/documents/index.html#11162010.

782 http://drrc.lbl.gov/system/files/lbnl-1244e.pdf.

783 http://drrc.lbl.gov/system/files/lbnl-3889e.pdf.

784 Piette, Mary Ann, Girish Ghatikar, Sila Kiliccote, Ed Koch, Dan Hennage, Peter Palinsky, and Charles McParland. *Open Automated Demand Response Communications Specification (Version 1.0)*, 2009. LBNL-1779E.

regulation services.[785] The project evaluated heating, ventilation, and air conditioning systems, lighting, plug loads, and other end uses to characterize the response times and potential duration of load reduction to be used for renewable integration products. The research also included a series of case studies to demonstrate the performance of automated DR for fast DR with four-second telemetry on the loads. Some of the case studies examined thermal energy storage systems, refrigerated warehouses, industrial processes, and wastewater treatment facilities. These case studies employ OpenADR to facilitate response to DR price and event signals and spur innovations in building control technologies. This platform also provides a basis for a standardized, lower cost communication protocol, which historically has limited DR participation in the market.

- The communication and automation infrastructure needed to deliver consistent and dependable load reductions is the key to employing demand response for renewable integration. The DRRC is working within the commercial, residential, and industrial sectors to provide demonstration projects and develop end-use communication and visualization infrastructures. In addition, the DRRC is working with standards organizations to develop protocols and model standards for energy information management and control.
- Another study by LBNL involved a demonstration of DR as spinning reserve.[786] Spinning reserve is an electricity grid operator's first strategy for maintaining system reliability following a major contingency, such as the unplanned loss of a large generation facility or critical transmission line. The LBNL study used SCE customers on the Summer Discount Plan, an air conditioning load management program. Customers' air conditioning systems were cycled off for short durations of time and coordinated through a central energy management system. The centralized control allowed precise calibrations of load drops with response times significantly faster than the current North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) requirements. In the second phase of the demonstration project, connectivity was established to the California ISO to explore the capabilities of the system to respond directly to requests for dispatch of spinning reserve.

Current Research

- The Integrating Renewable Resources (IRR) Pilot Project expands on the work done through the 2009 PG&E Participating Load Pilot to provide additional customer-side products for renewable integrations. The pilot involves a collaboration effort of the California ISO, Akuacom, PG&E, and LBNL's PIER Demand Response Research Center (DRRC) to assess

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785 Kiliccote, Sila, Pamela Sporborg, Imran Sheikh, Erich Huffaker, and Mary Ann Piette. 2010. *Integrating Renewable Resources in California and the Role of Automated Demand Response*, (LBNL-4189E), http://drrc.lbl.gov/sites/drrc.lbl.gov/files/lbnl-4189e.pdf

786 Eto, J., J. Nelson-Hoffman, E. Parker, C. Bernier, P. Young, D. Sheehan, J. Kueck, and B. Kirby. 2009. *Demand Response Spinning Reserve Demonstration – Phase 2 Findings From the Summer of 2008*. (LBNL-2490E), http://certs.lbl.gov/pdf/lbnl-2490e.pdf.

- The PIER program is completing research to evaluate how much energy storage and automated demand response is needed to support integrating high levels of renewables on the California grid.[788]
- The Demand Response Research Center is conducting demonstrations in 2011 to evaluate the speed of response of several potential DR loads for ancillary services. These loads will include both storing electricity as well as reducing electric loads. Current research is examining what loads are available at different times of the day.[789]
- The next phase of ADR research is focused on integrating larger quantities of ADR onto the grid using the OpenADR protocol not only in the commercial and industrial markets, but also into the residential market. The lessons learned from using the OpenADR protocol for commercial and industrial customers will be directly transferrable to homes as Open ADR has several years experience with commercial and industrial customers. As smart meters are installed throughout California, the opportunities to increase the ADR capabilities to support the grid are substantial. PIER is funding several research projects to demonstrate the potential value of AMI installations. For example, the Residential Energy Display Survey (REDS) project will allow residential consumers to viscerally experience near real-time energy information from their newly installed smart (interval) meters when they want it and in ways of their own choosing using display devices that they already own and know how to use.[790] These devices include smart phones, computers, televisions, programmable communicating thermostats, and so forth. The smart meters will communicate with a secure gateway that will eventually become part of a consumer-owned router, cable box, or other communications center. The REDS gateway will act as the firewall between the homeowner and the utility to retrieve near real-time meter data. The REDS gateway will use only a restricted portion of the Smart Energy Profile (SEP) 1 software that is already embedded in California smart meters. The REDS approach allows consumers to explore practical uses of

