Challenges and Effective R&D Paths for Promoting Repowering Wind Energy

Presented in the Staff Workshop
California Energy Commission
January 28, 2016
9:00 a.m – 12 p.m.

Agenda

9:00 a.m. – 12 p.m.

Time	Session
9:00 a.m.	Welcome and Introductory Presentation (Rizaldo Aldas and Silvia Palma-Rojas, CEC)
9:10 a.m.	**Session I**: Challenges and Priority R&D Paths to Promote Cost-Effective Wind Repowering. (Moderator: Nancy Rader, CalWEA) (Panelists: representatives from DNV LG, Siemens, PG&E, SCE, NREL, OGIN)
10:50 a.m.	**Session II**: Original Equipment Manufacturer's Perspective on Wind Repowering. (Moderator: Silvia Palma-Rojas, CEC) (Panelists: representatives from Siemens, UC Davis, Senvion USA Corp., OGIN)
11:50 a.m.	**Session**: Q&A and public comments

Housekeeping

- Facilities
- Emergency Exit
- Sign-In Sheet

Commitment to Diversity

The Energy Commission adopted a resolution strengthening its commitment to diversity in our funding programs. We continue to encourage disadvantaged and underrepresented businesses and communities to engage in and benefit from our many programs.

To meet this commitment, Energy Commission staff conducts outreach efforts and activities to:

- Engage with disadvantaged and underrepresented groups throughout the state.
- Notify potential new applicants about the Energy Commission's funding opportunities.
- Assist applicants in understanding how to apply for funding from the Energy Commission's programs.
- Survey participants to measure progress in diversity outreach efforts.

We Want to Hear From You!

1 Minute Survey

- The information supplied will be used for public reporting purposes to display anonymous overall attendance of diverse groups.

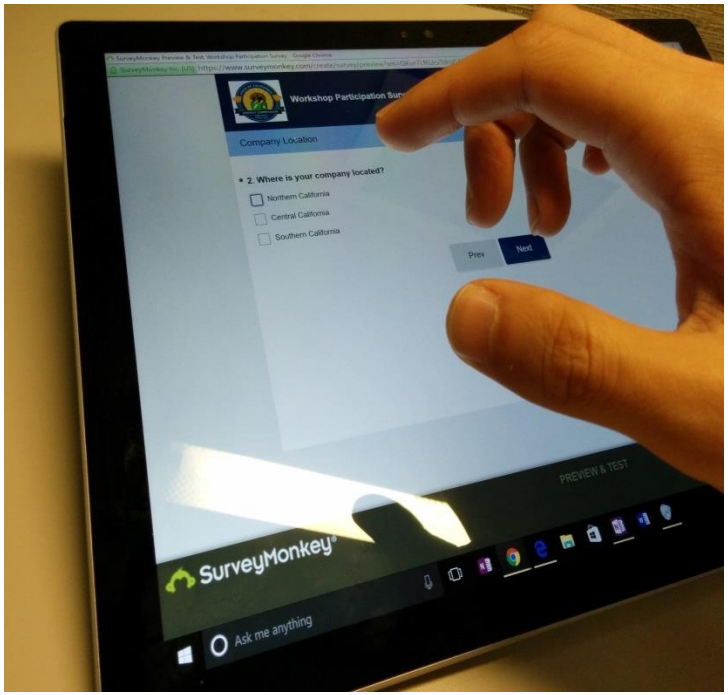
- **iPads are being passed around the room**

- **Online SurveyMonkey for WebEx Participants:**

https://www.surveymonkey.com/r/CEC-1-28-2016

- **We have also hard copies in the room**

Thanks for your time!



Connect With Us

Commission's listserves
www.energy.ca.gov/listservers

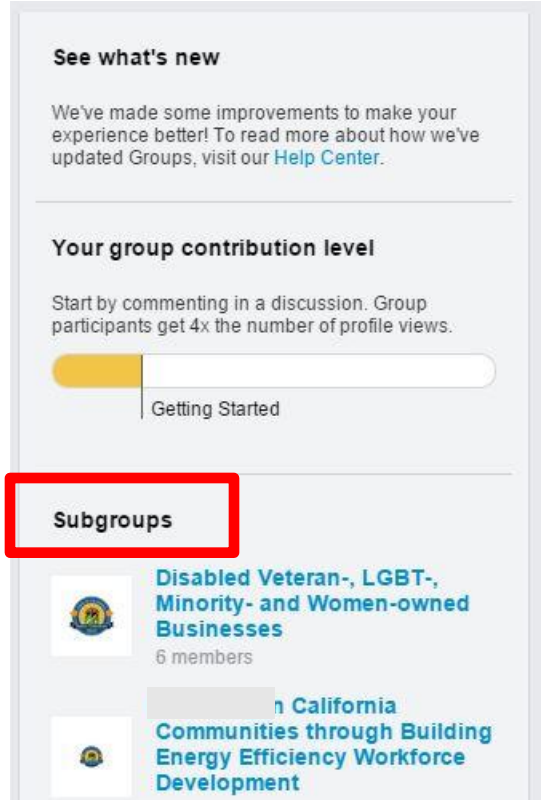
Find Partners via LinkedIn

The Energy Commission has created a user-driven LinkedIn group page to help potential applicants **connect, collaborate** and **partner** on proposals for funding opportunities.

•Participants can join the "California Energy Commission Networking Hub" by:

- Searching for the "California Energy Commission Networking Hub" group; or
- Entering this link into your browser: (bit.ly/CalEnergyNetwork)

•Once there, find and join the desired solicitation subgroup.



Background

- The Electric Program Investment Charge (EPIC) is funded by an electricity ratepayer surcharge established by the California Public Utilities Commission (CPUC) in 2011.
  - Annual program funds total $162 million per year (adjusted for inflation) with 80% administered by the California Energy Commission.
- The purpose of EPIC is to:
  - Benefit the ratepayers of the three largest electric investor-owned utilities, Pacific Gas and Electric Co., San Diego Gas and Electric Co., and Southern California Edison
  - Funds clean energy technology projects that promote greater electricity reliability, lower costs, and increased safety.
  - Encourage technological advancement and breakthroughs to overcome the barriers that prevent the achievement of the state's statutory energy goals.

EPIC Second Investment Plan Funding Initiative 4.4

- Funding Initiative 4.4: Upgrade California's Aging Wind Turbines: Design, Cost, and Developing Improvements That Meet Local Needs.

- This initiative will develop technologies and strategies that address the challenges to repowering California's wind resources, leading to improved system performance while taking into consideration the regulatory and social barriers to wind repowering.

- Feedback or suggestions gathered from stakeholders during this workshop will be used to inform and refine the grant solicitation related to this EPIC Second Investment Plan Funding Initiative.

Agenda: Why, What, How and When

- **Why** we are here?

Obtain feedback from wind energy stakeholders on the challenges and effective research and development (R&D) paths for repowering wind energy in California.

- **What** questions are we trying to answers:

- Do we have sufficient technology needed for repowering?
- How can we better deploy new and innovative wind technology to help repower and maximize use of California's wind resources?
- Are the O&M costs and capital costs the primary drivers for repowering decisions?
- Is the life cycle perspective included in the design of the current or newer wind technology?
- What do you see as the role of R&D for addressing those barriers and what R&D initiatives should be prioritized to repower wind energy in California?

Agenda: Why, What, How and When

- **How** we can use the feedback and suggestions from stakeholders?

Feedback or suggestions gathered from stakeholders during this workshop will be used to inform and refine the grant solicitation that will be released in support of the EPIC Second Investment Plan Funding Initiative 4.4

- **When** CEC is planning to release the grant solicitation?

Solicitation Announcement: Spring 2016

Role of Technology and Innovation in Repowering Wind Energy

Financial analysis:

