CALIFORNIA
ENERGY
COMMISSION

PIER Strategic Program-Strategic Distributed Energy Resources Research Assessment

CONSULTANT REPORT

OCTOBER 2001
P600-01-016F

Gray Davis, *Governor*

CALIFORNIA ENERGY COMMISSION

Prepared By:
Arthur D. Little
Acorn Park
Cambridge, MA 02140-2390
Contract No. 500-98-013

Prepared For:
David Navarro,
Contract Manager

Mark Rawson,
Project Manager

Laurie ten Hope,
Program Team Lead
PIER Energy System Integration

Terry Surles,
Deputy Director
Technology Systems Division

Steve Larson,
Executive Director

Legal Notice

Table of Contents

Section **Page**

List of Figures

Preface

This report presents Arthur D. Little's findings and observations related to Distributed Energy Resources (DER) for the California Energy Commission Public Interest Energy Research (PIER) Strategic Program. Inputs for this report included literature search results, interviews with stakeholders active in the development of DER, and feedback and discussions during a workshop held at the California Energy Commission on August 28, 2001. Comments or questions on any aspect of this report should be addressed to:

Mark Rawson

PIER Program: Strategic

California Energy Commission
(916) 654-4671

mrawson@energy.state.ca.us

Stan Blazewicz

Senior Manager
Arthur D. Little, Inc.

617-498-6434

blazewicz.stanley@adlittle.com

Executive Summary

Significant developments in Distributed Energy Resources[1] (DER) technology and the marketplace require a fresh analysis of the DER landscape to identify key challenges appropriate for public interest research. The California Energy Commission Public Interest Energy Research (PIER) Strategic Program is developing its five-year research plan in the area of DER relating to the following focus areas (Figure 1):

- Interconnection
- Grid effects
- Market integration

This report documents a major step in the research plan development process – to understand current research being conducted by industry, nonprofit organizations, and government, and to identify where gaps exist. From these efforts, the California Energy Commission PIER Strategic Area will develop a solicitation to address those activities.

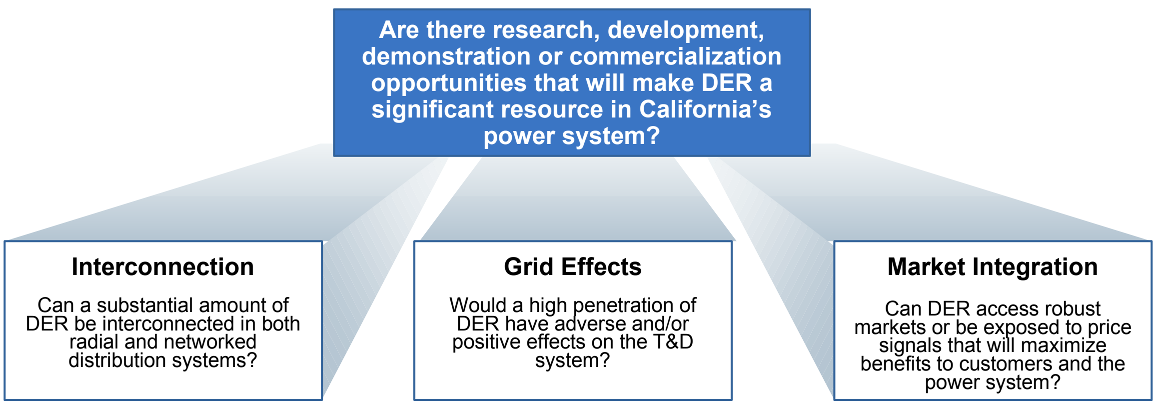


Figure 1: Focus Areas

Information was collected through research, interviews, and a public workshop to identify research gaps and prioritize public funding. A literature search of multiple sources was first conducted to determine past, present and planned research projects in the private and public sectors. Significant additional input was obtained through interviews with representatives of industry, nonprofit and government efforts in DER, and a public workshop held with stakeholders. Key issues and R&D strategies to address the three areas of interconnection, grid effects and market integration were identified and organized from the acquired information. A

[1] Distributed Energy Resources are broadly defined as generation or storage that is located close to the point of consumption. It is important to note that the issues and the magnitude of the issues vary widely by the size of the DER installation and by where it is located in the system. For example, interconnection requirements, costs and process are less of a concern for a large (>1MW) DER facility than for a smaller facility. Interconnection costs do not scale with project size; as the project size increases the interconnection costs on a $/kW basis decreases. In addition, the industry has much more experience interconnecting larger (>1MW) DER installations.

framework was created for assessing the status of the DER research efforts (Figure 2). **Issues** are the critical questions facing the development of DER in the areas of interest. These issues have driven, or will drive, the creation of **Strategies** to address these questions. **Strategic Thrusts** are a group of aligned strategies within a focus area. Current and potential **Projects**, in each of the three areas, are employing these strategies. There are also crosscutting projects that are addressing issues in more than one area. Each project/activity identified can be mapped to the appropriate strategy and issue.

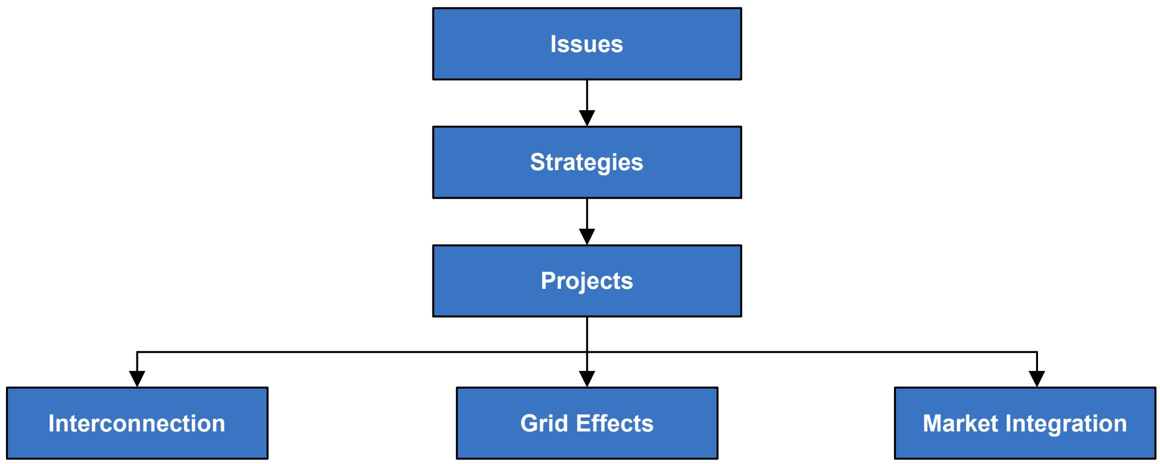


Figure 2: Framework of Analysis

The identified strategies in the interconnection area, which could allow for a substantial amount of DER to be interconnected in radial and networked systems, fall into three strategic R&D thrusts:

- Standardization and adoption of new requirements and processes
- Cost reduction and product improvement
- Compatibility

In the grid effects area, there are four strategic R&D thrusts that could lead to an understanding of what impact a high penetration of DER would have on the electric power system:

- Modeling and testing
- System impact studies
- Microgrids
- Wires company information needs

In the market integration area, there are three strategic R&D thrusts that may provide DER with access to robust markets and/or exposure to price signals that will maximize the benefits of DER to customers and the power system:

- Current market
- Advanced market concepts

- Enabling technologies

Each of the projects and strategies were mapped by its stage of technology development and its competitive impact. The four stages of technology development are research, development, demonstration and commercialization. Competitive impact follows a pathway through four levels, defined as follows:

Base: Although essential to the business, these technologies do not provide significant competitive advantage.

Key: These technologies are critical for today's bases of competition.

Pacing: Although not fully embodied in current products, these technologies may, if successfully applied, have a substantial impact on the basis of competition in the reasonably near future.

Emerging: These technologies may have an impact on competition in the future but this is far from certain.

Additionally, the degree to which the strategies had been pursued was captured such that each of the strategies is identified as either having significant, moderate or little/no gap. A more significant gap implies greater opportunity for public support.

From the information obtained, the following observations can be drawn:

- Challenges involved with interconnection have just begun to be addressed.
- Research to better understand the negative impact of DER on the grid must be balanced with efforts to better understand its potential positive impact.
- Microgrids are emerging as an important aspect of DER. However, there is no common definition of the microgrid concept, and details of how a microgrid is to be effectively operated and controlled to bring about meaningful benefits is still far from clear.
- A lack of a clear successful business model will continue to prevent DER from making a breakthrough into the electricity industry.
- Integration, optimization and operation are vital to realizing a large penetration of DER. However, understanding the requirements for integration, optimization and operation may not be possible until a clear business model emerges.
- Regulations and policies need to keep pace with and reflect new information and understanding of DER. In many instances, technology is available but deployment is constrained by current policy.
- Significant gaps exist in interconnection, grid effects, and market integration research activity where California Energy Commission PIER Strategic funding can make a dramatic impact.

The priorities for public funding of technology development should be driven by where there are significant gaps in the strategies and where it is appropriate for public funding to be invested. The gap analysis revealed strategies with significant gaps in each of the three areas of analysis: interconnection, grid effects, and market integration. These strategies all offer a program such as California Energy Commission PIER Strategic opportunities to make a significant impact in areas that have not been explored in great detail thus far. The strategies most appropriate for public funding of technology development are:

- Those in the base technology area, as these do not provide any one company with a competitive advantage; and emerging and some pacing technologies as it is still too early to tell if they are a source of competitive advantage and more likely to need public funding to remove these uncertainties
- Strategies in the research, development and demonstration phases of the technology development chain. The commercial area should be avoided unless special circumstances exist where private funding is constrained.
- Strategies that involve technology rather than policy development and strategies that require collaborative efforts

Interconnection

Interconnection strategies with significant gaps are found in the *Standardization and adoption of new requirements and processes* thrust. There is general consensus that there is a need to support the adoption of new interconnection requirements by industry, customers and utilities. Specifically, these strategies are:

- Understand impact of and adopt new interconnection requirement
- Initiate type-testing and certification of interconnection solutions
- Develop guidelines and best practices for interconnection
- Educate stakeholders on new requirements, contracts and processes

These strategies are in the demonstration phase, with the exception of educating stakeholders. With the exception of type-testing, they are all base technology strategies. Type-testing and certification would provide competitive advantage to individual companies, particularly in the short run, as some companies have type-tested and/or certified products and others do not. However, there is a collaborative aspect of doing type-testing and certification that would be appropriate for public funding. For example, a publicly funded lab or government agency could run the type-testing and certification labs and activities. Public funding could also be used to analyze and develop approaches for type-testing and certification.