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787 Kiliccote, Sila, Pamela Sporborg, Imran Sheikh, Erich Huffaker, and Mary Ann Piette. 2010. *Integrating Renewable Resources in California and the Role of Automated Demand Response*, (LBNL-4189E), http://drrc.lbl.gov/sites/drrc.lbl.gov/files/lbnl-4189e.pdf.

788 AutoDR: Dave Watson, Mary Ann Piette, Nance Matson, Sila Kiliccote, Janie Page (Lawrence Berkeley National Laboratory); Corfee, Karin, Betty Seto, Ralph Masiello, John Masiello, Lorin Molander, Samuel Golding, Kevin Sullivan, Walt Johnson, David Hawkins (KEMA). *Automated Demand Response as a Grid Balancing Resource for the Integration of Renewables*. Prepared for the California Energy Commission. In Press. 2011. Storage: KEMA, Inc. 2010. *Research Evaluation of Wind and Solar Generation, Storage Impact, and Demand Response on the California Grid*. Prepared for the California Energy Commission. http://www.energy.ca.gov/2010publications/CEC-500-2010-010/CEC-500-2010-010.PDF.

789 Ancillary Services field demonstrations are in process and are funded by PG&E's Emerging Technology Program.

790 The draft specification for the REDS gateway is located at: http://drrc.lbl.gov/news/residential-energy-display-survey-reds-pilot.

their smart meter while the utilities resolve logistical and technical issues with the proposed more secure SEP 2 software.

Distribution-Level Integration

Current Research

- Renewable Energy Secure Communities (RESCOs): [791] In 2008, the Energy Commission released the first RESCO solicitation to cross-leverage between natural gas and electricity research funding sources. RESCO projects (see Table H-2) develop and demonstrate mixed renewable technologies in an integrated and sustainable way coupled with advancements in energy efficiency, demand response, smart grid integration, energy storage, combined cooling, heating and power, and coproduction of value-added products like biofuels to help make California's electricity and transportation fuels more diverse, safe, clean, and affordable. Implementation of RESCOs requires reliable, secure energy supply at a competitive cost that can be estimated and forecast with high confidence. Reliability of products and systems is typically achieved through design, development, piloting, pre-commercial demonstration, and later incremental improvement and/or innovation. The RESCOs are helping to build the market connectedness of renewable technologies with grid integration, storage, and efficiency, while reducing costs.

- PIER is funding a number of projects to develop and demonstrate advanced energy technology solutions for wastewater treatment facilities. Sonoma County is conducting a pilot project to demonstrate the integration of multiple distributed generation technologies at the Santa Rosa Airport's Wastewater Treatment Plant. The Dublin/San Ramon Services District's Regional Wastewater Treatment Facility in Pleasanton is demonstrating an energy storage system combined with on-site fuel cell power generation. Furthermore, the Energy Commission – along with the City of Riverside and Viresco Energy LLC of Riverside – is cofunding the further development of a promising new waste-to-energy technology known as a Steam Hydrogasification Reactor.[792]

- Current PIER-funded projects are demonstrating advanced energy technology solutions that are helping to turn waste products from California's industrial and agricultural communities into energy. Gills Onions, located in Oxnard, is demonstrating an onsite process that converts onion peel waste products into clean power and heat. The process works by digesting the onion waste in a 145,000-gallon anaerobic digester to produce biogas which is cleaned, conditioned, and fed into two high-efficiency fuel cells that each generates

791 RESCO project summaries can be found at: http://cal-ires.ucdavis.edu/research/.

792 2010 Pacific Southwest Organic Residuals Symposium presentation, *Steam Hydrogasification Research Overview, September 2010,* http://www.epa.gov/region9/organics/symposium/2010/4-Park-SHR%202.pdf.