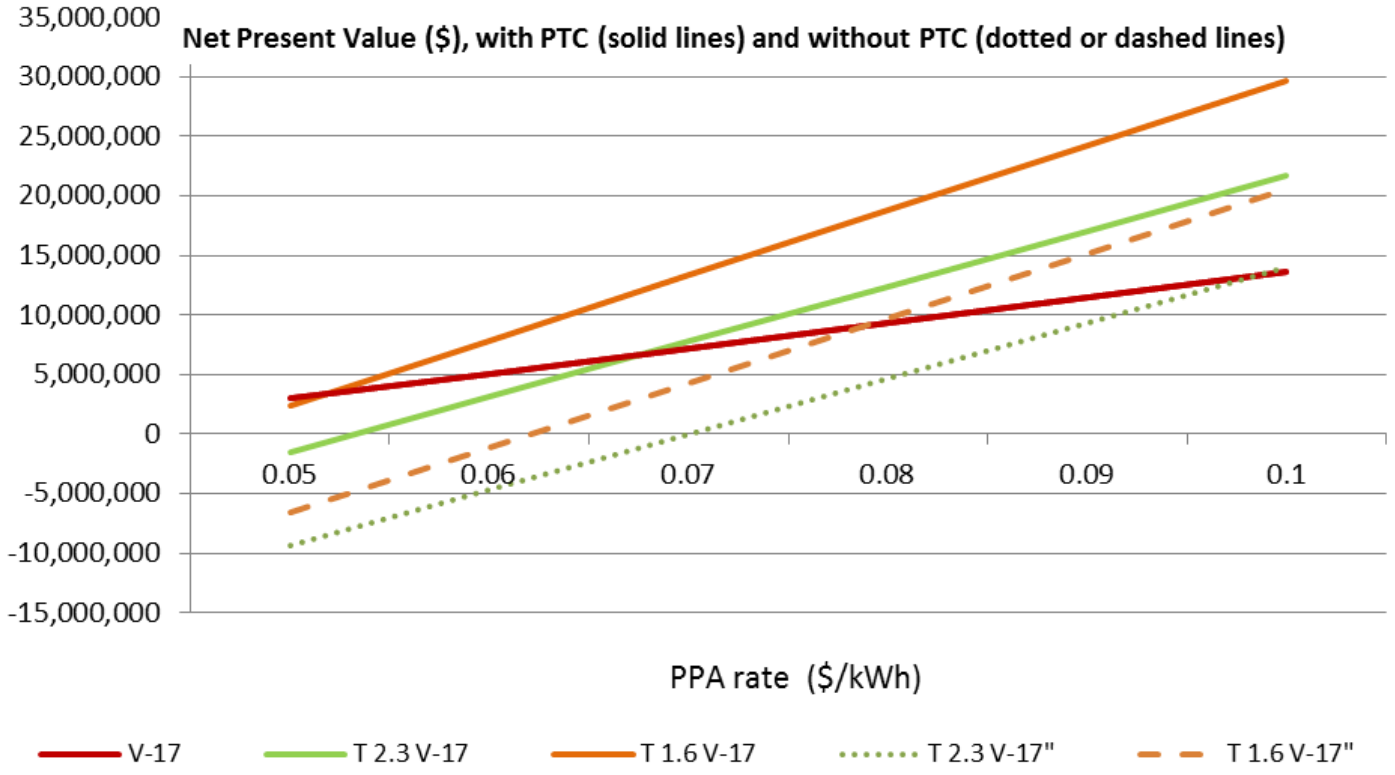
- Understand the decision-making process in repowering wind farms from the operator's perspective.
- Identify the primary driver of repowering decision
- The role of research and development in the process of promoting repowering wind energy

Scenarios for wind Farm V-17

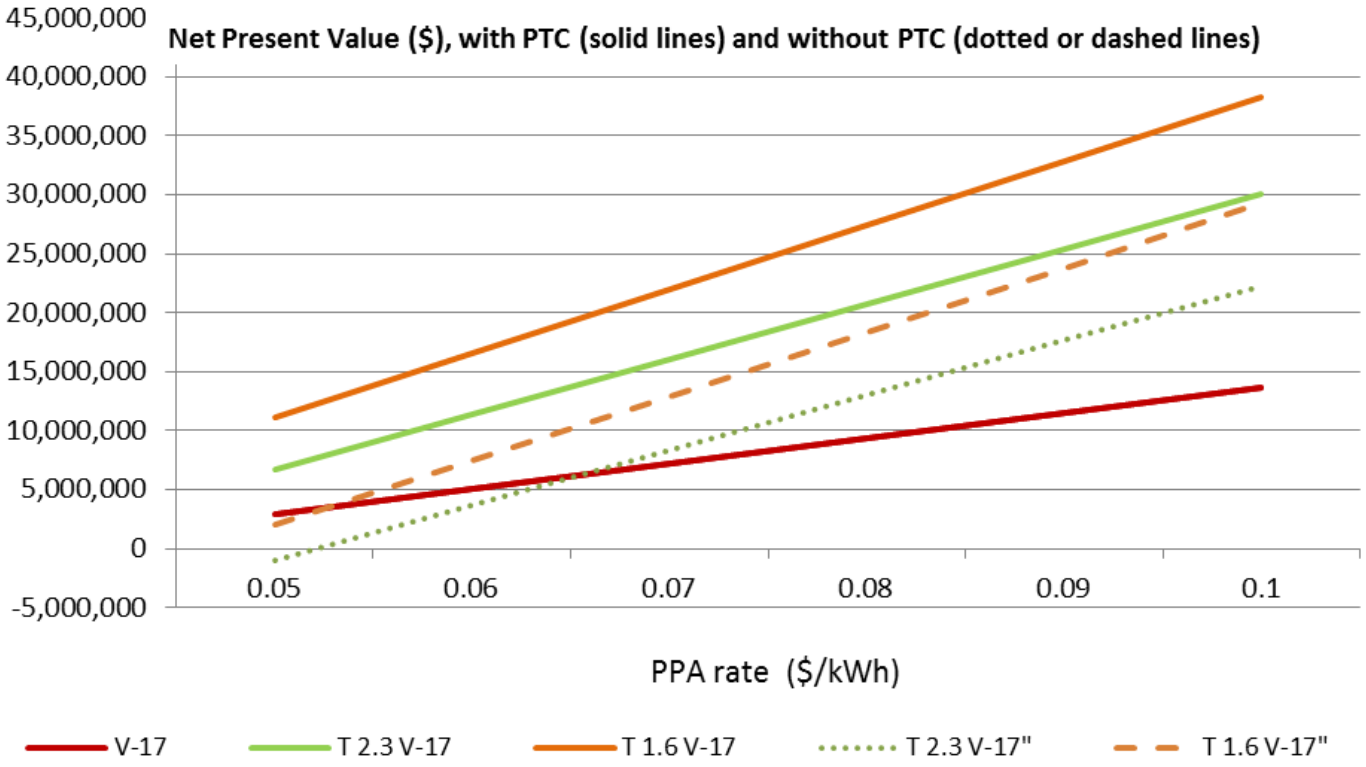
Altamont Scenarios	Number turbines	Energy Capacity (MW)	AEP per unit (MWh)	Total AEP* (MWh)
Alameda wind farm V-17				
Baseline V-17	200	19	125	24,966
Repowering scenario 1 T 2.3	8	19	6,628	54,751
Repowering scenario 2 T 1.6	12	19	5,689	67,556

Source: CEC energy Almanac and Christenson, C and Donohoe, S. Does it pay to repower an U.S. aging wind site? North American windpower. 2013.

Some Results!



What happen if capital and installation cost reduces 30% with innovative technology?



Preliminary Insights

- Technology and innovation can help to promote repowering wind energy in California.
- Profitability is a primary driver of repowering decision.
- PPA rate is an important variable to consider when repowering wind energy.

Session I: Challenges and Priority R&D Paths to Promote Cost-Effective Wind Repowering

Moderator: Nancy Rader, California Wind Energy Association
Panelists:
Alex Byrne - DNV LG
Farshid Arman - Siemens Technology to Business Center
John Pappas - Pacific Gas & Electricity Company (PG&E)
Marie Fontenot - Pacific Gas & Electricity Company (PG&E)
Maureen Hand - National Renewable Energy Laboratory (NREL)
Thomas Smith - OGIN

Repowering 1980s-Vintage Turbines: Benefits & Barriers

Nancy Rader, Executive Director
California Wind Energy Association

Workshop for Identifying Challenges and Effective R&D Paths for Promoting Repowering
California Energy Commission
January 28, 2016

Expiring 1980s PURPA Contracts & Estimated Repower Potential*

- **1,700 MW Wind Contracts Expiring 2014-2024**
  - Most are 1980s-vintage PURPA contracts, 51-100 kW turbines, ~22% c.f.
  - ~Half of these contracts expired prior to 2016
  - ~Half will expire 2016-2023, most by 2020
  - Primarily in Alameda, Contra Costa, Kern and Riverside counties
- **Already Repowered:**
  - ~200 MW (?) occurred late-'90s (prior to PTC change)
  - Approx. 300 MW repowered/in process of repowering since 2002 RPS
- **Not Repowered:**
  - At least 700 MW (62 projects) under 50 MW
  - Approx. 373 MW (38 projects) under 20 MW

*CalWEA estimates based on PG&E, SCE and SDG&E RPS Compliance Reports for 2014, filed with the CPUC; AWEA wind project database; and CPUC RPS Project Status Table (December 2015). Turbine size and capacity factors from 2008 CEC repower report (CEC-300-2008-004).