Grid Effects

The strategies with significant gaps in the grid effects area are:

- Demonstrate and test varying levels of DER penetration in a distribution system
- Demonstrate and test microgrids

Modeling and analysis of DER's effect on the grid is already underway, but demonstrating and testing DER in a distribution system has barely begun. Unless the effect of high degrees of DER penetration is understood through real world demonstration and testing, concerns may not be credibly addressed and modification of distribution system design approaches cannot begin. It was the consensus during the workshop that this area would provide the greatest leverage to the ultimate success of DER. While microgrids have received increased attention of late, much of that work has focused on modeling and analysis. Without demonstrating and testing microgrids, potential stakeholders cannot begin to develop and design guidelines for their operation and understand their value. Both these emerging technology strategies are in the demonstration stage and may well require a collaborative element, making them candidates for public funding.

Market Integration

There are significant gaps in strategies in the three market integration thrusts. The strategies with significant gaps in the *Current Market* thrust are:

- Assess current wholesale market rules for applicability to DER
- Modify market rules as appropriate to reduce participation costs (fees, metering, process) for DER
- Reduce costs by creating critical mass through a demonstration program
- Assess requirements for tariffs or rates
- Develop market mechanisms to capture and monetize additional DER benefits (e.g., T&D, reliability, environmental, CHP, etc.)

Significant work is needed to alter current markets to accommodate DER participation. The first steps are to assess current wholesale market rules and then modify these rules and possibly tariffs and rates as well. After these steps are complete development of market mechanisms to capture the unique benefits provided by various forms of DER can begin to take place. Most of these strategies are in the commercial stage of technology development, with responsibility for pursuing them falling primarily on regulatory bodies. Therefore, they could not be a prime focus for public technology development funding. However, there might be a research component to understanding how market rules, tariffs and rates ought to be modified. This effort could be done in a collaborative manner supported by public R&D funding. There is also research and analytical work required on DER benefits to better understand their value and how they might be captured. This strategy is a base/demonstration strategy making, it well-suited for public funding. A large-scale demonstration program can help validate concepts and benefits in parallel with the development of new rules and market mechanisms. This demonstration program may also serve to jumpstart the market for DER in California; however, it is a pacing strategy where the ultimate competitive impact is still unknown.

There was one strategy with a significant gap in the *Advanced Market Concepts* thrust*:*

- Launch a new market for DER that captures all value generated–start from scratch, develop the best market structure for DER now and in the future

Ultimately, launching a new market would require regulatory and perhaps legislative action. However, before this market is even piloted, there is a lot of research and analytical work that would need to be done in a collaborative fashion. The ultimate competitive impact of this research is still uncertain, making it an excellent area for public funding.

There was one strategy with a significant gap in the Enabling Technologies thrust:

- Develop standards/protocols for communications/control

Creating standards and protocols for communication and control equipment is essential to integrating DER into the current power markets as well as creating opportunities in new markets. This strategy is base, not providing any competitive advantage. It would also require a collaborative effort, making it a good opportunity for public funding.

This report provides an understanding of where there are current gaps in technology development and provides a basic prioritization of these gaps for public funding. However, the ultimate decision of where to allocate public funding resources will also be driven by the funding agency's objectives, budget, timing for results, and overall portfolio balancing requirements.

Chapter 1: Introduction

Significant developments in Distributed Energy Resources (DER) technology and the marketplace require a fresh analysis of the DER landscape to identify key challenges appropriate for public interest research. The California Energy Commission Public Interest Energy Research (PIER) program Strategic Area is currently developing its five-year DER research plan.

Given the PIER Strategic Area's task to focus on systems-level and cross-cutting areas of technology development, it would be inappropriate to focus on, for example, renewable energy or environmentally preferred generation options in a more isolated context. Thus, despite the wide range of technologies associated with DER, the Strategic Area specifically is focusing on the following areas:

- Interconnection
- Grid effects
- Market integration

A major step in the research plan development process was to understand current research being conducted by industry, nonprofit organizations and government, and to identify where gaps exist and prioritize public funding. Information was collected through research, interviews, and a public workshop. From these efforts, the California Energy Commission PIER Strategic Area will develop a solicitation to address the gaps and priorities.

Background Research and Interviews

This research effort began with a preliminary literature search of multiple sources to determine past (within the last several years), present and planned (in the next 1 to 3 years) research in the private and public sectors. Results of the literature search served as a preliminary roadmap for identifying major research topics as well as potential interviewees for additional information on DER research activities.

Significant additional input was obtained through interviews with selected representatives of industry, nonprofit and government efforts in DER. Interviews and completed questionnaires captured concerns, additional information, and insight into the nature of research and development efforts. The information gathered in the literature search and the interviews was used to formulate the key issues and strategies facing DER in the areas of interconnection, grid effects and market integration.

Appendix VI contains organizations found to be active in DER technology development. Representatives from more than half of these organizations were interviewed during the course of this analysis.

Framework of Analysis

In parallel with and incorporating the information gathered from the background research and interviews, a framework was created for assessing the status of DER research efforts (Figure 3).

Issues are the critical questions facing the development of DER in the areas of interest. These issues have driven, or will drive, the creation of **Strategies** to address these questions. **Strategic Thrusts** are a group of aligned strategies within a focus area. Current and potential **Projects,** in each of the three areas, are employing these strategies. There are also cross-cutting projects that are addressing issues in more than one area. Each project/activity identified can be mapped to the appropriate strategy and issue. Chapter 2 delves deeper into the details surrounding the process by which the issues were identified and elaborates on the strategies that address those issues.

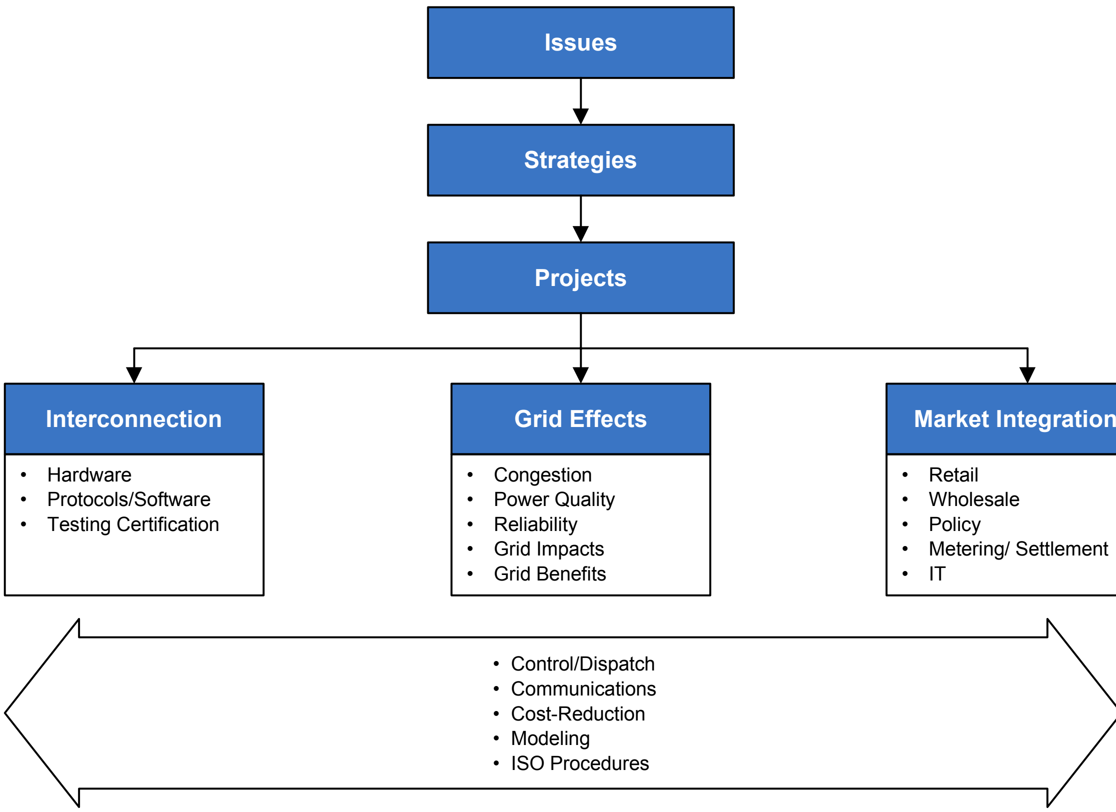


Figure 3: Taxonomy of Analysis Framework

Representative research projects most applicable to the research objectives of the California Energy Commission Strategic Area are detailed in Chapter 3. The strategies are mapped by competitive impact and technology development stage in Chapter 4. In Chapter 5, the level and concentration of activities are mapped out and gaps where funding might be warranted are revealed. Inclusion of the elements stated thus far opens the way for a more effective discussion among the various stakeholders in DER development. Conclusions, observations and funding priorities are detailed in Chapter 6.

Public Workshop

On August 28, 2001, a public workshop was held at the California Energy Commission in Sacramento, CA. Over 60 representatives from government, academia, research organizations, utilities, customers and technology providers participated in this full-day event with the following objectives:

- Review and comment on the interim report made available prior to the workshop
- Clarify and add to areas of interest for Strategic Program DER Integration RD&D
- Contribute to potential priorities for PIER Strategic Program DER strategy
- Provide additional insights regarding potential strategies

The workshop consisted of three distinct phases intended to achieve these objectives (Figure 4).

Both specific and general comments collected during and after the workshop have been incorporated into this report. The raw output and list of attendees can be found in the Appendices.