Table H-2: PIER-Funded Renewable Energy Secure Communities Projects

Recipient	Title	Goals
Alameda County	Consortium for Electric Reliability Technology Solutions, Smartgrid Demonstration with Renewables and Large-Scale Energy Storage Integration Project at Santa Rita Jail	• Demonstrate the commercial implementation of a CERTS Supergrid. • Enable effective interface to local utility grids. • Reduce the peak load and reduce air emissions. • Improve grid reliability, efficiency and security. • Enhance security reliability w/onsite power.
El Dorado Irrigation District	El Dorado County Water Systems Energy Generation, Storage, Efficiency, Demand Management and Grid Support Project	• Quantify peak demand generation and load shifting that could be achieved with existing facility reoperation; peak and off-peak period energy savings form efficiency, new storage, and load shifting; and amount of temporary load shedding available on-call to the serving utility. • Estimate costs.
Local Power, Inc.	San Luis Obispo Renewable Energy Secure Community (SLO-RESCO)	• Produce an inventory of resources and sites with potential for renewables development. • Develop methods, policy tools, models, spreadsheets, and strategies for designing a renewable portfolio. • Produce a policy-technical-financial-commercial template for RESCO communities.
Los Angeles Community College District	Energy Demand Optimization Program for LA Trade Tech College Building F	• Offset 96% of building's energy consumption and demand during peak periods. • Develop a program to train and educate a future technical workforce. • Demonstrate integration of renewable technologies.
Makel Engineering	Biogas Fueled Homogenous Charge Compression Ignition Power Generation System for Distributed Generation	• Demonstrate the market ready potential of low-emission conversion technology. • Generate electric power (200 kW target). • Meet or exceed current and future California atmospheric emissions requirements.
Redwood Coast Energy Authority	Planning for Renewable-based Energy Security and Prosperity in Humboldt County	• Strategic plan that will delineate options and identify preferred ones, develop a roadmap, and identify near-term pilot scale projects.
Sonoma County Water Agency	Renewable Energy Secure Sonoma County	• An anaerobic digester using manure from surrounding dairies. • Solar photovoltaic (PV) with a peak output of 500kW. • 10 kW wind turbine. • A geothermal heat pump system using treated wastewater to reduce heating and cooling costs. • Buildings retrofit and conservation measures. • A web-based integration model.

Recipient	Title	Goals
Southern California Edison	Proposed Deployment Study of a High Penetration of Renewable Energy on Santa Catalina Island	• Perform analysis to optimize renewables and energy storage. • Achieve self-sustainability for the island.
Summers Consulting	Energy, Economic, and Environmental Performance of Dairy Bio-power and Biomethane Systems	• Analyze mass, volume, and energy flows for the integrated dairy power system. • Cost/benefit information.
UC Davis	West Village Renewable-based Energy Secured Community	• Become a zero-net energy community by integrating renewables into the grid and lower energy usage by improving energy efficiency.
UC Irvine	Piloting the Integration and Utilization of Renewables to Achieve a Flexible and Secure Energy Infrastructure	• A roadmap for 100% renewable secure energy for the campus. • A method for a renewable energy infrastructure at UCI that is transferable to other communities. • Demonstrate 1 MW of PV, EVs, Smart BEV charging, necessary energy storage, 24/7 H2 production and power for transportation.
UC Merced	Piloting an Integrated Renewable Energy Portfolio for the UC Merced Community	• A 1 MW solar generation system. • A 300 kW pilot plasma gasification system. • Energy efficiency improvements. • An integration model to identify an optimal generation strategy.
UC San Diego	Regents of the University of California, San Diego	• The goals of this project will provide intelligence driven solutions that enables multiple and individual customer renewable energy generation that: -Reduces electricity and natural gas costs with better efficiency. -Reduces carbon. -Allows direct electricity market participation.