1980s-Vintage Technology

Benefits of Repowering (1)

- **Efficiently use California's best wind resource areas**
  - Raise capacity factors from low-20% range to mid-to-high-30% range
  - Preserve remaining ~1,000 MW of in-state "legacy" capacity, while increasing energy by ~330-MW equivalent, for California's 50% RPS
- **Modern turbines bring grid benefits**
- **Environmental & aesthetic benefits**
- **Tax & jobs benefits** (next slide)

Potential Benefits from Repowering Wind Projects

(<50 MW projects only, by County)*

	Alameda/ Contra Costa	Riverside	Kern	Total
Total Megawatts	104	251	350	**705**
Repower Investment Potential	$177 million	$427 million	$594 million	**$1.2 billion**
Associated Property Tax - Annual	$2.2 million	$5.2 million	$6.0 million	**$13.4 million**
Associated Sales Tax – Initial Turbine Purchase	$11.5 million	$26 million	$45 million	**$82.5 million**
Construction Jobs – Short-term (not including "induced" jobs)	133	320	445	**898**
Operations Jobs – Long-term (not including "induced" jobs)	40	97	134	**271**

*reflects all projects with PPAs expiring on or before 2020

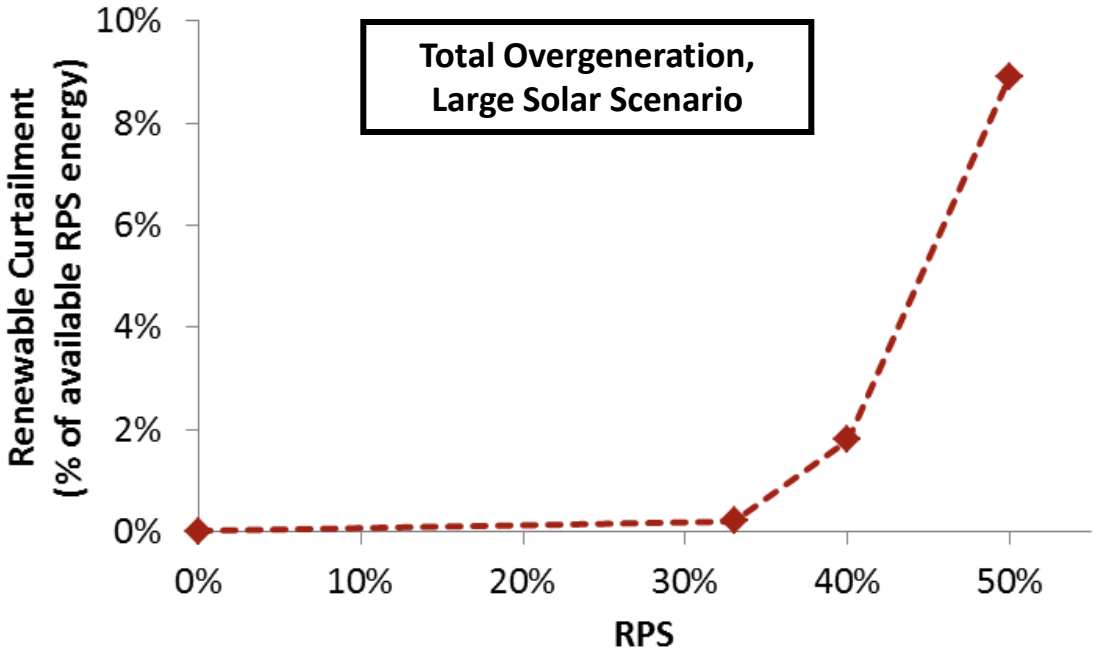
New Technology

Benefits of Repowering (2)

- Significant wind energy will be required for cost-effective achievement of 50% RPS
- Adding wind to the RPS portfolio is much cheaper than all-solar or solar + storage combination
- Repowering is one of the few remaining opportunities for (preserving &) generating more wind energy in California
- County and DRECP land-use restrictions will severely restrict new CA wind development

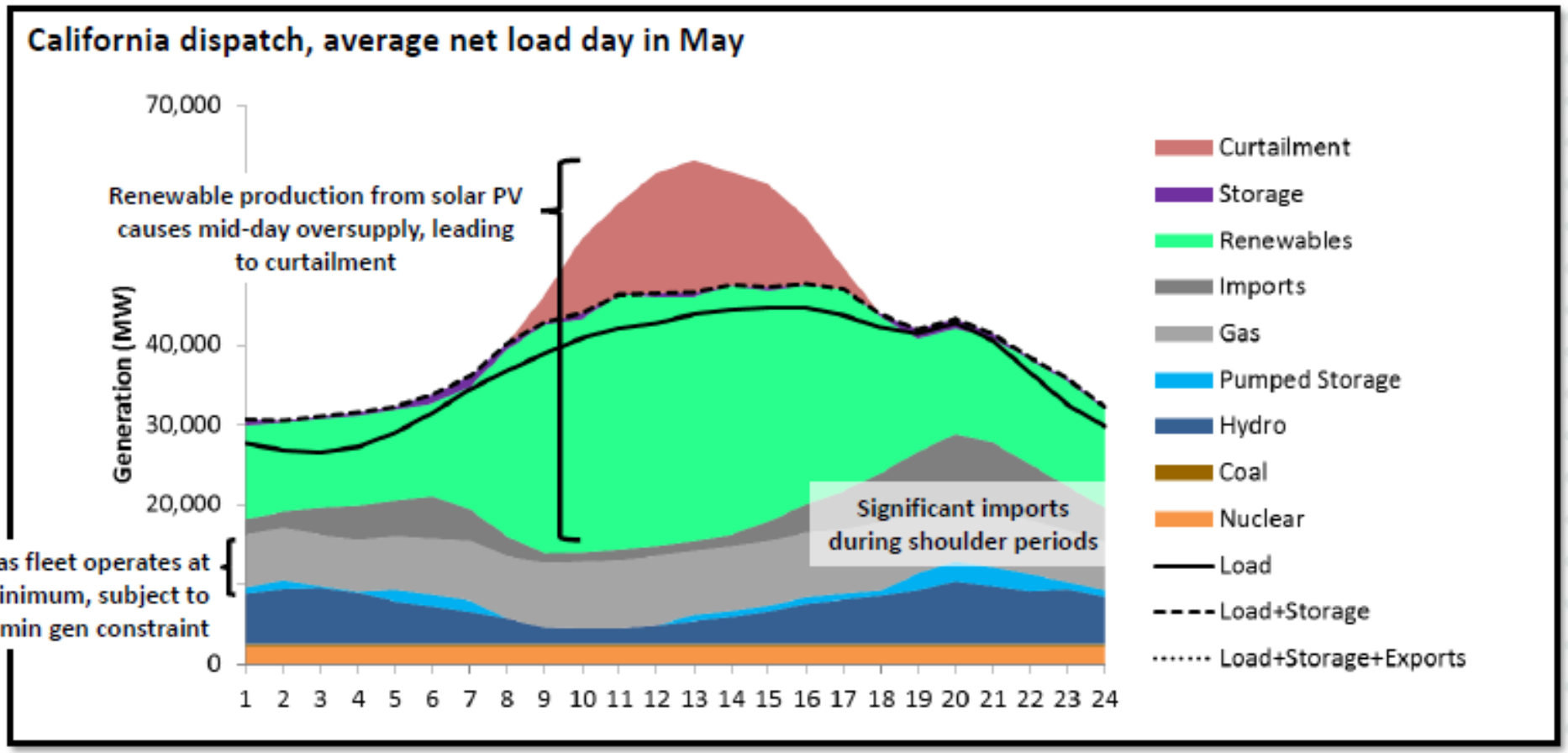
Overgeneration challenge gets worse at higher penetrations

- **Overgeneration is minimal at 33% RPS, but increases dramatically above 40%**
- **Saturation drives marginal overgen to unsustainable levels for solar PV**



Overgeneration Statistics	33% RPS	40% RPS	50% RPS, Large Solar
Total Overgeneration (GWh/yr.)	190	2,000	12,000
% of hours with overgeneration	1.6%	8.6%	23%
% of available RPS energy	0.2%	1.8%	8.9%
Marginal overgeneration for Solar PV	5%	26%	65%
Marginal overgeneration for Wind	2%	10%	22%