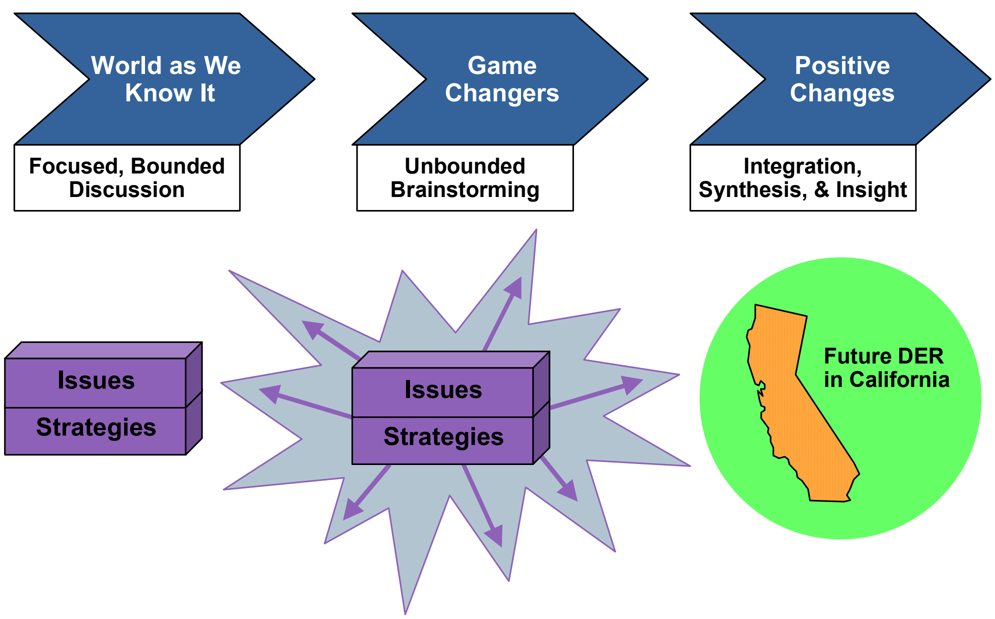


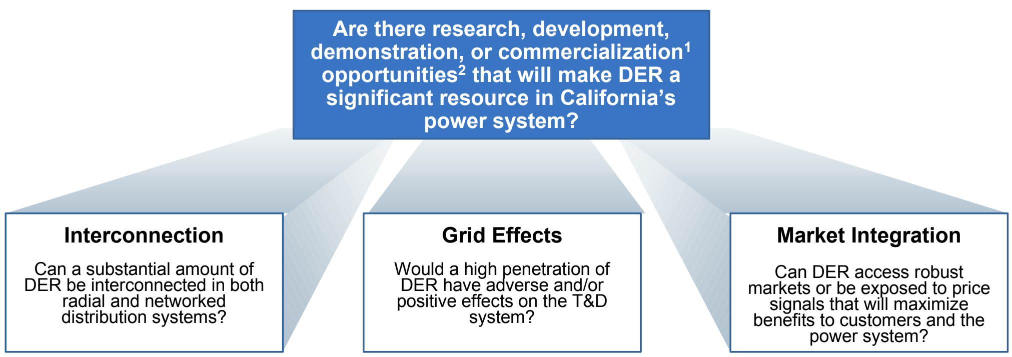
Figure 4: Workshop Approach

Chapter 2: Issues and Strategies

The literature search and interviews provided essential inputs to isolate issues facing Distributed Energy Resources and the strategies to address these issues. In the interviews, representatives of industry, nonprofit organizations and government expressed their visions for DER, where key obstacles exist, where their DER efforts are focused, and the expected outcome of such efforts. Feedback and discussions from the August 28, 2001 workshop further enriched the information gathered, providing guidance for additional potential issues and strategies.

Issues

The information collected during the literature search, project identification and interviews was pooled, organized, and carefully examined for key issues. Workshop discussions and comments provided additional insight. While it is not in California Energy Commission PIER's domain to engage in activities involving the commercialization of technologies, commercial impacts are included in the analysis for the sake of completeness. The identified issues are in the form of critical questions and arranged along the lines of the three topic areas: interconnection, grid effects and market integration (Figure 5).



- Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems?
- Can interconnection solutions be deployed in a timely fashion?
- Can interconnection be made more user-friendly to the end-use consumer?
- Is a single DER unit compatible with end-use equipment or other DER equipment?

- Do we understand what benefits DER can provide to the power system?
- Do we understand DER's impact on the grid?
- Do we understand how DER will interact with other DER and the grid in real-time?
- Is there a limit to the level of DER that the system can absorb without adverse impacts? Can we understand that limit?
- Are there limitations on bi-directional power?
- Should distribution design philosophy be modified to accommodate DER?
- Can engineering studies be eliminated, standardized or streamlined?
- Can microgrids be utilized effectively?
- Can the power system or the expansion thereof be built around microgrids?
- Can we understand the information needs of wires companies with DER deployed in their systems?

- Can market rules/regulations be modified to allow DER to participate in current markets? Will they be consistent/stable? Can transaction/participation costs be reduced for DER? Could the full range of DER participate?
- Are there tariffs or rates that could be crafted to provide better price transparency to DER? Could participation costs be reduced? Could the full range of DER participate?
- Should a separate market structure be created for the full range of DER technologies?
- Could this market be structured to maximize/aggregate the benefits at reasonable costs?
- Should the DER market paradigm shift toward decentralized rather than centralized control?
- Do we know how DER affects the assignment of risk?
- How should additional DER benefits be captured?
- Can we aggregate and remotely operate and control DER to better respond to market signals?
- Can it be made easier for consumers to maximize their investment in DER?
- Should standards for control/communication be developed?

1. Commercialization includes policy and regulatory changes.
2. Opportunities refer to those beyond the microturbines, fuel cells, and other DER generation technologies.

Figure 5: DER Issues Analysis

Strategies

Current and proposed paths to overcoming the issues were identified during the interview process and workshop, and formed the basis of the strategies identified. The strategies address the issues in the three topic areas of interconnection, grid effects and market integration.

Interconnection

There are 15 strategies that make up three strategic thrusts (Figure 6) that could allow for a substantial amount of DER to be interconnected in radial and networked systems:

- Standardization and adoption of new requirements and processes
- Cost reduction and product improvement
- Compatibility

Specific comments regarding interconnection issues and strategies made during the interviews and the workshop are provided below.

Interconnection

Can a substantial amount of DER be interconnected in both radial and networked distribution systems?

Issues	Strategies	
	Standardization and Adoption of New Requirements and Processes	**Cost Reduction and Product Improvement**
Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? Can interconnection solutions be deployed in a timely fashion? Can interconnection be made more user-friendly to the end-use consumer?	• Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions • Understand impact of and adopt new interconnection requirement • Standardize designs around new requirements • Initiate type-testing and certification of interconnection solutions • Develop guidelines and best practices for interconnection • Modify standardized requirements and standardized designs based on modeling, testing and field experience • Educate stakeholders on new requirements, contracts and processes • Develop standardized products for small DER	• Reduce costs of interconnection components • Improve reliability and performance of interconnection components (e.g., power electronics) • Integrate interconnection functions with other DER functions • Develop turnkey solutions that integrate DER functions • Develop new technologies that would reduce or eliminate some requirements or costs of interconnection
Is a single DER unit compatible with end-use equipment or other DER equipment?	**Compatibility** • Develop test protocols for compatibility and power quality testing of DER • Test and understand compatibility and power quality issues	

Figure 6: Interconnection Issues and Strategies

Interconnection Quotes from Interviews

"The largest DER impediments are…the lack of a consensus *national* utility interconnection document…"

-A non-profit organization

"With Rule 21, interconnection is no longer an issue. [in California]"

-Electricity distribution company

"We need to start looking beyond 1547, there is more to it than just writing a standard. We need to understand the impact of the standard, educate stakeholders, and develop guidelines."

- Research institute

"A nightmare for us is a different standard from state to state or utility to utility."

- An interconnection component manufacturer

"The [interconnection] solutions have got to be more customer-focused…easier, faster, cheaper or we won't even get a chance to be considered."

- DR technology developer

Interconnection Feedback at Workshop

"Increase stakeholder involvement. Get institutional representatives to review and assist with barriers. Engage institutional barrier representatives as stakeholders in standards development."

- Rita Norton (Rita Norton and Associates, SVMG)

"Integration and dispersed storage are key. Reliability, response characteristics, and impact on transmission all need to be examined."

-Ross Fernandes (Southern California Edison)

"Top-down approach is being assumed. Assume distributed control. If islanding were considered part of the system, the whole approach would change. That would be a real game changer….Plugging in a generator should be more economical than a load of the same size."

-Richard Ely (ADM Associates)

Grid Effects

There are 11 strategies that make up four major thrusts (Figure 7) that could lead to an understanding of what effect a high penetration of DER would have on the electric power system:

- Modeling and testing
- System impact studies
- Microgrids
- Wires company information needs

Specific comments regarding interconnection issues and strategies received during the interviews and workshop are provided below.

Grid Effects

Would a high penetration of DER have adverse and/or positive impacts on the T&D system?

Issues	Strategies
Do we understand what benefits DER can provide to the power system? Do we understand DER's impact on the grid? Do we understand how DER will interact with other DER and the grid in real-time? Is there a limit to the level of DER that the system can absorb without adverse impacts? Can we understand that limit? Are there limitations on bi-directional power? Should distribution design philosophy be modified to accommodate DER?	**Modeling and Testing** • Model and analyze the grid with varying levels of DER penetration • Demonstrate and test varying levels of DER penetration in a distribution system • Modify distribution system design approaches
Can engineering studies be eliminated, standardized or streamlined?	**System Impact Studies** • Develop models to understand system impacts • Develop software to facilitate impact studies • Modify requirements for impact studies as appropriate
Can microgrids be utilized effectively? Can the power system or the expansion thereof be built around microgrids?	**Microgrids** • Model and analyze microgrids • Demonstrate and test microgrids • Develop design guidelines for microgrids
Can we understand the information needs of wires companies with DER deployed in their systems?	**Wires Company Information Needs** • Perform analysis of the information and data needs of wires companies • Develop and demonstrate systems for wires companies to monitor DER

Figure 7: Grid Effects Issues and Strategies

Grid Effects Quotes from Interviews

"Clarity on interconnection allowing people to sell power back to the grid will bring investors in DER further benefits. Market power vested interests are another major obstacle. Technically, there are some concerns that a lot of power flowing back and forth can be unsafe…which may be a smoke screen for the market vested interests."

-An interconnection package manufacturer

"There is no solid proof of reliability given the lack of protection coordination devices allowing for bi-directional flow of electricity."

-A diversified equipment manufacturer

"What exactly is the level of penetration of DG before it will have a negative impact? Right now we are just using thumb rules. Will we need to change our requirements when the penetration goes up?"

-Utility distribution engineer

"Microgrids and power parks could provide significant benefits and should not be overlooked."

-University researcher

"We need to understand the dynamic interaction between DER units within microgrids...we need to develop control and protection schemes and dispatch algorithms."