Source: California Energy Commission

300 kW of power.[793] PIER is also funding research to demonstrate a process that will produce fuel locally, from nonfood sources, in a manner less complex and more efficient than competing processes. Initially, this process will concentrate on waste from almond and grape processing. Almond hulls and wine grapes present a challenge to conventional biofuel processes. Thus the successful demonstration of economically viable biofuel production from these two sources gives confidence that the method can be extended to a wide array of nonfood-based agricultural waste feedstocks and thus yield maximum economic and environmental benefits.

- The PIER Program is conducting an industrial-scale demonstration project at the Community Fuels Biodiesel (American Biodiesel) production plant in Stockton.[794] The proposed water treatment system will integrate three distinct technologies, distillation, ultrafiltration and reverse osmosis for treating and recycling spent biodiesel wash water. This system will reduce the consumption of water for biodiesel washing by an estimated 85 percent and result in a zero-discharge wash process. It will constitute the first industrial-scale demonstration of these combined technologies applied to treating effluent from biodiesel production.
- The PIER Program is funding a number of projects to demonstrate energy storage at commercial and industrial facilities. Premium Power, Wal-Mart, and SDG&E are working together to demonstrate the technical and economic performance of a 150 kWh battery energy storage system – connected on the customer side of the meter – that will store power during off-peak hours and discharge during peak hours. The system is constructed with milk jug-grade plastics and uses inexpensive and readily available salt brine complexes to make it cost competitive with lower performance, lead acid storage technologies.[795]
- Distribution Monitoring Initiative: This project is coordinating collection of data among California IOUs from distribution feeders to analyze and predict the impacts of DG on distribution circuits. A scoping study was prepared by CIEE, and a stakeholder working group has formed to cooperatively develop criteria for the installation of new

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793 California Energy Commission, *The Natural Gas Research, Development, and Demonstration Program Proposed Program Plan and Funding Request for Fiscal Year 2009-2010*, April 2009, http://www.energy.ca.gov/2009publications/CEC-500-2009-069/CEC-500-2009-069.PDF.

Press release about State Leadership in Clean Energy (SLICE) award found at: http://www.energy.ca.gov/releases/2010_releases/2010-11-01_slice_awards.html.

794 California Energy Commission, Staff Decision Memo for American Biodiesel, "Integrated System for Reducing Water Consumption and Wastewater Discharge of Biodiesel Production Facilities in California, http://www.energy.ca.gov/business_meetings/2010_packets/2010-08-25/2010-08-25_Item_09_American_Biodiesel/.

795 California Energy Commission, Staff Decision Memo for Premium Power Corporation, Demonstration on Zinc Flow Energy Storage System, http://www.energy.ca.gov/business_meetings/2010_packets/2010-07-14/2010-07-14_Item_08/.

monitoring equipment, data specifications, and information sharing. Future PIER funding will support data analysis and modeling based on information provided by utilities. This initiative is critical in view of utility concerns about technical challenges associated with the implementation of 12,000 MW of DG, combined with the relative paucity of sensing data available on most distribution circuits to date.