California Overgeneration Driven by Mid-day Solar Production

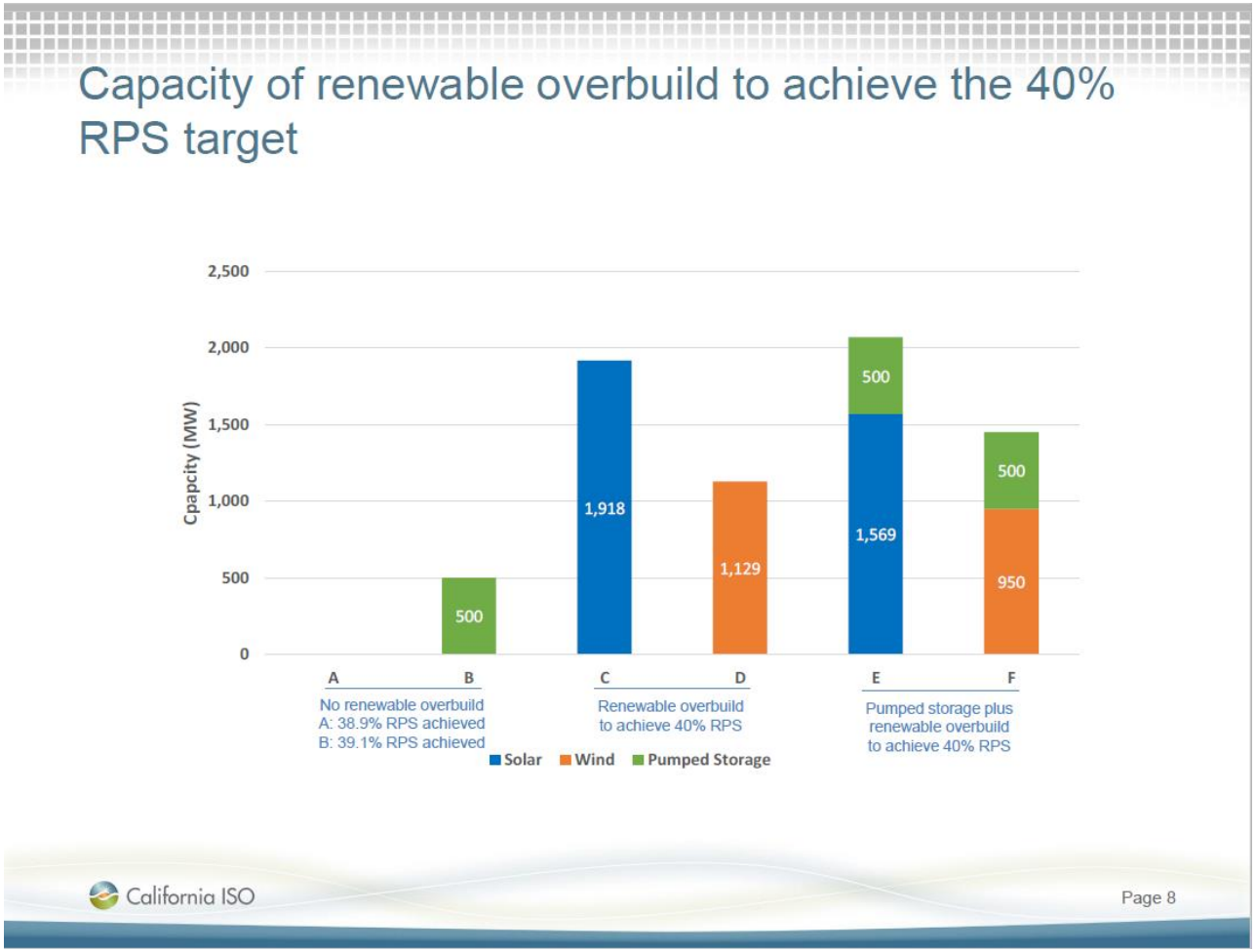


Renewable Penetration: 50%
(% of load)

Renewable Curtailment: 8.7%
(% of annual renewables)

Curtailment Frequency: 20%
(% of hours per year)

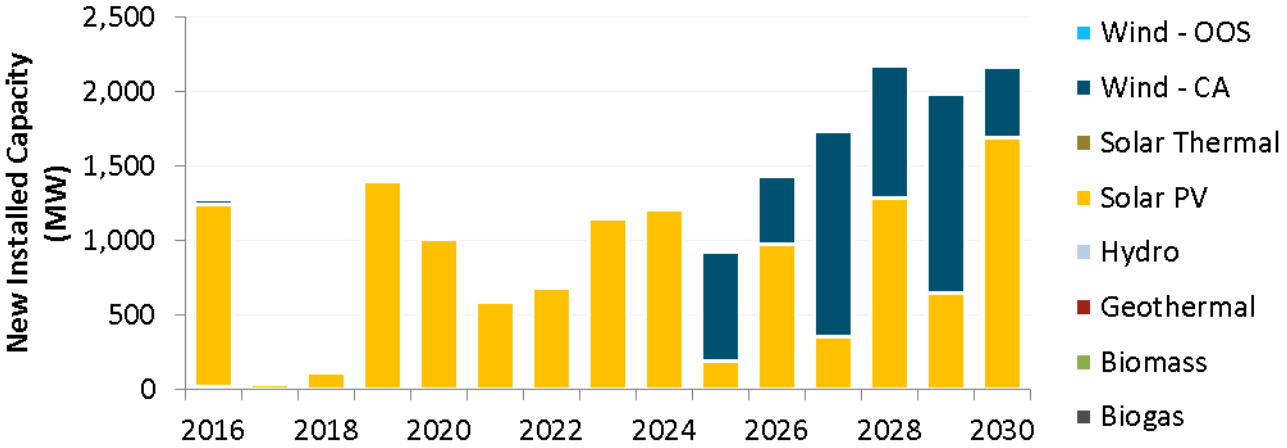
Adding Wind Is Least-Cost Solution Compared to More Solar, Solar+Storage



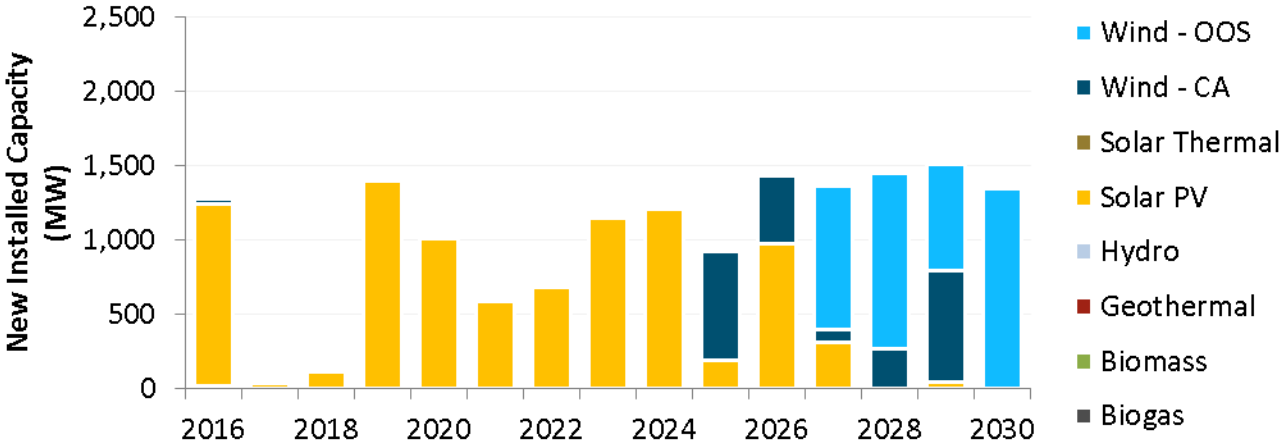
CAISO, "A CAISO Bulk Energy Storage Case Study," CPUC/CEC Joint Workshop on Bulk Energy Storage (Nov. 20, 2015).

Out-of-state wind resources increasingly important after 2025

- California-only case dominated by in-state solar



- Model picks 4000 MW of out-of-state wind if allowed



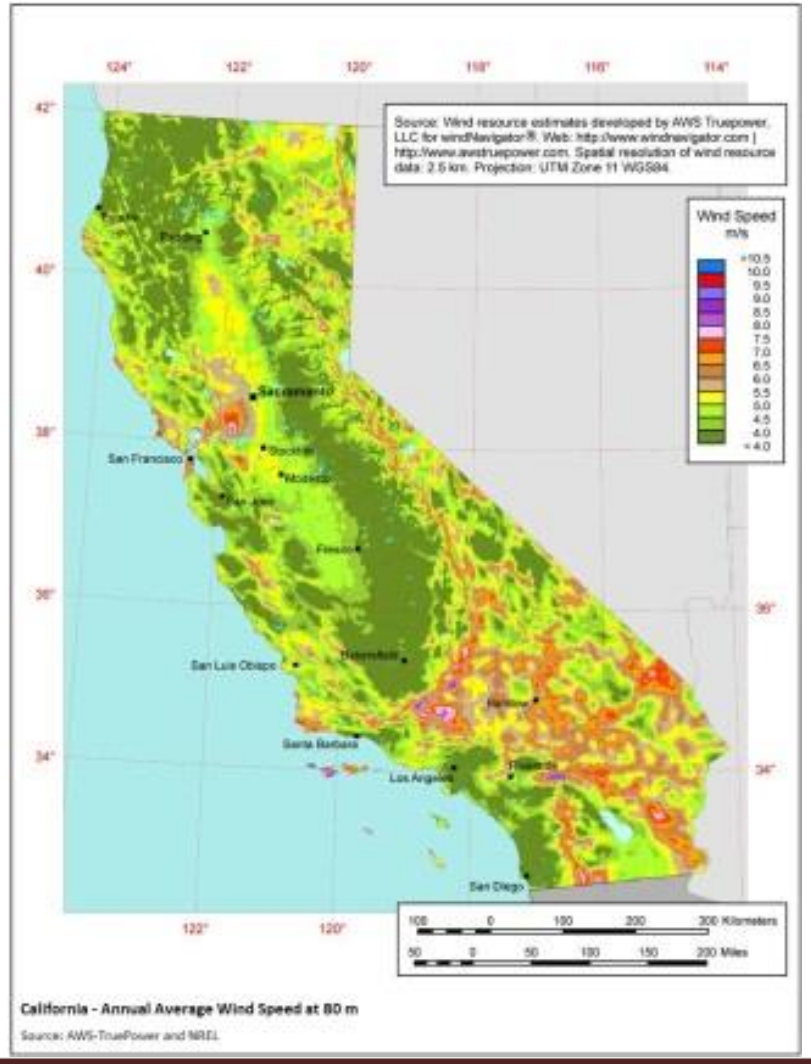
Wind Repowering is One of the Few Remaining Opportunities for Wind in CA