-National laboratory researcher

"Much of the DR commercial development has been working around the wires companies. I think this is a mistake. Wires companies need to be involved to maximize the benefits. The first step is having a system that will let the wires companies know where the DR is currently installed in their systems…eventually they will see the benefits to their systems."

-Nonprofit research organization

Grid Effects Feedback at Workshop

"Think of a more decentralized power system. Can the power system or the expansion thereof be built around microgrids?"

-Chris Marnay (Berkeley Labs)

"Do site-specific studies rather than generic, unnecessary ones."

-Robert Wichert (US Fuel Cell Council)

"How do these things interact in real-time? Is there a limit to the amount of DG on the grid? Maybe 30 percent? Look for a dynamic rather than a static answer."

-Joe Iannucci (Distributed Utility Associates)

Market Integration

There are 14 major strategies that make up three strategic thrusts (Figure 8) that may provide DER with access to robust markets and/or exposure to price signals that will maximize the benefits of DER to customers and the power system:

- Current market
- Advanced market concepts
- Enabling technologies

Specific comments regarding market integration issues and strategies received during interviews and the workshop are provided below.

Market Integration

Can DER access robust markets or be exposed to price signals that will maximize benefits to customers and the power system?

Issues		Strategies	

Should the DER market paradigm shift toward decentralized rather than centralized control?
 	
Do we understand how DER will affect the assignment of risk?
 	
How should additional DER benefits be captured and monetized (e.g., T&D, reliability, environmental, CHP, etc.)?
 	
Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?
 	
Can it be made easier for consumers to maximize their investment in DER?
 	
Should standards for communications/control be developed?
	Can market rules/regulations be modified to allow DER to participate in current wholesale markets? Will they be consistent/stable? Can transaction/ participation costs be reduced for DER? Could the full range of DER participate?
	
	Are there tariffs or rates that could be crafted to provide better retail price transparency to DER? Could participation costs be reduced? Could the full range of DER participate?
	
	Should a separate market structure (retail market or exchange) be created for the full range of DER technologies?
	
	Could this market be structured to maximize/aggregate the benefits at reasonable costs?
		Current Market
		• Assess current wholesale market rules for applicability to DER
		• Modify market rules as appropriate to reduce participation costs (fees, metering, process) for DER
		• Reduce costs by creating critical mass through a demonstration program
		• Integrate required technologies to reduce costs of participating in markets
		• Assess requirements for tariffs or rates
		• Develop market mechanisms to capture and monetize additional DER benefits (e.g., environmental, CHP,etc.)
		
		Advanced Market Concepts
		• Launch a new market for DER that captures all value generated
		  • Start from scratch, develop the best market structure for DER now and in the future
		  • Assess system requirements for communications, control, metering, software for billing and settlement
		  • Pilot and then launch
		• Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)
			Enabling Technologies
			• Demonstrate aggregation and control of DER
			• Develop low-cost metering
			• Develop low-cost communications and control
			• Develop software to optimize DER in response to market price signals
			• Develop standards/protocols for communications/control
			• Develop advanced storage to optimize DER in response to market price signals

Figure 8: Market Integration Issues and Strategies

Market Integration Quotes from Interviews

"ISO tariff changes and participation requirements may be necessary before DER can participate in the ISO markets and function as part of the ISO's control area resources, even if the technologies are fully developed."

-A regulatory body

"The technology to maximize the benefits of DER is there; however, it does need to be integrated and that is not trivial… and, of course, tariffs and market rules would have to change."

-Software developer

"The biggest obstacles are the uncertainty of what you can and cannot do…we need consistency, clarity and stability."

-DR technology developer

"Scheduling fees, metering, applications fees, wholesale distribution tariffs…I can't see how small DER projects could economically participate with the ISO market."

-Electricity distribution company

"We need to develop scale in the marketplace to reduce costs…subsidizing infrastructure or acting as a catalyst to bring this together would be a good role for the California Energy Commission."

-DR technology developer

"Inexpensive, broadly deployed monitoring, control and communications systems are key. Wireline communications for 10 to 12 DG units works fine…but when you are talking about hundreds or thousands of units this approach is limited…you are going to have to look for alternative approaches…understand the costs and what data is actually needed and when."

-DG communications developer

"Start educating architects and engineers on DG: technology and economic aspects…There need to be analytical tools to quantify the benefits to the utility."

-A nonprofit organization

Market Integration Feedback from Workshop

"Look at where the risk flows. Risk assignment and risk analysis in strategic planning is needed."

-Richard Ely (ADM Associates)

"Look at storage as an enabling technology."

-Unidentified workshop attendee (similar message reiterated by several others)

"A pilot program for market participation may be helpful to develop market participation mechanisms."

-Dan Rastler (EPRI)

Chapter 3: Current R&D Projects

Many companies and organizations were found to be conducting distributed energy research and technology development regarding interconnection, grid effects, and market integration. To determine the focus of current research, the issues and strategies being addressed by each project or project category were identified. To gain further insight into the nature of this research and technology development, the projects were also analyzed by their stage of technology development and their competitive impact.

All technology development follows a natural progression through four stages: research, development, demonstration, and commercialization (Figure 9). At any given time, a technology's stage of development is fixed regardless of the industry to which the technology is applied. Therefore, the technology development stage is *intrinsic* to that technology.

Research	Development	Demonstration			Commercialization	
		Initial System Prototypes	Refined Prototypes	Pre-Commercial Activity	Market Entry	Market Penetration
• General assessment of market needs • Assess general magnitude of economics • Concept and Bench testing • Basic research and sciences (e.g., materials science)	• Research on component technologies • Development of initial product offering • Pilot testing	• Integrate component technologies • Initial system prototype for debugging • Demonstrate basic functionality	• Ongoing development to reduce costs or for other needed improvements • "Technology" (systems) demonstrations • Some small-scale "commercial" demonstrations	• "Commercial" demonstration • Full-size system in "commercial" operating environment • Communicate program results to early adopters/ selected niches • Standards creation • Testing and certification	• Initial commercial orders • Early movers or niche segments • Initial product reputation is established • Business concept implemented • Market support usually needed to address high-cost production	• Follow-up orders based on need and product reputation • Broad(er) market penetration • Infrastructure developed • Full-scale manufacturing

Figure 9: Technology Development Stages

Competitive impact describes how important a technology is to the way companies compete. As such, it always refers to a given product or industry. Competitive impact, therefore, is *extrinsic* and closely related to the industry in which the technology is applied. Competitive impact follows a pathway of four levels (Figure 10), defined as follows:

- BASE: Although essential to the business, these technologies cannot provide significant competitive advantage.
- KEY: These technologies are critical for today's bases of competition.
- PACING: Although they are not fully embodied in current products, these technologies may, if successfully applied, have a substantial impact on the basis of competition in the reasonably near future.
- EMERGING: These technologies may have an impact on competition in the future but this is far from certain.

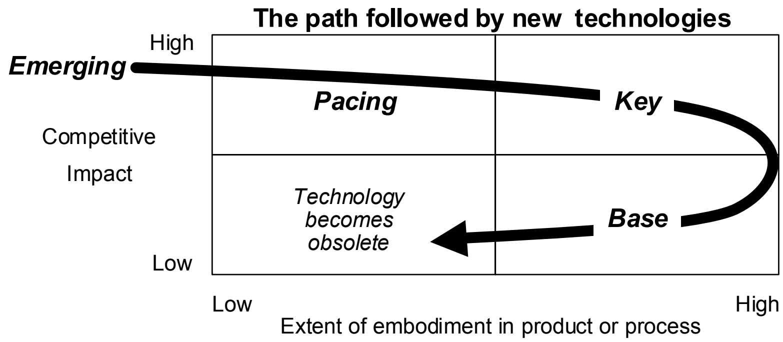


Figure 10: Competitive Impact

Examining the technology development stage (intrinsic) and competitive impact (extrinsic) characteristics of a technology provides a useful format to determining which technologies should be pursued, the appropriate level of investment, and the timing for that investment. Technical risk varies by technology development stage, the highest risk being associated with research. Market risk varies along the level of competitive impact; the highest risk is seen with emerging technologies. Reward does not vary by technology development stage; however, emerging technologies offer higher rewards than do base technologies. Therefore, research in emerging technologies has the highest technical/market risk and the highest reward; commercial, base technologies have the lowest market/technical risk and the lowest reward. For emerging commercial technologies, there is little technical risk, but high market risk and high rewards.

In preparing this report, both private sector and publicly funded technology development efforts were profiled and basic information collected. The issues and strategies each technology or project is pursuing were identified, and its technology development stage and competitive impact assessed.

Private Sector

Private sector technology development was further organized into seven general categories (Figure 11) to facilitate the strategic analysis:

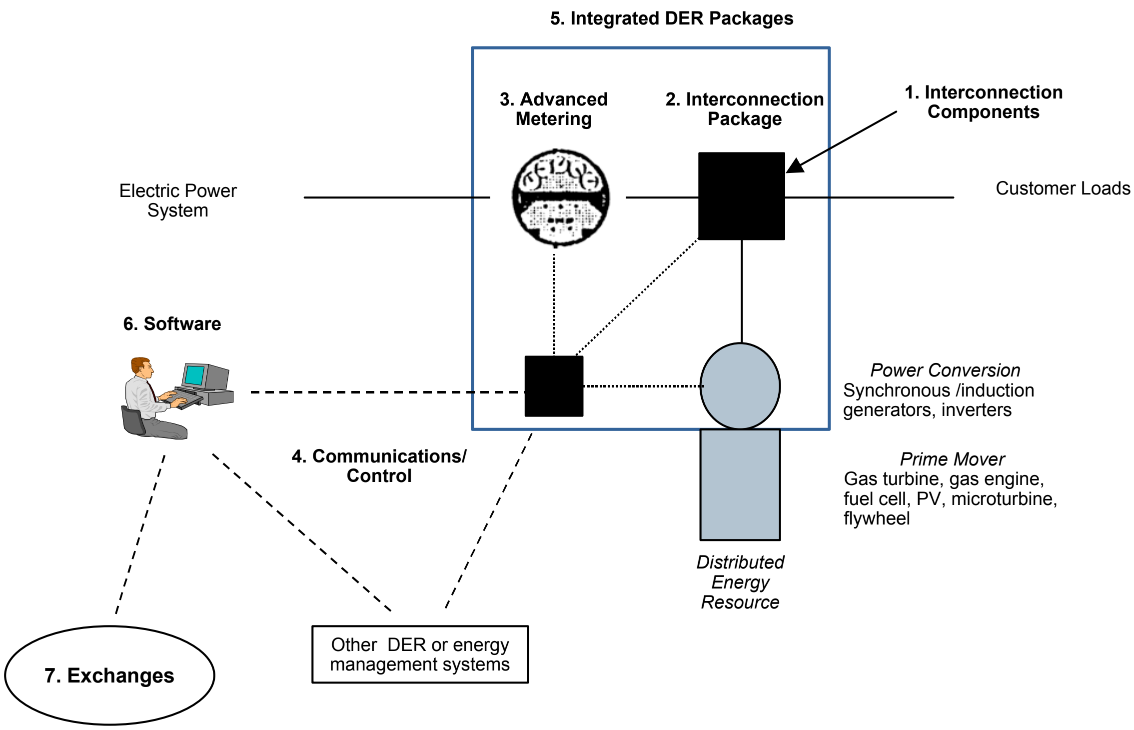


Figure 11: Private Sector Technologies Categories

1. *Interconnection Components* – Provides functionality (e.g., protection and parallel operation) of the interconnection package; Includes transfer switches, breakers, relays, and inverters
2. *Interconnection Package* – Provides safe and reliable parallel operation and isolation between DER units and the electric power system, and protection for the electric power system
3. *Advanced Metering* – Provides information and data to optimize DER, verification, billing and settlement
4. *Communications/Control* – Provides remote monitoring, control, and aggregation of DER. The communication might be two-way and include control signals to respond to price signals, perform diagnostics, or provide information and status reports. Communication could be with other DER devices, ISOs, central control, or a building energy management system. Communication technology options include SCADA, telephone lines, LAN, Internet, paging, and cellular.
5. *Integrated DER Packages* – Provides a turnkey solution at lower costs by integrating the interconnection components, controls, power conversion, communication, and/or metering into a single package.

6. *Software* – Optimizes DER, performs economic dispatch, provides billing and settlement and aggregation; Uses information and real-time or near real-time data from the DER, the marketplace, customer energy management system, ISO, and/or other DER units
7. *Exchanges* – Provides a site where DER owners can sell their output, demand reduction, transmission congestion benefits, or other benefits to ISOs, utilities, wires companies, power marketers, energy retailers, or other customers

Products/technologies, issues, strategies, and a sample of the companies[2] involved were determined for each of the seven categories (Figures 12 through 18).

[2] Not all companies involved in DER are captured in this report

Products/Technology	Issues	Strategy	
Interconnection Components (e.g., switchgear, inverters, relays)	Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems?	• Reduce costs and improve reliability of components • Improve performance of interconnection components (e.g., power electronics) • Integrate interconnection functions with other DER functions • Develop new technologies that would eliminate or reduce some requirements or costs of interconnection	
Illustrative Companies	ABB ASCO Eaton GE Zenith Controls Satcon Sustainable Energy Technologies Ltd Woodward Industrial Controls Xantrex	**Technology Characteristic**	**Key/Base**
		Technology Status	**Commercial**

Figure 12: Interconnection Components (1)

Products/Technology	Issues	Strategy	
Interconnection Package	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection solutions be deployed in a timely fashion? • Can interconnection be made more user friendly to consumers?	• Standardize designs around new requirements • Integrate interconnection functions with other DER functions • Develop turnkey solutions that integrate DER functions • Develop new technologies that would eliminate or reduce some requirements or costs of interconnection • Develop new standardized products for smaller DER	
Illustrative Companies	ASCO ENCORP Enercon Engineering GE Zenith Controls Thomson Technology	**Technology Characteristic**	**Base**
		Technology Status	**Commercial**

Figure 13: Interconnection Package (2)

<table>
<tr><th>Products/Technology</th><th>Issues</th><th colspan="2">Strategy</th></tr>
<tr><td>Advanced Metering</td><td>Can the transaction/participation cost be reduced for DER to participate in power markets?</td><td colspan="2">Develop low-cost metering</td></tr>
<tr><td rowspan="2">Illustrative Companies</td><td rowspan="2">Itron
Power Measurement
Connectisys
Invensys
American Meters</td><td>Technology Characteristic</td><td>Key</td></tr>
<tr><td>Technology Status</td><td>Demonstration/ Commercial</td></tr>
</table>

Figure 14: Advanced Metering (3)

<table>
<tr><th>Products/Technology</th><th>Issues</th><th colspan="2">Strategy</th></tr>
<tr><td>Communications/Control</td><td>• Should standards for communications/ control be developed?
• Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?
• Can it be easier for consumers to maximize their investment in DER?</td><td colspan="2">• Develop standards/protocols for communications/control
• Develop low cost communications and control
• Integrate the required technologies to reduce costs of participating in the power market</td></tr>
<tr><td rowspan="2">Illustrative Companies</td><td rowspan="2">Electrotek Concepts
ENCORP
Omnimetrix
ALSTOM ESCA
Cannon Technologies
Engage Networks</td><td>Technology Characteristic</td><td>Pacing</td></tr>
<tr><td>Technology Status</td><td>Demonstration</td></tr>
</table>

Figure 15: Communications/Control (4)

Products/Technology	Issues	Strategy	
Integrated DER Products/Interconnection/ Control	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection solutions be deployed in a timely fashion? • Can interconnection be made more user-friendly to the consumers? • Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	• Standardize designs around new requirements • Integrate interconnection functions with other DER functions • Develop turnkey solutions that integrate DER functions • Integrate required technologies to reduce costs of participating in power markets • Develop low-cost communications and control	
Illustrative Companies	Capstone Cummins Kohler	**Technology Characteristic**	**Key**
		Technology Status	**Demonstration/ Commercial**

Figure 16: Integrated DER Packages (5)

Products/Technology	Issues	Strategy	
Software	*Grid Effects:* • Do we understand what benefits DER can provide to the power system? • Do we understand DER's impact on the grid? • Is there a limit to the level of DER that the system can absorb without adverse impacts? *Market Integration:* • Can it be made easier for consumers to maximize their investment in DER? • Can we aggregate and remotely operate and control DER to better respond to market signals?	*Grid Effects:* Model and analyze the grid with varying levels of DER penetration *Market Integration:* Develop software to optimize DER in response to market price signals	
Illustrative Companies	*Grid Effects:* Siemens, ALSTOM, ABB *Market Integration:* Enermetrix, Power Technologies Inc., Powerweb Technologies, Retx, Silicon Energy, Sixth Dimension	**Technology Characteristic**	**Pacing**
		Technology Status	**Demonstration**

Figure 17: Software (6)

<table>
<tr><th>Products/Technology</th><th>Issues</th><th colspan="2">Strategy</th></tr>
<tr><td>Exchanges</td><td>• Should a separate market structure be created for the full range of DER technologies? Could this market be structured to maximize/aggregate the benefits at reasonable costs?
• Can the transaction/participation cost be reduced for DER to participate in power markets?</td><td colspan="2">• Reduce participation costs
• Launch a new market for DER</td></tr>
<tr><th rowspan="2">Illustrative Companies</th><td rowspan="2">Apogee Interactive</td><th>Technology Characteristic</th><td>Pacing/Emerging</td></tr>
<tr><th>Technology Status</th><td>Commercial</td></tr>
</table>

Figure 18: Exchanges (7)

Public/Collaborative/Non-Profit

There were 42 public/collaborative or nonprofit projects identified (Figures 19 through 59):

1. CERTS DOE
2. CERTS California Energy Commission
3. MIT Energy Laboratory, Competitive Power Systems Group
4. University of Wisconsin, Pricing Models
5. University of Wisconsin, Location of DG
6. University of Wisconsin, Inverter Technologies
7. University of Wisconsin, Inverter Control Technologies
8. GTI – Integrated Switchgear and Interconnection Systems
9. GTI – Distributed Energy Technology Development Center
10. GTI – Remote Monitoring
11. IEEE/P1547 Electric Power Resources Interconnected with the Power System
12. GE Corporate R&D: DG/Utility System Interconnect
13. DTE – Aggregation Model and Field Testing
14. Distributed Utility Integration Test
15. NiSource – Advanced CHP Systems
16. Electrotek and NYSERDA – Aggregated DG
17. NRECA – Fuel Cells Performance
18. NRECA – Microturbines Performance
19. Industrial DG, Varying Load
20. GTI & ENCORP – Innovative Interconnection
21. Kelso Starrs and Associates – Interconnection Barriers
22. Regulatory Assistance Project
23. Urban Consortium Energy Task Force
24. UL 1741
25. Rule 21
26. UC, Irvine – Unified Control Inverter
27. UC, Irvine – Microgrids
28. UC, Irvine – Interconnection Design
29. UC, Irvine – SCAQMD Microturbine Demonstration
30. EPRI – IEEE P1547
31. EPRI – Completing the Circuit
32. EPRI – DER Engineering Guide and Workstation
33. EPRI – Development of DR Microgrids
34. EPRI – System Modeling for DR Impacts
35. EPRI – Interconnection Hardware
36. EPRI – DER Status and Condition Information System
37. Alternative Energy Systems Consulting – Smart*DER
38. DENNIS
39. Pleasanton Power Park
40. Sixth Dimension
41. Vehicle-to-Grid Power
42. Distributed Generation Services for Transmission and Distribution

Project/Technology Development/Product	Issues	Strategy	Expected Results
CERTS has 5 related projects, focuses on advancing the implementation of the microgrid concept. • Microgrid Outreach • Presentation to the Power System (requirements for grid integration of DER) • Protection Requirements • Microgrid Control • Study Tools (distribution system model, software)	• Can microgrids be utilized effectively? • Can the power system or the expansion thereof be built around microgrids?	• Model and analyze microgrids • Demonstrate and test microgrids • Develop design guidelines for microgrids	Ultimately, the microgrid will be integrated into the power system and become another power source for the country.