- The PIER Program is also funding a number of research projects to demonstrate how smart grid technologies can support the integration of renewable resources in California's residential communities.
    - In 2009, SDG&E began research to demonstrate how smart grid technologies such as microgrids can coordinate and manage various integrated distributed resources. This demonstration is taking place in Borrego Springs, California, an area with an average of nine blackouts per year. PIER-funded microgrid research is demonstrating through the San Diego Gas & Electric Microgrid Project how a microgrid can use multiple advanced and innovative technologies to support the integration and management of utility- and customer-based energy resources in an interconnected network. Multiple customers interconnect and receive their power from a local portfolio of utility and nonutility interconnected resources. This network relies on a mix of high-efficiency and renewable distributed generation, storage, as well as energy reduction programs and strategies to meet most of the demand of customers on the network. Distribution automation and other smart grid technologies are being used to address operational and stability issues. The research also evaluates everyday operations of the network to assure it can consistently provide reliable and stable power to all customers. Attention is focused on understanding how to improve system performance in both peak and nonpeak periods.[796]
    - The PIER Program is also providing funding to the Sacramento Municipal Utility District (SMUD) to demonstrate and validate technologies developed under the Energy Commission-funded Microgrid Laboratory Test Bed by the Consortium for Electric Reliability Technology Solutions (CERTS). The SMUD microgrid will demonstrate the integration of distributed generation, renewable technologies, combined heat and power systems, and energy storage. SMUD hopes to demonstrate that the microgrid can successfully separate from the utility system and provide reliable power.[797]

Future Research

- Modifications that will have to be made to protection practices to accommodate current levels of DG interconnected to the system.

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796 http://cal-ires.ucdavis.edu/files/events/2011-resco-symposium/torre-william_cal-ires-resco-sdge.pdf.

797 2010 Microgrid Symposium presentation, Microgrid and Smart Grid Activities at SMUD, July 2010, http://der.lbl.gov/sites/der.lbl.gov/files/vancouver_rawson.pdf.

- Advanced systems to develop new and better islanding protection algorithms, equipment, and practices needed to accommodate high penetrations of DG.[798]
- The time- and location-dependent relations between feeder segment loads and PV output.
- The impact of increased DG through detailed modeling of voltage profiles that will be necessary to manage voltage sags, imbalances, transients, and harmonics in the future. This type of model will help distribution operators have more visibility into the distribution system to address problems created by increased amounts of DG.
- Exploration of smart grid technologies such as using smart meters to enable dynamic conservation voltage reduction that adjusts automatically to keep voltages within Rule 2 limits.
- Distribution Feeder Characterization: Building on the Distribution Monitoring Initiative and past Energy Commission-funded work on distribution feeder modeling, future research will be needed to generalize from these models and predict impacts of increasing DG penetrations in specific situations.
- Advanced Technology Development and Demonstration: The PIER Program has developed a number of advanced DG technologies over the past decade. However, individual technology development has recently received a significant boost in funding from USDOE, including a number of projects awarded in California. By continuing to fund technology development and commercialization at some level, California can leverage private and federal funding and continue to be a clean tech research hub for the nation.
- Integrated Community Energy Development and Demonstration: High upfront cost, risk, consumer demand, lack of demonstration, and other issues prevent decision-makers from moving forward with the deployment of advanced energy technologies and methods. Research is needed to demonstrate integrated approaches that address these issues in California's existing communities within the context of existing jurisdictional boundaries – including buildings, districts, municipalities, and counties. Integrating DG, CHP, energy storage, smart grid, and other advanced technologies in these settings offers California the potential to achieve its energy and environmental goals with the full-fledged involvement of local governments, communities, and business park owners.

Research to Address Cost and Financing Challenges

Current Research – Solar, Biomass, Wind, and Geothermal Technologies[799]

- Low-Cost Installation of Concentrating Photovoltaic (GreenVolts, Inc.): GreenVolts, Inc., is demonstrating a new concentrating photovoltaic (CPV) system with low installation

798 As described in Chapter 6, *islanding* refers to a situation in which a DG generator continues to provide energy, even though power from the utility is no longer present.

799 PIER publishes annual reports that highlights and summarizes research projects and activities including some of these examples. The reports are available at http://www.energy.ca.gov/research/annual_reports.html.

and manufacturing costs, technical performance improvements, and minimal ground footprint. This new CPV system will speed the deployment and adoption of CPV technology in various applications. Because of its scalable nature, it can be used for distributed near-load locations, as well as scaled up to multimegawatt utility-scale power plants. The system's design for rapid deployment and simple assembly significantly reduces installation costs, which helps increase the number of deployment sites, serving the commercial, industrial, agricultural, and wholesale (utility) markets.