Solano County
Wind moratorium north of Hwy 12 likely to be extended due to Travis AFB concerns

Los Angeles County
Wind energy to be prohibited in Antelope Valley area

San Diego County
Unattainable sound standard

DRECP
Wind prohibited on 80% of BLM high-quality Wind Resource Areas



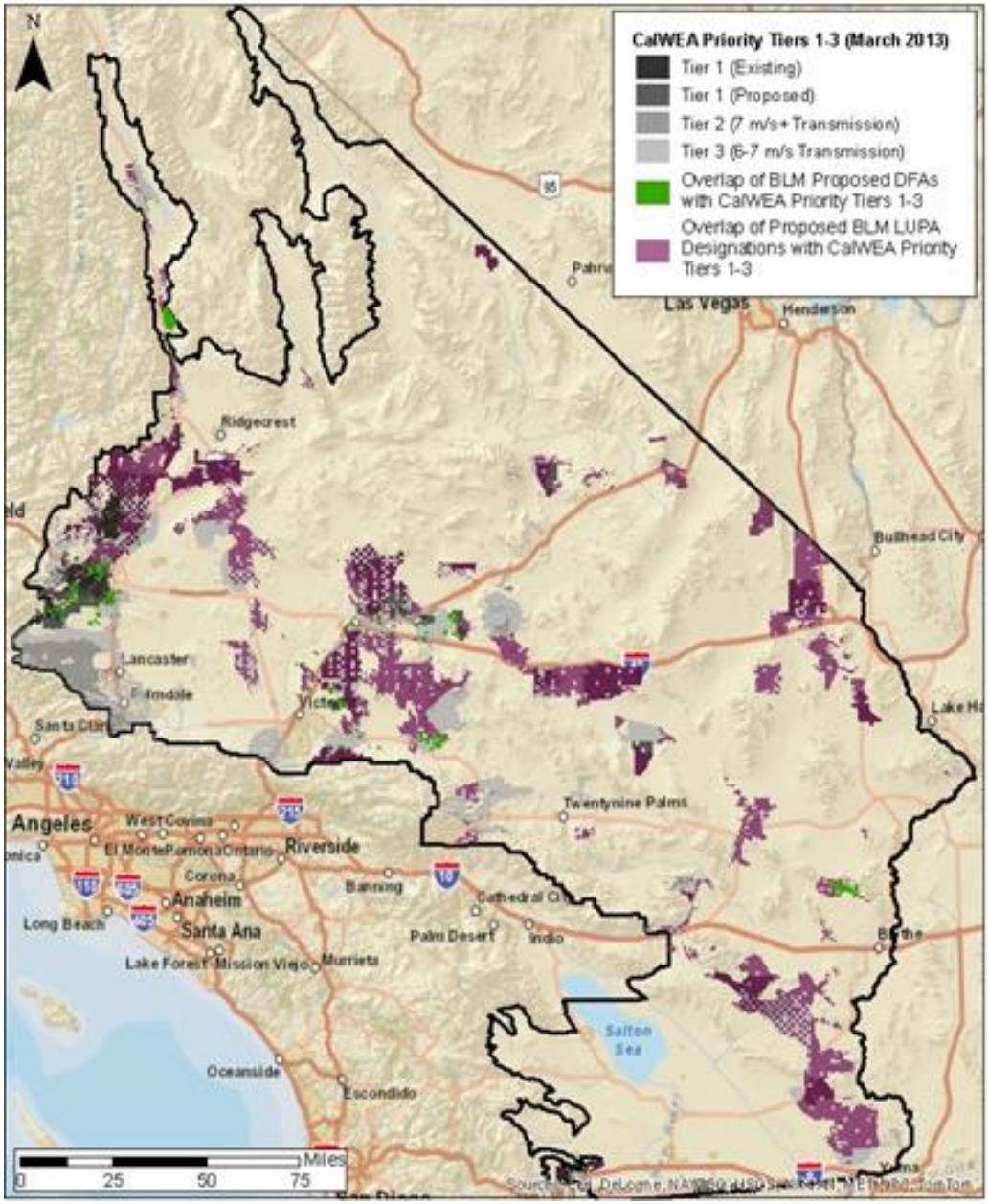
DRECP: BLM Wind Exclusions

The best wind resources within the DRECP region are shown in shades of gray.

BLM wind prohibition areas are shown in purple-overlay

Wind permitted in Development Focus Areas – green-overlay areas

CalWEA estimated DRECP max new wind potential = 1,000 MW. All CA = 2,000 MW



Barriers to Repowering (1)

- **Contracts expiring at a time of little RPS demand, low market prices**
- **Stiff competition from solar PV** (and larger wind projects, particularly out-of-state)
- **Significant tax policy disadvantages**
  - CA solar property tax exemption (worth 0.5 c/kWh)
  - Federal wind PTC phasing out faster than solar ITC

Wind PTC Phase-Out vs. Solar ITC

	WIND	SOLAR	OTHER
Projects "Starting Construction" By December:	% of Current ($0.023/kWh) PTC Value*	% of Current (30%) ITC Value	% of Current Geothermal, Biomass, Landfill Gas PTC
2016	100%	100%	100%
2017	80%	100%	0%
2018	60%	100%	
2019	40%	100%	
2020	0%	87%	
2021		73%	
2022		33%	

Barriers to Repowering (2)

- **Lag on the least-cost, best-fit bid evaluation components likely to favor wind**
  - integration costs, capacity value, curtailment valuation
- **Small & fragmented projects**
- **Military height restrictions (Kern County)**
- **Timing gap:** despite clear long-term need for wind, it could be several years before repowers become competitive (if competitive vs. OOS)

The result: 70x more solar than wind repowers in development

IOU Projects - Approved in Development or Pending Approval*

Technology	MW	Notes
Wind	**808**	Includes: 438 MW out-of-state wind 312 MW new, in-state **40 MW repower, in-state** 18 MW existing, in-state
Geo & Bio	**339**	Includes 275 MW existing Geysers
Solar PV	**2,742**	

*** Calculated from data in CPUC RPS Project Status Table, December 2015. In addition, NextEra has contracted 86 MW of repowered wind capacity from its Golden Hills project to Google and Kaiser Permanente.**

Ways to Encourage Repowers

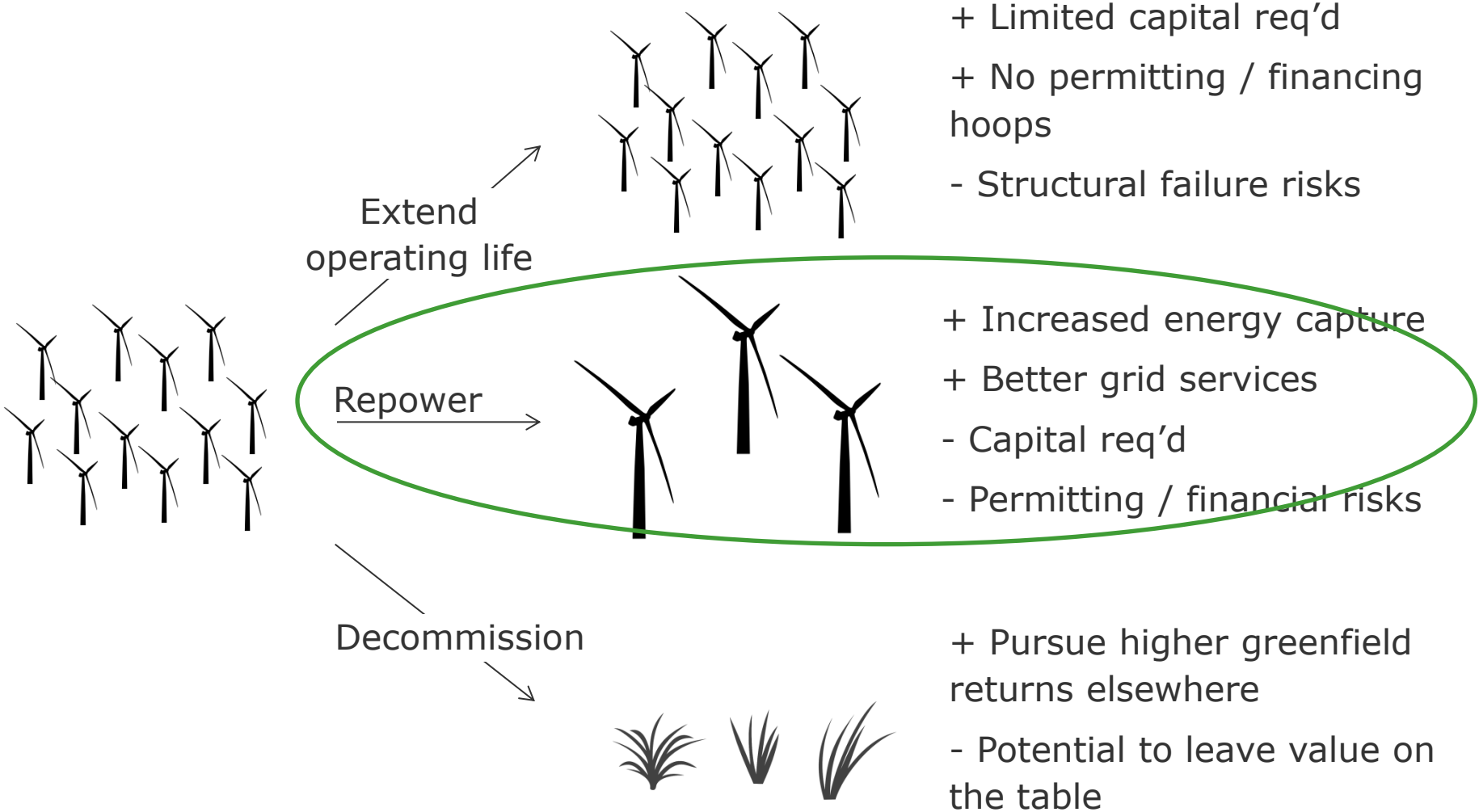
- Ease "QF Conversion" metering/telemetry requirements until repowering occurs (CAISO)
- Accelerate development of LCBF values, especially projected curtailment (CPUC)
- Facilitate the continued use of shared facilities – transformers (CPUC/IOUs)
- R&D – ? – Looking forward to your ideas