Funding/Source	Participants	Point of Contact
DOE Transmission Reliability Program $750K (for FY01)	CERTS, which includes Pserc, Sandia National Laboratories, Pacific Northwest National Laboratories, Lawrence Berkeley Laboratory	Joseph Eto Lawrence Berkeley National Laboratory 1 Cyclotron Road, MS 90-4000 Berkeley, CA 94720 Tel: (510) 486-7284 Fax: (510) 486-6996 jheto@lbl.gov

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Microgrids	Emerging	Research

Figure 19: CERTS DOE (1)

Project/Technology Development/Product	Issues	Strategy	Expected Results
CERTS has 5 related projects, focuses on advancing the implementation of the microgrid concept. • Microgrid Outreach • Presentation to the Power System (requirements for grid integration of DER) • Protection Requirements • Microgrid Control • Study Tools (distribution system model, software)	• Can microgrids be utilized effectively? • Can the power system or the expansion thereof be built around microgrids?	• Model and analyze microgrids • Demonstrate and test microgrids • Develop design guidelines for microgrids	Ultimately, the microgrid will be integrated into the power system and become another power source for the country.

Funding/Source	Participants	Point of Contact
DOE Transmission Reliability Program $750K (for FY01)	CERTS, which includes Pserc, Sandia National Laboratories, Pacific Northwest National Laboratories, Lawrence Berkeley Laboratory	Joseph Eto Lawrence Berkeley National Laboratory 1 Cyclotron Road, MS 90-4000 Berkeley, CA 94720 Tel: (510) 486-7284 Fax: (510) 486-6996 jheto@lbl.gov

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Microgrids	Emerging	Research

Figure 20: CERTS California Energy Commission (2)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The competitive power systems group is developing models and software that will allow real-time transactions management, power flow control and pricing, examining uncertainties under open access. They are also examining a market model addressing the overlaps in business plans for the DG technology provider, end user, and the wires companies and utilities.	Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	Develop software to optimize DER in response to market price signals	Integration of the needs and requirements among parties involved in DG, a better understanding and a model of the market

Funding/Source	Participants	Point of Contact
ABB, Constellation Power Source, Electricité de France (EdF), and TransÉnergie U.S. Ltd. (a subsidiary of Hydro Québec), and the U.S. DOE's Energy Information Administration	MIT Energy Laboratory	Dr. Marija D. Ilic Principal Investigator (617) 253-4682 ilic@mit.edu Stephen R. Connors Supporting Investigator (617) 253-7985 connorsr@mit.edu

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Modeling	Emerging	Research/Development

Figure 21: MIT Energy Laboratory, Competitive Power Systems Group (3)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The University of Wisconsin is working on developing pricing models to determine the effect of interruptible power programs. Through computer analysis and fieldwork, impact of system reliability as well as providing maximum value to the customer are being examined.	• Do we understand DER's impact on the grid? • Could it be made easier for consumers to maximize their investment in DER? • Can the transaction/ participation costs be reduced for DER?	• Model and analyze the grid with varying levels of DER penetration • Develop software to optimize DER use	Determine the effect of interruptible power pricing on consumers and its impact on system reliability.

Funding/Source	Participants	Point of Contact
Undetermined	Wisconsin Electric Machines & Power Electronics Consortium (WEMPEC), University of Wisconsin, CERTS	Fernando Alvarado University of Wisconsin 1415 Engineering Drive Madison, WI 53706

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Modeling, Grid Impacts	Pacing	Research

Figure 22: University of Wisconsin, Pricing Models (4)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The University of Wisconsin is conducting a study to determine where on the grid distributed generation would prove to be the most valuable. System considerations and constraints as well as DG's impact on the grid are being examined.	• Do we understand what benefits DER can provide to the power system? • Do we understand DER's impact on the grid? • Is there a limit to the level of DER that the system can absorb without adverse impacts?	• Model and analyze the grid with varying levels of DER penetration • Demonstrate and test varying levels of DER penetration in a distribution system	Determine where within the grid DG can be placed to maximize its benefits.

Funding/Source	Participants	Point of Contact
Undetermined	Wisconsin Electric Machines & Power Electronics Consortium (WEMPEC), University of Wisconsin	Fernando Alvarado University of Wisconsin 1415 Engineering Drive Madison, WI 53706

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Modeling, Grid Benefits	Pacing	Research

Figure 23: University of Wisconsin, Location of DG (5)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The University of Wisconsin is working on one aspect of microgrid technologies with CERTS: increasing the modularity of inverters to help decrease cost and improve reliability. The creation of a standard design for inverters should be reduce engineering time and integration efforts.	Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems?	• Reduce cost of components • Improve reliability and performance of components • Develop standardized products for small DER	Create a standard inverter model that can be connected in parallel to meet varying size needs

Funding/Source	Participants	Point of Contact
Undetermined	Wisconsin Electric Machines & Power Electronics Consortium (WEMPEC), University of Wisconsin, CERTS	Giri Venkataramanan University of Wisconsin 1415 Engineering Drive Madison, WI 53706 608 262-4479 giri@engr.wisc.edu

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware	Pacing	Development

Figure 24: University of Wisconsin, Inverter Technologies (6)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The University of Wisconsin is examining improving power quality and reliability through operating clusters of inverters. This expensive technology is beneficial for those areas where reliability and power quality are critical.	Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems?	• Reduce cost of components • Improve reliability and performance of components	Improving reliability and power quality of inverters operating in parallel

Funding/Source	Participants	Point of Contact
Undetermined	Wisconsin Electric Machines & Power Electronics Consortium (WEMPEC), University of Wisconsin, NREL	Giri Venkataramanan University of Wisconsin 1415 Engineering Drive Madison, WI 53706 608 262-4479 giri@engr.wisc.edu

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware	Pacing	Development

Figure 25: University of Wisconsin, Inverter Control Technologies (7)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Test facility for equipment connected to the grid • Examining generation and interconnection equipment performance and control strategies • Demonstrating performance before widespread implementation for utilities and utility coalitions • Began in 2000 and currently expanding capabilities	Is a single DER unit compatible with end-use equipment or other DER equipment?	Test and understand compatibility and power quality issues associated with DER	Improve understanding of equipment that may enter the DER

Funding/Source	Participants	Point of Contact
Cost shared among participants	GTI, utilities/utility coalitions, FERC	Ted Bronson Gas Technology Institute Assoc. Director of Distributed Generation 1700 S. Mt. Prospect Road Des Plaines, IL 60018-1804 (847) 768-0637 ted.bronson@gastechnology.org

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware	Key	Commercial

Figure 26: GTI - Integrated Switchgear and Interconnection Systems (8)

Project/Technology Development/Product	Issues	Strategy	Expected Results
This project is seeking to reduce capital costs by 25-50%, reduce installation time by 50%, conform to basic electric utility interconnection requirements, and begin to incorporate advanced interconnect/generator set protective functions, conform with existing and projected industry standards, and advance remote monitoring, communications and control functions.	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection be made more user-friendly for the end user?	• Reduce costs of interconnection components • Integrate interconnection functions with other DER functions	• Reduce and complexity and cost of interconnection • Advance operation of DER equipment

Funding/Source	Participants	Point of Contact
Cost shared among participants	GE Zenith Controls Gas Technology Institute	Ted Bronson Gas Technology Institute Assoc. Director of Distributed Generation 1700 S. Mt. Prospect Road Des Plaines, IL 60018-1804 (847) 768-0637 ted.bronson@gastechnology.org

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware, Cost-reduction	Key	Commercial

Figure 27: GTI - Distributed Energy Technology Development Center (9)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Providing interconnection standards for connecting to the electric power system and for performance, operation, testing, safety considerations, and maintenance	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection solutions be deployed in a timely fashion?	Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions	Development of Standard 1547: Standard for Resources Distributed Interconnected with Electric Power Systems

Funding/Source	Participants	Point of Contact
DOE, IEEE	Numerous stakeholders in distributed generation and interconnection	Richard Friedman Resource Dynamics Corp. (703) 356-1300 x203

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Testing Certification, Power Quality, Power Reliability, Control	Base	Demonstration

Figure 28: GTI - Remote Monitoring (10)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Test facility for equipment connected to the grid • Examining generation and interconnection equipment performance and control strategies • Demonstrating performance before widespread implementation for utilities and utility coalitions • Began in 2000 and currently expanding capabilities	Is a single DER unit compatible with end-use equipment or other DER equipment?	Test and understand compatibility and power quality issues associated with DER	Improve understanding of equipment that may enter the DER

Funding/Source	Participants	Point of Contact
Cost shared among participants	GTI, utilities/utility coalitions, FERC	Ted Bronson Gas Technology Institute Assoc. Director of Distributed Generation 1700 S. Mt. Prospect Road Des Plaines, IL 60018-1804 (847) 768-0637 ted.bronson@gastechnology.org

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware	Key	Commercial

Figure 29: IEEE/P1547 Electric Power Resources Interconnected with the Power System (11)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The objectives of this project include: • Support IEEE P1547 interconnect working group • Set up DG/EPS/ load virtual testbed for long-term research • Study DG power grid safety, reliability, stability, and power quality • Identify modifications to existing power systems and DG power electronics • Prototype DG-Grid Interconnection Interface • Set up beta test sites • Create power cost optimization & bulk system operation strategies	• Can engineering studies be eliminated, standardized or streamlined? • Is a single DER unit compatible with end-use equipment or other DER equipment?	• Develop models to understand system impacts • Develop test protocols for compatibility and power quality testing of DER • Test and understand compatibility and power quality issues associated with DER	• Increased insight into major issues around interconnection: safety, power quality and power reliability • Conceptual design of the interconnect by end of first year • Virtual testbed operational by end of first year

Funding/Source	Participants	Point of Contact
DOE	GE Corporate R&D, GE Power Systems Energy Consulting, Puget Sound Energy	Dr. Richard Zhang GE Corporate R&D Building K1, Room 2C33 Niskayuna, NY 12309 (518) 387-5313 zhangr@crd.ge.com

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Modeling, Communication, Software, IT	Pacing	Research

Figure 30: GE Corporate R&D: DG/Utility System Interconnect (12)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The project team will select and model two of Detroit Edison's distribution circuits and determine the impact of DR connection on circuit voltage and protection equipment.	Can engineering studies be eliminated, standardized or streamlined?	• Develop models to understand system impacts • Develop software to facilitate impact studies	Support for the work of IEEE SCC21 1547 and proposed testing (analysis and evaluation) requirements

Funding/Source	Participants	Point of Contact
60% DOE NREL/40% DTE Energy Technologies	DTE Energy Technologies and Detroit Edison	Murray Davis DTE Energy Technologies (248) 427-2221

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Modeling, Software	Pacing	Research