- Development and Demonstration of a Concentrating PV System for Commercial Applications with Integrated Active Micro-inverters and an Optional Daylighting Subsystem (UC Merced):[800] UC Merced is demonstrating the efficacy of a dual-axis concentrating photovoltaic (PV) system with integrated panel-level microinverters. Microinverters offer increased mitigation for losses due to partial shading and include maximum power point tracking to optimize generation of each panel at any given time. The results of this project will provide valuable lessons learned toward the ultimate goal of developing cell-level microinverters for use with PV systems.
- Enabling Photovoltaic Markets in California Through Building Integration, Standardization and Metering in the Carbon Economy (Silicon Valley Leadership Group): The goal of this project is to accelerate the growth of solar PV systems in California through cost reduction, energy efficiency increase, and removal of barriers that prevent market growth. This will be achieved through a demonstration of best practices for solar PV plug-and-play advanced technologies, optimizing energy generation and utilization profile through overall system design and monitoring, and developing innovative financial models and market mechanisms to ease the financing and permitting processes.
- Hybrid Solar-Fossil Thermophotovoltaics (EDTEK): EDTEK developed, manufactured, and demonstrated a hybrid prototype Solar-Fossil Thermophotovoltaics (SFTPV) cogeneration power system that can produce electric power and thermal energy on a 24-hour basis. This power system converts sunlight to electricity with 25 percent overall efficiency and natural gas to electricity at an overall efficiency of 20 percent while producing process-grade hot water at a recovery efficiency of 83 percent. In this system, highly concentrated sunlight is directed into a cavity where the surrounding walls are heated to incandescence, the state where visible light is emitted from a hot object. A natural gas flame is also directed into the cavity to heat its walls and excite the PV cells, as does the concentrated sunlight.
- Valley Fig Growers Anaerobic Digester (Valley Fig Growers, Inc.): California has more than 3,000 food processing establishments, that is, about 27 percent of the national total. Conversion of food processing wastes into energy is an economically and environmentally viable solution and also responds to an urgent need to solve issues that are faced by the

800 https://ucmeri.ucmerced.edu/research-focus-areas/solar-concentration/current-research and http://www.energy.ca.gov/2010publications/CEC-500-2010-FS/CEC-500-2010-FS-004.PDF.

food processing industry. The Valley Fig Growers designed and constructed an anaerobic digester to pretreat wastewater prior to disposal in the municipal sewer system. The Valley Fig Growers project demonstrated to other food processors the quantifiable economic and environmental benefits gained by installing and operating a digester. The goal was to create an economically feasible solution to energy and waste water issues facing food processors.