Technical challenges and opportunities to repowering

Alex Byrne

28 January 2016

End of life: A question of competing options



Environmental impacts

- Barriers to repowering:
  - Some environmental issues lessened with new technology, some are amplified
  - Challenges with permitting particularly where endangered species live or environmental damage has occurred[1]
- R&D needs:
  - Statewide research into environmental impacts of modern turbines
  - Statewide ordinance guidance or recommended practices for counties
    - Streamlined permitting procedures
  - Species ID technology to inform turbine shut-downs

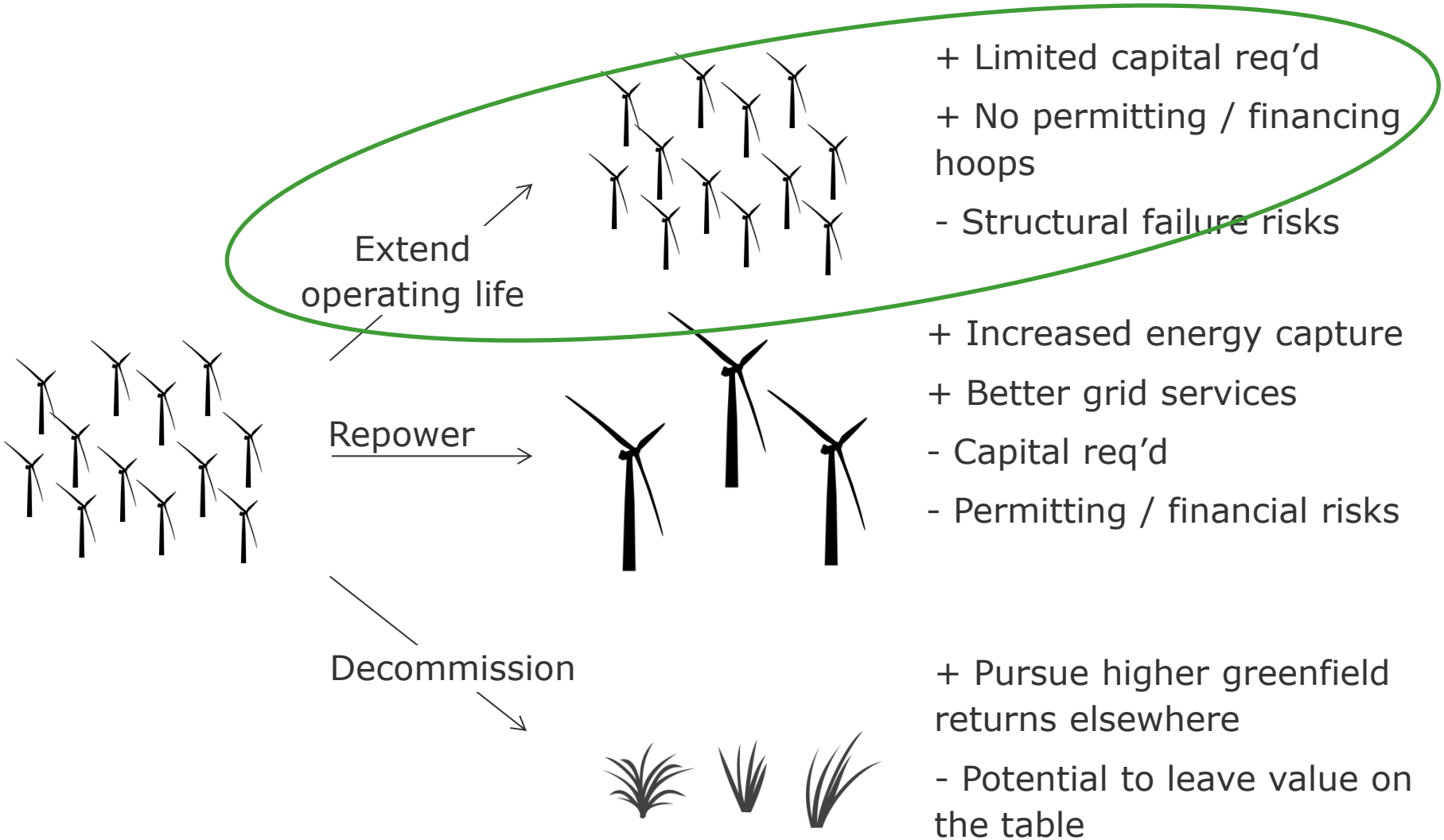
1 Lantz, E., et. al. Repowering Financial Feasibility, Decision Drivers and Supply Chain Effects. NREL 2013

Reduce cost of energy for repowered projects

- Barrier to repowering: cost of wind energy
- Lesson from Germany:
  - 4.5 euro/MWh on top of normal feed-in-tariff for repowering
  - 35% of country's 2014 wind installations were repowering efforts
- R&D solutions to reduce COE in lieu of direct financial support:
  - DOE Wind Vision Report[2] for specific recommendations
  - R&D areas targeting 5-yr horizon with highest potential impact for California:
    - High risk/high reward concepts: very large rotors, very tall towers
    - Grid integration
    - Reliability measures
    - Advanced controls solutions
    - Transportation (including modular technologies)

2 Wind Vision: A New Era for Wind Power in the United States. US DOE March 2015

End of life: A question of ~~competing~~ complementary options



Ungraded

Extending operating life

- Complementary path to repowering:
  - Find ways to maximize energy output without compromising safe operation
  - Keep existing turbines running to bridge gap to future period of lower cost wind
- Technical challenges:
  - Access to design and operating data on older turbines
  - Inspection and refurbishment know-how to curb structural failure
  - Supply chain for major components
- R&D needs:
  - Testing approaches to characterize turbine design
  - Development of risk based inspections and repairs
  - On-line condition monitoring of foundations and components
  - R&D for generic component designs that can be applied across turbine models
  - Component upgrades: Larger rotors combined with modern controls

Summary

- *Barriers:*
  - Cost of energy
  - Environmental permitting
- *Opportunities:*
  - Life extension
  - Upgrading existing turbines

- *Recommended R&D initiatives*
  - Life extension solutions
  - Environmental impact solutions
  - Technology to reduce cost of wind energy

Thank you!

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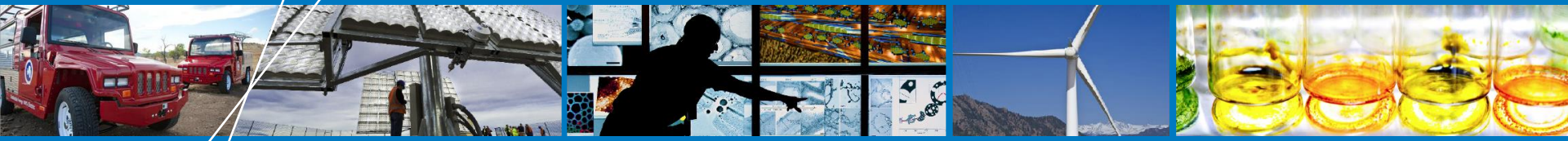
Repowering Wind Plants: Decisions and Drivers



M. Maureen Hand, Ph. D.

CEC Staff Workshop: Workshop for Identifying Challenges and Effective R&D Paths for Promoting Repowering Wind Energy

January 28, 2016

Sacramento, California

Background

- **Repowering can be defined in two ways:**
  - Full repowering: complete dismantling and replacement of turbine equipment at an existing project site
  - Partial repowering: replacing selected turbine or plant components to extend the life of a given facility at some cost that is less than full repowering; may also trigger fewer legal hurdles