Figure 31: DTE - Aggregation Model and Field Testing (13)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Large scale effort to examine DER technology and impacts: • Meet NREL/DOE needs for interconnection system integration activities • Plan, site and design Distributed Utility Integration Test (DUIT) • Develop test plan for Distributed Power testing at Nevada Test Site	• Do we understand DER's impact on the grid? • Do we understand how DER will interact with other DER and the grid in real-time? • Is there a limit to the level of DER that the system can absorb without adverse impacts? • Are there limitations on bi-directional power? • Can engineering studies be eliminated, standardized or streamlined?	• Model and analyze the grid with varying levels of DER penetration • Develop models to understand system impacts	Increased understanding of electrical issues, control systems, modeling techniques, utility distribution system benefits, and outreach/cooperation

Funding/Source	Participants	Point of Contact
DOE NREL and various participants	Distributed Utility Associates, California Energy Commission, Endecon Engineering, Caterpillar, Solar Turbines, Encorp, Pacific Gas and Electric Co., Exelon (Philadelphia Electric Co.), On-Site Energy, Gas Research Institute	Joseph Iannucci Distributed Utility Associates (925) 447-0624 dua@ix.netcom.com

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Power Quality, Power Reliability, Congestion, Grid Impacts	Pacing	Research

Figure 32: Distributed Utility Integration Test (14)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Three-phase, multi-year R&D effort to advance distributed power development, deployment, and integration • Develop, test, and optimize several (electric/natural gas/ renewable energy) stand-alone distributed power systems • Develop and initiate laboratory and field tests, methodologies, controls (including command, communications, monitoring, efficiency, and heat rate)	• How should DER benefits be captured and monetized? • Can it be made easier for consumers to maximize their investment in DER? • Can interconnection be made more user-friendly to the end-use consumer?	• Develop advanced controls and optimization approaches and technologies • Improve reliability and performance of interconnection components	Increased DER acceptance through ease of use and improved integration using advanced control technologies

Funding/Source	Participants	Point of Contact
DOE	NiSource	Dr. Robert A. Kramer Vice President and Chief Scientist Pete Disser Vice President NiSource Energy Technologies (219) 647-6070 ptdisser@nisource.com

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Control, IT	Emerging	Development

Figure 33: NiSource - Advanced CHP Systems (15)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Three year plan to incorporate distributed generators into the NYSERDA system Base Year: Develop metering/ algorithms/controls; conduct feasibility analyses, and survey backup generators in LIPA territory. Option Year 1: Develop, install and conduct pilot test; develop commercial design Option Year 2: Procure, install and operate a 30 MW commercial aggregation/ dispatch service.	Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	Demonstrate aggregation and control of DER	Improved understanding of the extent to which DG can replace/reduce the need for traditional installed capacity in the power grid

Funding/Source	Participants	Point of Contact
DOE NREL and NYSERDA	Electrotek, NYSERDA	Howard Feibus Electrotek Concepts, Inc. 703-655-7105 howardf@electrotek.com

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	IT, Control, Communication	Key/Pacing	Demonstration

Figure 34: Electrotek and NYSERDA - Aggregated DG (16)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Field testing of different fuel cells for rural power applications to improve understanding of potential benefits (e.g., improved reliability, reduced service cost, grid support for rural feeders, reduced cost to serve remote locations) and barriers (e.g., high cost of equipment, permitting, safety, interconnection) and provide technology benchmark for future action	• Do we understand what benefits DER can provide to the power system? • Do we understand DER's impact on the grid?	Demonstrate and test varying levels of DER penetration in a distributed system	Increased insight into the applicability and appropriateness of fuel cells to serve rural and remote communities in lieu of or as a backup for grid connected power

Funding/Source	Participants	Point of Contact
DOE NREL–up to $290,000 based on milestones over 3 years	National Rural Electric Cooperative Association (NRECA)–Cooperative Research Network	Edward Torrero 4301 Wilson Blvd. SS9-204 Arlington, VA 22203 (703) 907-5624 ed.torrero@nreca.org

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Power Quality, Power Reliability, Grid Benefits, Grid Impacts	Key	Demonstration

Figure 35: NRECA – Fuel Cell Performance (17)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Field testing of microturbines for rural power applications to improve understanding of potential benefits (e.g., improved reliability, reduced service cost, grid support for rural feeders, reduced cost to serve remote locations) and barriers (e.g., high cost of equipment, permitting, safety, interconnection) and provide technology benchmark for future action	• Do we understand what benefits DER can provide to the power system? • Do we understand DER's impact on the grid?	Demonstrate and test varying levels of DER penetration in a distributed system	Increased insight into the applicability and appropriateness of microturbines to serve rural and remote communities in lieu of or as a backup for grid connected power

Funding/Source	Participants	Point of Contact
DOE Oak Ridge National Lab–up to $200,000 based on milestones over 3 years	National Rural Electric Cooperative Association (NRECA)–Cooperative Research Network	Edward Torrero 4301 Wilson Blvd. SS9-204 Arlington, VA 22203 (703) 907-5624 ed.torrero@nreca.org

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Power Quality, Power Reliability, Grid Benefits, Grid Impacts	Key	Demonstration

Figure 36: NRECA – Microturbines Performance (18)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Mitigate the impact of highly varying loads on power system generation control; involves modeling/predicting power system Area Control Error and load-control flexibility; initially working with an arc furnace, extending project to a rolling mill and then multiple steel facilities	Can interconnection solutions be deployed in a timely fashion?	Improve reliability and performance of interconnection components	Increase insight into the ability of DG controls to cope with highly varying loads for industrial applications

Funding/Source	Participants	Point of Contact
$342,000 DOE Share first year (3 years in total), DOE OPT and OIT	Northern Indiana Public Service Co., Purdue University, Colorado School of Mines, Steel mill	Mike Karnitz Oak Ridge National Laboratory

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Modeling, Hardware	Key	Demonstration

Figure 37: Industrial DG, Varying Load (19)

Project/Technology Development/Product	Issues	Strategy	Expected Results
• Develop cost-effective DER grid interconnection products, software and communication • Improve economics for broad range of DER power systems • Enhance DER product capability to integrate, interact, and provide operational benefits including building energy mgmt systems, resource planning, ancillary services, and load/demand management	Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	• Develop low-cost communications and control • Develop software to optimize DER in response to market price signals	Cost-effective interconnection and control solutions will make DER power solutions more feasible and attractive

Funding/Source	Participants	Point of Contact
DOE	GTI and ENCORP	William Liss Gas Technology Instititute (847) 768-0753

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	IT, Software, Metering, Control/Dispatch, Communications	Key	Demonstration

Figure 38: GTI & ENCORP - Innovative Interconnection (20)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Through surveys and interviews with DG facility developers and owners, a list of problems encountered while interconnecting their equipment will be developed and categorized	Can interconnection solutions be made more user-friendly to the end-user?	Understand impact of new interconnection requirement; Identify best practices for interconnection	A summary of current barriers and some preliminary conclusions regarding potential steps for overcoming those barriers

Funding/Source	Participants	Point of Contact
DOE	Kelso Starrs and Associates	Tom Starrs Kelso Starrs and Associates 14502 SW Reddings Beach Road Vashon, WA 98070 (206) 463-7571

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware, Policy	Base	Commercial

Figure 39: Kelso Starrs and Associates - Interconnection Barriers (21)

Project/Technology Development/Product	Issues	Strategy	Expected Results
• Write and publish four papers for regulatory audience on the following: • Simplified costing methods for distribution systems • Develop system for de-averaged distribution credits • Case studies for DER and reliability • Options to incorporate DER in wholesale markets • Organize and deliver two workshops to state regulators • Organize and participate in national working group on model rule for DER emission performance standard	• Can market rules be modified to allow DER to participate in current markets? • Are there tariffs or rates that could be crafted to provide better price transparency for DER?	• Assess current wholesale market rules for applicability to DER • Assess requirements for tariffs or rates	Additional information to help reveal the value of DER to customers, distribution companies, wholesale market participants and regulators.

Funding/Source	Participants	Point of Contact
DOE	Regulatory Assistance Project	Cheryl Harrington Regulatory Assistance Project rapmaine@rapmaine.org

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Wholesale, Policy	Pacing/Key	Commercial

Figure 40: Regulatory Assistance Project (22)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Educate 50 of the largest cities and counties on DG issues and technologies; Participate in solving local government barriers to DG; Investigate aggregate purchasing power of Local Gov'ts for DG products; Act as resource for local governments on DG issues.	Can interconnection solutions be deployed in a timely fashion?	Educate stakeholders on new requirements, contracts and processes	Increased understanding and adoption of DER solutions to challenges in cities across the U.S.

Funding/Source	Participants	Point of Contact
DOE and task force members	Urban Consortium Energy Task Force and member cities	Roger Duncan Austin Energy (800) 852-4934 roger.duncan@austinenergy.com

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware, Policy	Base	Commercial

Figure 41: Urban Consortium Energy Task Force (23)

Project/Technology Development/Product	Issues	Strategy	Expected Results
UL 1741: Standard for Inverters, Converters and Controllers for use in Independent Power Systems. The standard against which photovoltaic, fuel cell, microturbine and wind turbine inverters and converters are evaluated for electrical safety and many utility interconnection requirements.	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection solutions be deployed in a timely fashion?	Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions	UL 1741 as a standard to assist in harmonizing the different stakeholders and technologies

Funding/Source	Participants	Point of Contact
Various stakeholders	Underwriters Laboratories and various stakeholders in DER	Tim Zgonena Senior Project Engineer 333 Pfingsten Rd. Northbrook, IL 60062 timothy.p.zgonena@us.ul.com

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Testing Certification, Power Quality, Power Reliability	Base	Demonstration

Figure 42: UL 1741 (24)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Activities (e.g., workshops and case studies) to help create interconnection standards for DER and streamline permitting in California to ensure safety and quality of the power supply before more universal standards are adopted. 12 case studies will examine DER project in terms of processes and their impact on the grid.	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection solutions be deployed in a timely fashion? • Do we understand DER's impact on the grid?	• Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions • Model and analyze the grid with varying levels of DER penetration	Increase clarity on interconnection requirements and simpler permitting processes for DER equipment in California

Funding/Source	Participants	Point of Contact
California Energy Commission	California Energy Commission, Overdomain, Reflective Energies, and various stakeholders in DER	Cris Cooley Overdomain (805) 683.0938 ccooley@overdomain.com Edan Prabhu Reflective Energies edanprabhu@home.com

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware, Power Quality, Power Reliability	Base	Demonstration

Figure 43: Rule 21 (25)