- Development and Demonstration of a Distributed Biogas Energy System Utilizing Organic Solid Wastes (UC Davis):[801] University of California, Davis demonstrated the anaerobic-phased solids (APS) digester technology with advanced design features that enhance the effectiveness of bacterial degradation of organic wastes, provide efficient material handling solutions, and combine favorable features of both batch and continuous operations in a single biological system. Testing and analysis of the APS-Digester at scales larger than bench-scale were needed before full-scale system commercialization. This project demonstrated that the APS Digester, in conjunction with a clean burn engine-generator, is an environmentally sound, cost-effective distributed energy system capable of degrading high solid wastes (food residues, community green wastes, and agricultural byproducts) while producing renewable energy, soil amendments, and fiber products.
- Development and Demonstration of 50 kW Small Modular Biopower System (Community Power Corporation): The Community Power Corporation's BioMax 50 is a modular biopower system that converts a wide range of biomass residues such as nut shells, forest thinnings, and wood scraps into clean and green power and heat. This biomass gasifier system was installed in November 2007 at the Dixon Ridge Farms in Winters, California, where it is used to produce combined heat and power by gasification of the walnut shells. This project offsets host site electrical needs by up to 40 percent, and provides heat for walnut drying operations and buildings. This work built upon a prior project (a small modular biopower (SMB) system rated at 12 ½ kW) that was successfully developed and demonstrated using waste forest slash and thinnings to provide utility grade power to the greenhouse complex and heat to maintain seedling bed temperature at Hoopa Valley.
- Biogas Fueled HCCI Power Generation System for Distributed Generation (Makel Engineering Inc.): This project is a subsequent phase of Makel's prior project that developed the homogenous charge compression ignition (HCCI) technology. Makel Engineering is demonstrating generation of up to 200 kW of electric power under this project using the HCCI technology while meeting or exceeding California's emissions standards. Under the previous PIER cofunded agreement, Makel successfully developed and demonstrated a 30 kWe landfill gas-fueled HCCI power generation system. This system demonstrated power generation at an active California landfill site (Neal Road Landfill, Chico), which is currently flaring land fill gas. This project has already

801 http://www.energy.ca.gov/pier/portfolio/Content/06/Ren/Development%20and%20 Demo%20Wastes.htm.

achieved over 500 hrs of operating time with LFG, operated at an efficiency of 35 percent with NOx emissions on the order of 5 PPM.

- The Next Generation Turbine Development Project (The Wind Turbine Company): The Wind Turbine Company developed a two-bladed, downwind, horizontal-axis wind turbine with flexible blades as a proof-of-concept vehicle for demonstrating cost savings by reducing the weight and manufacturing cost of key wind turbine components. Lessons learned from the 250 kilowatt prototype, which amassed more than 1,000 operating hours at the National Renewable Energy Laboratory test facility in Colorado, led to a follow-up project to scale-up the design to a more commercially viable 500 kilowatt platform and to further refine the innovative flap motion controls developed for the prototype to achieve optimal performance and safety.

- Wind Turbine Company EMD Turbines (The Wind Turbine Company): Building on successful demonstration of its innovative prototype downwind, horizontal-axis wind turbine in the Next Generation Turbine Development Project, the Wind Turbine Company scaled-up the design to a more commercially viable 500 kilowatts. The anticipated cost-reducing features of the design included the use of two (as opposed to three) lightweight, flexible turbine blades; employing innovative flap motion controls to optimize performance and enhance safety of the design; and using large-diameter commercial steel pipe with guys instead of conventional tubular or lattice tower technology. The 500 kilowatt demonstration unit was deployed near Lancaster, California, and saw 70 hours of operation when it experienced a blade-tower strike due to an error in the blade protection software. Subsequent efforts to recover from the mishap were unsuccessful.
- Composite Taller Towers for Low to Moderate Wind Shear (Wind Tower Systems LLC): Wind Tower Systems designed a space frame tower that would expand California's recoverable wind resource in marginal areas by permitting developers to economically reach higher wind speeds available at greater heights above ground level. Tower cost reductions over conventional tubular towers are achieved by avoidance of oversized trucking charges, and self-erecting tower technology permits the use of smaller cranes than would otherwise be employed. Though unable to deploy and demonstrate the technology itself, Wind Tower System sold to sell the concept to General Electric.
- SMUD – 4.5 Distributed Generation Geartrain for Megawatt Turbines (Sacramento Municipal Utility District): Under a programmatic subcontract with SMUD, Clipper Windpower designed and built a commercial scale (1.5 MW) distributed generation drive train and controller and successfully tested the system for more than 600 hours on a dynamometer at the National Wind Technology Center. The innovative geartrain splits torque on the low-speed side of the gearbox along multiple parallel pathways, thereby reducing gear tooth stress and improving gearbox life and reliability. Lessons learned from this project were subsequently employed by Clipper Windpower to develop its Liberty 2.5 MW wind turbine, which splits torque between four permanent magnet generators.