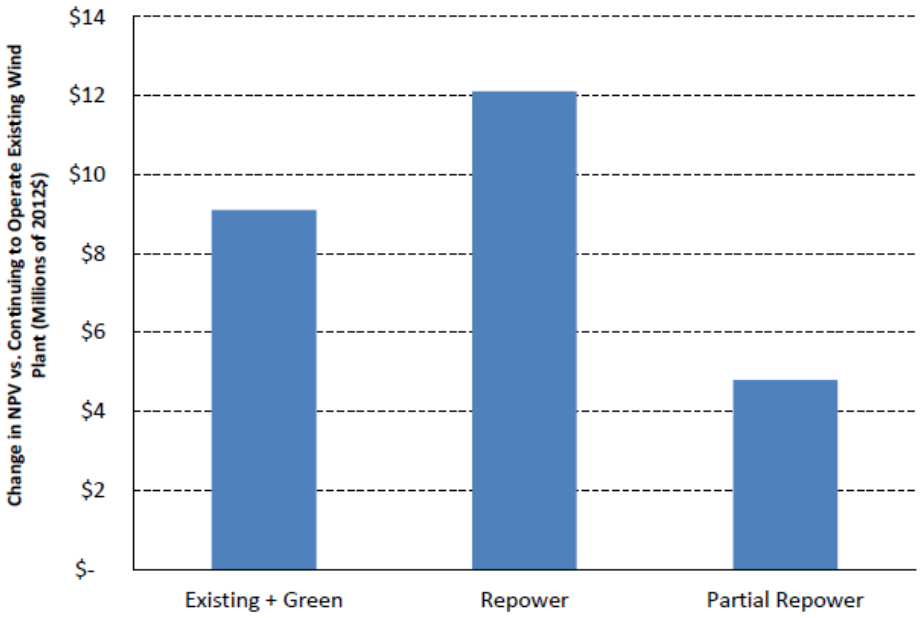
- **Repowering offers various opportunities:**
  - Increased project productivity
  - Better utilization of high-value resource areas
  - Improved grid support and interactions
  - Reduced visual impacts (fewer turbines per overall capacity)
  - Potentially reduced avian and wildlife impacts

- **Repowering first emerged in the early 1990s in the California and Danish wind power markets and was followed by the Dutch and German markets in the 1990s and 2000s.**

U.S. Case Study

- **Projects that "operate in the black" have little incentive to repower, relative to investing in new greenfield sites**
- **Around 20-25 years of operation, the choice between investing in greenfield sites and repowering becomes viable but depends on:**
  - Cost and performance of new technology
  - Anticipated energy production of comparable greenfield site
  - Durability and reliability of turbine equipment
  - Usefulness of existing infrastructure
  - Wholesale market electricity prices and existing contractual arrangements
- **Partial repowering solutions that can be realized at a lower cost would likely prove more viable**
  - Analysis of partial repowering assumes:
    - An increase in net capacity factor (NCF) from 30% to 37%
    - A 15% cost reduction relative to a green field (~10% relative to repowering).

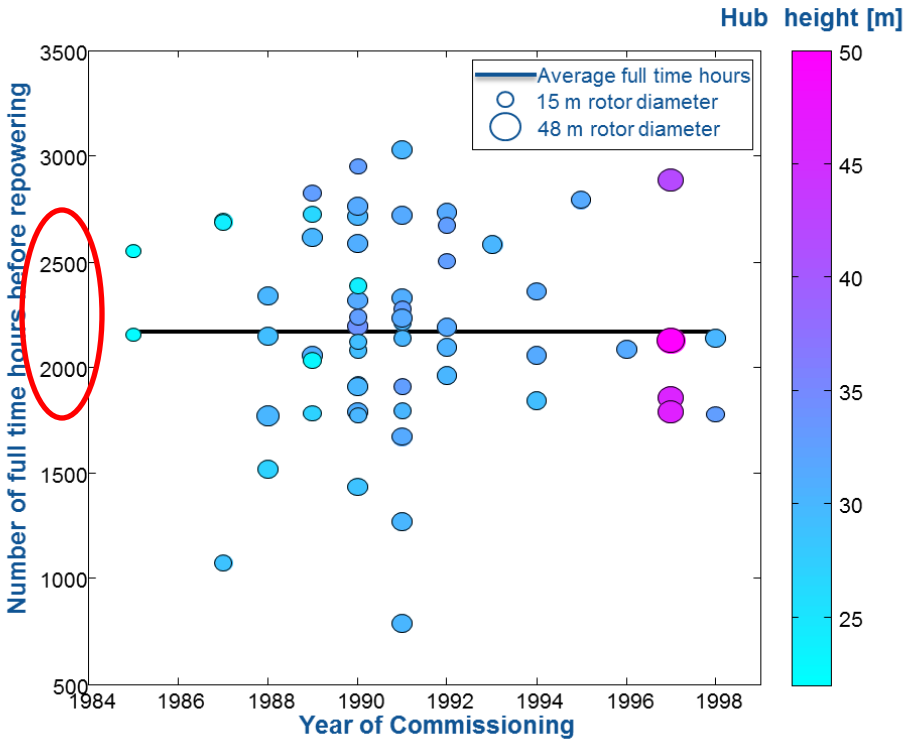
Cash Flow Analysis of 2003 Vintage Wind Plant in 2025



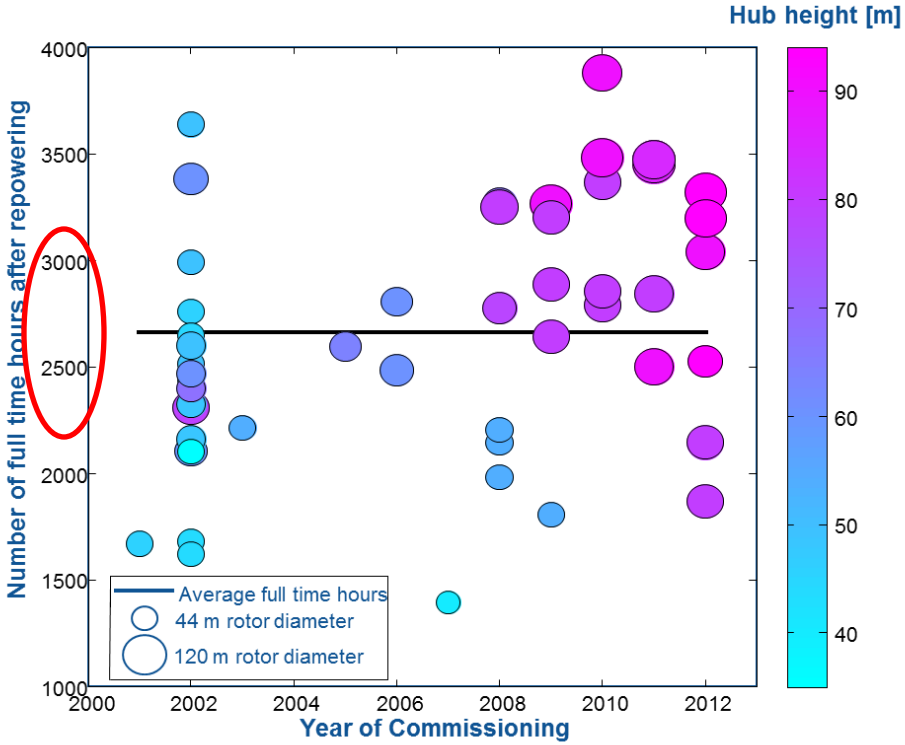
Source: Lantz et al. 2013. Note: data in the figure illustrate value gained or lost as a result of a specific investment decision; as each of these plants is modeled at an equivalent size, the change in plant-specific net present value can be compared across time; however, caution is advised against any direct assessment of wind plant profitability or return on investment, as the overall magnitude of net present value is highly correlated to plant size

European Experience

Before Repowering



After Repowering



Note different scales.

Source: Buzau et al. (forthcoming)

- Repowered wind plants have an increased hub height (2X), rotor diameter (3X), and rated capacity (5X), resulting in increased productivity. For example, the number of average full time hours has increased about 20%.
- The figures show an analysis of 48 wind plants in Denmark installed in the 1990s and repowered in the 2000s.

Research and Development Opportunities

- **To what extent can existing infrastructure be used to support taller towers, larger rotors, and/or improved site layout to increase project productivity?**
  - Could innovative drive-system and/or blade designs make partial repowering financially attractive?
- **How will unused materials be recycled or repurposed?**
- **Would improved energy capture at high-value resource areas enable California to meet carbon emission reduction goals more cost effectively than development of greenfield sites or importing electricity from other states?**
- **What technology innovations are needed to improve grid support? And would enhanced grid services from repowered wind projects affect California system reliability or transmission expansion requirements more generally?**
- **Would visual impacts be reduced?**
- **Would avian and wildlife impacts be reduced?**

Sources and Contact Information

- Lantz, E., M. Leventhal, I. Baring-Gould. 2013. *Wind Power Project Repowering: Financial Feasibility, Decision Drivers, and Supply Chain Effects* (Technical Report). TP-6A20-60535. National Renewable Energy Laboratory (NREL), Golden, CO (US). http://www.nrel.gov/docs/fy14osti/60535.pdf
- Buzau, M., Serrano-Gonzalez, J., Lacal-Arántegui, R. (forthcoming). Wind farm repowering: an analysis of wind farm performance. Ongoing work, Joint Research Centre of the European Commission.