- Dual Horizontally Completed Injection Well To Enhance Geothermal Production at the Geysers (Northern California Power Agency): A dual horizontally completed injection well was drilled to a depth of about 8,000 feet at The Geysers geothermal field in Northern California. This project was to develop and demonstrate a substantially more effective means to inject and distribute an increasing supply of wastewater for additional recovery of injection-derived steam. The increase in steam production resulted in an increased electricity being generated from the existing power plants for distribution to consumers.
- Geothermal Exploration Under The Salton Sea Using Marine Magnetotellurics (Schlumberger Carbon Services, a division of Schlumberger Technology Corporation): This project was to apply new marine magnetotelluric technology to delineate potential geothermal reservoirs extending beneath the Salton Sea, which will help developers effectively explore, develop, drill fewer dry holes, and reduce the cost of electricity generation. This project demonstrated the first combined land/marine magnetotelluric survey which delineated the geothermal reservoir extending beneath the Salton Sea, Imperial County, and provided valuable structural geophysical data of the area previously unknown.
- Pilot-Scale Geothermal Silica Recovery at Mammoth Lakes (Lawrence Livermore National Laboratory): Lawrence Livermore National Laboratory (cofunded by U.S. DOE) led the development of a silica extraction technology that produced high-purity colloidal silica from geothermal waters. The process used reverse osmosis to concentrate the silica up to 1,000 parts per million to enhance and resulted in 99.6 percent silica purity. Colloidal silica was also captured in extraction tests. The resulting product is potentially marketable to various industrial users of silica, including the solar industry. The technology will enable geothermal operators to secure a second revenue stream, which increases the cost-effectiveness of geothermal generated energy.
- Improving Energy Recovery at The Geysers Geothermal Field by Delineation of In-Situ Saturation (Stanford University): This project used three related approaches to examine the best way to determine the measurement of fluid filled spaces (fluid saturation) in the rock at The Geysers. This project considered (1) making laboratory measurements of the saturation in rock cores; (2) collecting historical field data to use to infer saturation from model matching; and (3) applying theory and models to estimate saturation from output characteristics. Knowing the initial and current fluid saturations at The Geysers allowed for more effective energy production and the development of the best strategy to prolong the resource's life. The project aided in developing a more efficient strategy in determining where and how to engineer future large and small scale injection programs.

Future Research

- Surveying best practices and policies that have been used to reduce costs in other states and nations to determine the greatest opportunities for cost savings. For example, the installed cost of solar PV is $5.9/W in Japan, compared to $7.5/W in the United States. One strategy Japan is using is to limit rebates for rooftop PV to systems for which installation costs are

under a certain percentage that gradually becomes lower over time. California should continue to monitor activities in other states and countries to learn from their efforts and implement cost-reduction strategies that could apply to California's system.

- Developing strategies to encourage solar manufacturers to standardize the manufacture of components, and to design ground-up integrated systems to make it easier and faster for installers (plug and play). PIER has funded more than 40 bioenergy projects and studies and will build on those efforts in the future on the following research areas to expand the use of biomass and biogas for electricity generation:[802]
    - PIER will investigate possible research on colocating biopower or biofuel refineries with other biomass to energy projects, manufacturing facilities, or waste diversion, composting, transfer/processing, or disposal facilities.
    - PIER will explore research to reduce the cost of biomethane gas clean up to meet gas quality standards for injection into the natural gas pipeline.
    - PIER will explore working with the California Biomass Collaborative, the Department of Food and Agriculture, the U.S. Environmental Protection Agency, and industry associations to update and renew an existing Web-based database to provide location, volume, quality, and seasonality of biodegradable waste suitable for codigestion at wastewater treatment plants. The database will include waste from California's agriculture, food processing, and dairy industries.

802 California Energy Commission, *2011 Bioenergy Action Plan*, http://www.energy.ca.gov/2011publications/CEC-300-2011-001/CEC-300-2011-001-CTF.PDF.