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PG&E Presents:

Effective R&D Paths for Promoting Wind Repowering in California

John Pappas – Renewable Energy Strategy & Policy

January 28, 2016

Agenda

1) Current Landscape
   - California Repowering Outlook
   - R&D Priorities to Support Wind Repowering
2) Economic Factors
   - Tax Implications
   - Other Economic Considerations
3) Renewable Integration
4) Recommendations

Current Landscape

California Repowering Outlook

- **Near-term repowering efforts in California are expected to peak in the next few years**
  - Attempt to leverage Production Tax Credit before phase-out
  - Many original 30-year QF contracts expiring mid-decade

- **Appetite for wind projects to accommodate repowering will likely be from more diverse counterparties than previous contract generations**
  - In addition to IOUs, other retail sellers may be seeking opportunities to procure from repowered projects.
  - Under SB 350, RPS rules will likely change, leading to more variability and flexibility in contract arrangements.
  - Commercial & Industrial customers seeking renewable resources.

Altamont Pass Wind Resource Area (APWRA) Repowering

- **Alameda County Planning Board approved the final program environmental impact report for Alameda County's portion of the APWRA in November 2014.**
  - Set framework for next 30 years of Altamont Pass wind energy repowering.
  - Also approved CUP for two wind energy repowering projects:
    - Golden Hills Wind Energy Facility.
      - Remove 775 existing wind turbines
      - Install up to 52 new 1.7 MW with nameplate capacity of 88.4 MW
    - Patterson Pass Wind Farm Repowering Project
      - Repower existing 21.8 MW windfarm, originally containing 336 sixty-five kW turbines with 8-12 turbines with a total nameplate capacity of 19.8 MW
  - Approved total buildout in excess of 400 MW. This buildout is expected to occur over four years following the EIR approval.

R&D Priorities to Support Wind Repowering

Cost Reduction

- Seek methods to achieve reductions in the lifetime cost of wind turbine technologies through integrated design approach.
- Increase performance and reliability, improve O&M effectiveness and gain manufacturing efficiencies.
- Evaluate potential capacity factor impacts at existing wind sites, given increased capacity factor of new turbines.
- Evaluate economic impacts of co-locating storage facilities with existing and new wind facilities.

Wind Energy Integration

- Develop familiarity with wind generation providing flexibility, load following and grid support in other States.
- Improve wind power forecasting capabilities.
- Incorporate grid reliability into project design.

Economic Factors

Tax Implications

- **Federal Renewable Energy Production Tax Credit was extended through 2017, followed by phase down. Ends in 2019.**
- **Consolidated Appropriations Act, 2016 – not yet interpreted by the IRS.**
- **Impact of PTC – Repower was historically eligible.**
- **Developers must maintain a continuous program of construction**
- **Wind projects that begin construction in 2016 for full value of PTC are eligible to take the PTC or the 30% Investment Tax Credit in lieu of the PTC**
- **Developers can establish that they have begun construction by:**
  - Performing physical work of a significant nature
  - Meeting 5% Safe Harbor Provisions by paying or incurring at least 5% of total eligible cost of the facility

Other Economic Considerations

- **Primary cost to repower:**
  - Capital costs
  - Annual O&M
  - Large projects benefit from economy of scale; however owners of multiple projects may have ordering economies
- **Primary expense:**
  - Debt service associated with buying & installing new turbines
- **More diverse financing options today**
  - Bank Debt (a long-standing option)
  - Tax Equity
  - Term Loan B
  - Project Bonds
- **More diverse contracting opportunities for renewable developers today than in earlier generations**

Renewable Integration

Renewable Integration Challenges

	Issue	Action
Changing Load Curve	Resources are no longer dispatched to meet total system demand. Dispatch follows Net Load	Flexible resources. Ability to ramp quickly &/or start up twice per day.
Overgeneration	Daytime over generation an issue under 33% RPS. Expect more extreme events under 50% RPS.	Dispatchability provisions in contracts. Modern turbines that ramp very quickly.
Variability	Expected change in generation within scheduling intervals.	Anticipate providing Ancillary Services including spinning reserves & Regulation.
Uncertainty	Unknown deviation of generation from forecast. Risk decreases as you move from Day-Ahead into Real-Time operation	Frequency response initiative to ensure dynamic response to frequency changes in the seconds to 1-minute after contingency

Recommendations

Recommendations

- **Cost Reduction**
  - Integrated design approach
  - Lessons learned and looking to the future

- **Wind Integration**
  - Benchmarking
  - Forecasting
  - Project design

Thank You

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Questions for Panel

From your perspective, what are primary barriers as well as opportunities for repowering California's existing wind capacity that are coming from 20-30 year old turbines?

Questions for Panel

What do you see as the role of R&D for addressing those barriers and what R&D initiatives should be prioritized to repower wind energy in California?

Session II: Original Equipment Manufacturer's Perspective on Wind Repowering

Moderator: Silvia Palma-Rojas, California Energy Commission
Panelists:
Brent Reardon - Siemens Wind Power Americas
Henry Shiu - University of California, Davis (UC Davis)
Oliver Kijas - Senvion USA Corp.
Thomas Smith - OGIN

1. Questions for Panel

Do we have sufficient technology needed for repowering? From your perspective, are there technological barriers or further innovations needed to better take advantage of opportunities from repowering older wind facilities?

Repowering: Thoughts on Technology

Henry Shiu, hjshiu@ucdavis.edu
University of California, Davis

CEC Repowering Workshop
Sacramento, CA
28 January 2016

Repowering Conventional Wisdom

	+	-
Prime wind resource	Presumably at an early developed site with a prime wind resource	
Leveraging existing infrastructure	Foundations, roads, collection system, interconnection already in place; reduced cost of balance of plant	Likely inadequate for modern turbines; additional cost of removing old infrastructure
Higher efficiencies	Higher aerodynamic, mechanical, and electrical efficiencies → increased capacity factors	Large capital expenditure
Taller hub heights	Taller turbines reach greater winds	RADAR, obstruction evaluation, visual impact (including lighting), birds, larger setbacks
Grid support	New turbines offer VAR support, ZVRT, ramp control	Little award for these services
Reduced O&M	New turbines with higher reliability	Long term experience with old hardware
Birds		
Summary	Extract more energy and profits	Reopen a multi-year Pandora's box permitting process. Exchange a steady sure-thing profit for a risky, large capex.

1. Technology Sufficiency

"…are there barriers or further innovations needed to better take advantage of opportunities from repowering older wind facilities?"

- Technology for repowering not significantly different than that for greenfield development
  - Current turbine R&D also applies to repowering; e.g., innovative blade and tower structures, active aerodynamic load control
- But are there any deviations in the design spaces of repowering and new development?
  - Are there additional constraints? e.g., height, rotor size, capacity, noise
    - There is a dearth of mid-sized (sub-megawatt) turbines
    - Transmission/interconnection upgrade deferral – opportunity for energy storage
  - Ground work needed to survey potential repowering sites and assess novel constraints
    - To provide sufficient economic impetus to technology manufacturers, need to extend beyond California market
  - Are there additional opportunities?
    - Years of SCADA data could better characterize the wind resource of a repowering site than assessments of new sites
    - Opportunities for very low or high turbulence sites?
    - Caveat: SCADA data could be low quality, at defunct hub heights

2 & 3. RD&D

”How can we better deploy new… technology to help repower…? …what research and development is needed to address the cost issues?”

- RD&D of technology products requires:
  - Long term investment to support development stages from proof of concept to commercial deployment
    - CEC could start support at a high TRL threshold, but cannot exit until a very high TRL
  - Appropriate technical monitoring
- Coordinate with other RD&D funding agencies

4. End of Life

”Is the end-of-life perspective included in the design of the current or newer wind technology?”

- No
- Even though wind turbine evolution has been incremental over the last 30 years, wind plant development/installation could/can not be economically future-proofed to anticipate hardware growth/changes
- Hopefully, current installations are bonded for decommissioning
- Steel, copper can be economically reclaimed and recycled. Methods exist for recycling fiberglass, but unsure of economic viability
- Innovative technologies in active development can help
  - e.g., Blade and tower structures currently being explored significantly reduce material utilization and ease transport

References

- Leighty, Wayne and C.P. van Dam, “Repowering California Wind: A Summary of Potential Benefits and Barriers”, manuscript submitted to California Energy Commission, 2009.
- Wiser, Ryan et al., “A Scoping-Level Study of the Economics of Wind-Project Repowering Decisions in California”, CEC-300-2008-004, August 2008.

2. Questions for Panel

How can we better deploy new and innovative wind technology to help repower and maximize use of California's wind resources? What is limiting the deployment of these technologies?

3. Questions for panel

Are the O&M costs and capital costs the primary drivers for repowering decisions? If so, what research and development is needed to address the cost issues?

4. Questions for panel

How is the end-of-life aspect of the current fleet of older wind turbine being addressed? In 20-30 years, we will have the need of repowering the “new” old fleet. Is the end-of-life perspective included in the design of the current or newer wind technology? Please provide an insight on what might be expected in the end-of-life phase of the new turbines.

Questions and Answers

Please send all questions to:

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Deadline to submit questions is February 12, 2016 5:00 PM PDT!