Project/Technology Development/Product	Issues	Strategy	Expected Results
University of California, Irvine has developed the Unified Control Inverter –a patented inverter technology with improved stability and power quality with better performance particularly at part load	Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems?	• Reduce costs of interconnection components • Improve reliability and performance of interconnection components (e.g., power electronics)	A low-cost, improved dynamic range performance inverter for microturbines, photovoltaics and fuel cells

Funding/Source	Participants	Point of Contact
University of California, Irvine Internally funded project	University of California, Irvine	Jack Brouwer National Fuel Cell Research Center University of California, Irvine Irvine, California 92697-3550 (949) 824-1999 x221 (949) 824-7423 jb@nfcrc.uci.edu

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware	Key	Development

Figure 44: UC, Irvine - Unified Control Inverter (26)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The University of California, Irvine research park was built “DG ready” and has a distribution system that can be easily modified to test the impact of DG on different distribution system configurations.	• Do we understand DER’s impact on the grid? • Can microgrids be utilized effectively? • Can the power system or the expansion thereof be built around microgrids?	• Demonstrate and test varying levels of DER penetration in a distribution system • Modify distribution system design approaches • Demonstrate and test microgrids • Develop design guidelines for microgrids	Better understanding of the interaction of DG and its impact in a microgrid

Funding/Source	Participants	Point of Contact
Not currently funded	University of California, Irvine	Jack Brouwer National Fuel Cell Research Center University of California, Irvine Irvine, California 92697-3550 (949) 824-1999 x221 (949) 824-7423 jb@nfcrc.uci.edu

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Microgrids	Key	Development/Demonstration

Figure 45: UC, Irvine – Microgrids (27)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The National Fuel Cell Research Center has been interconnecting microturbines with the SCE distribution system. They have developed insight into reducing the cost of interconnection by removing unnecessary requirements and standardizing designs.	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection solutions be deployed in a timely fashion?	• Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions • Standardize designs around new requirements	Low-cost interconnection and simplified interconnection agreements

Funding/Source	Participants	Point of Contact
University of California, Irvine Internally funded project	University of California, Irvine	Jack Brouwer National Fuel Cell Research Center University of California, Irvine Irvine, California 92697-3550 Phone (949) 824-1999 x221 Fax (949) 824-7423 jb@nfcrc.uci.edu

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Hardware	Base	Commercial

Figure 46: UC, Irvine - Interconnection Design (28)

Project/Technology Development/Product	Issues	Strategy	Expected Results
The South Coast Air Quality Management District (SCAQMD) is installing 200 Capstone microturbines in the SCAQMD. National Fuel Cell Research Center is assisting SCAQMD with an operating strategy that includes identifying communications, control and software requirements.	• Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)? • Can it be made easier for consumers to maximize their investment in DER?	• Demonstrate aggregation and control of DER • Develop low-cost metering • Develop low-cost communications and control • Develop software to optimize DER in response to market price signals	Understanding of the optimum control and operating strategy as well as the advantages and disadvantages of different communication paths and transaction verification

Funding/Source	Participants	Point of Contact
SCAQMD-$100k	University of California, Irvine, Real Energy, Silicon Energy, Connectisys	Jack Brouwer National Fuel Cell Research Center University of California, Irvine Irvine, California 92697-3550 Phone (949) 824-1999 x221 Fax (949) 824-7423 jb@nfcrc.uci.edu

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Communications/Control	Pacing	Demonstration

Figure 47: UC, Irvine - SCAQMD Microturbine Demonstration (29)

Project/Technology Development/Product	Issues	Strategy	Expected Results
EPRI is supporting the IEEE P1547 effort. Additional activities include in-house training for utility staffs and state-level education on the standard and its implications.	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection solutions be deployed in a timely fashion?	• Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions • Educate stakeholders on new requirements, contracts and processes	Timely adoption of IEEE P1547 standard

Funding/Source	Participants	Point of Contact
EPRI base and tailored collaboration funding	EPRI	Dan Rastler EPRI Solutions 3412 Hillview Avenue Palo Alto, CA 94304 (650) 855-2521

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection	Power Quality, Power Reliability, Control Systems	Base	Demonstration

Figure 48: EPRI - IEEE P1547 (30)

Project/Technology Development/Product	Issues	Strategy	Expected Results
A coordinated series of projects to address technical issues preventing or delaying interconnection. The projects will test and certify equipment and solve compatibility problems: • Lab trials of Proposed IEEE P1547 • Certification of grid-connected DER • System compatibility testing of DG and energy storage for end-use applications • Dynamic interaction of interconnected devices for end-use applications • Prevention of unintentional islanding of DER	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection solutions be deployed in a timely fashion? • Is a single DER unit compatible with end-use equipment or other DER equipment? • Do we understand DER's impact on the grid?	• Understand impact of and adopt new interconnection requirement • Type-testing and certification of interconnection solutions • Develop guidelines and best practices for interconnection • Develop test protocols for compatibility and power quality testing of DER • Test and understand compatibility and power quality issues associated with DER	Practical steps to facilitate the reliable, cost-effective and safe interconnection of DER and thereby make the benefits of DER possible. Participants have their investment leveraged and used to address important interconnection issues that otherwise would have to be addressed and funded by individual utilities.

Funding/Source	Participants	Point of Contact
$500k over multiple years from participating energy companies	The research will be conducted by EPRI PEAC, which operates test facilities including a Power Quality Test Facility and a Power Quality Distributed Resources Park	EPRI Bill Steely (650) 855-2203 Ben Banerjee (650) 855-7925

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection, Grid Effects	Interconnection, Power Quality, Grid Impacts	Base	Commercial

Figure 49: EPRI - Completing the Circuit (31)

Project/Technology Development/Product	Issues	Strategy	Expected Results
EPRI is developing an engineering guide and workstation to better integrate DER with the distribution system. The software is a "how-to" guide to apply P1547 and includes communications and control issues and system impacts.	• Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems? • Can interconnection solutions be deployed in a timely fashion? • Should distribution design philosophy be modified to accommodate DER? • Can engineering studies be eliminated, standardized or streamlined?	• Understand impact of and adopt new interconnection requirement • Develop models and software to facilitate impact studies	Step-by-step primer and workstation for enhanced DER system integration engineering

Funding/Source	Participants	Point of Contact
Tailored collaboration to be completed in 2001; included in DR base program funding	EPRI and its members	Dan Rastler EPRI Solutions 3412 Hillview Avenue Palo Alto, CA 94304 (650) 855-2521

Project Area	Project Focus	Technology Characteristic	Project Type
Interconnection, Grid Effects	Interconnection and Power Quality	Base	Development/ Demonstration

Figure 50: EPRI - DER Engineering Guide and Workstation (32)

Project/Technology Development/Product	Issues	Strategy	Expected Results
EPRI Technical Assessment: Development of Distributed Resources Micro-Grids	• Can micrograds be utilized effectively? • Can the power system or the expansion thereof be built around micrograds?	• Model and analyze microgrids • Develop design guidelines for microgrids	Better understanding of the potential and pitfalls of small-scale distribution systems with embedded DER

Funding/Source	Participants	Point of Contact
Tailored collaboration to be in 2001; Included in DR base program funding	EPRI and its members	Dan Rastler EPRI Solutions 3412 Hillview Ave. Palo Alto, CA 94304 (650) 855.2521

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Microgrids	Key	Development

Figure 51: EPRI - Development of DR Microgrids (33)

Project/Technology Development/Product	Issues	Strategy	Expected Results
System modeling to determine distributed resources' impact on distribution systems	• Do we understand DER's impact on the grid? • Can engineering studies be eliminated, standardized or streamlined?	• Model and analyze the grid with varying levels of DER penetration • Develop models and software to facilitate impact studies	Data set for modeling distributed resources in electric power system simulations

Funding/Source	Participants	Point of Contact
Tailored collaboration completed in 2000; included in DR base program funding	EPRI and its members	Dan Rastler EPRI Solutions 3412 Hillview Ave. Palo Alto, CA 94304 (650) 855-2521

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Modeling, Grid Impacts	Base	Development/ Demonstration

Figure 52: EPRI - System Modeling for DR Impacts (34)

Project/Technology Development/Product	Issues	Strategy	Expected Results
A breakthrough low-cost interface box	Are there safe, reliable and cost-effective interconnection solutions for radial and networked distribution systems?	Develop new technologies that would eliminate or reduce some requirements or costs of interconnection	Lower cost interconnection

Funding/Source	Participants	Point of Contact
$150k; included in DR base program funding	EPRI and its members	Dan Rastler EPRI Solutions 3412 Hillview Ave. Palo Alto, CA 94304 (650) 855-2521

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Modeling	Base	Development/ Demonstration

Figure 53: EPRI - Interconnection Hardware (35)

Project/Technology Development/Product	Issues	Strategy	Expected Results
EPRI is developing a hardware and software system for utility control centers to identify DER resources located in the utilities system and understand the status of these resources	Can we understand the information needs of wires companies with DER deployed in their systems?	• Perform analysis of the information and data needs of wires companies • Develop and demonstrate system for wires companies to monitor DER	Prototype of the system

Funding/Source	Participants	Point of Contact
Prototype system is included in this year's base funding. Demos will require additional funding.	EPRI and its members	Dan Rastler EPRI Solutions 3412 Hillview Ave. Palo Alto, CA 94304 (650) 855-2521

Project Area	Project Focus	Technology Characteristic	Project Type
Grid Effects	Software and Hardware	Pacing	Development/ Demonstration

Figure 54: EPRI - DER Status and Condition Information System (36)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Smart*DER - Intelligent Software Agents for Control and Scheduling of DER. An intelligent agent is a software-based device that acts on behalf of the end-user and can exploit knowledge, learn and reason, and communicate. Their ability to collaborate make them well-suited to controlling and scheduling large numbers of assets.	• Can it be made easier for consumers to maximize their investment in DER? • Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)	The Phase I effort addressed the difficulty in introducing the DER paradigm to the power industry, demonstrated the viability of this approach, and provided demonstration software to facilitate technology transfer. Phase II addresses issues related to selecting the commercialization path for moving this technology to the marketplace.

Funding/Source	Participants	Point of Contact
Phase II - $500k (15-18 months) CEC PIER Program	Alternative Energy Systems Consulting, Reticular Systems Inc., CEC	Gerald Gibson Program Manager Alternative Energy Systems Consulting 4715 Viewridge Avenue, Suite 200 San Diego, CA 92123

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Control Systems, Dispatching	Emerging	Development/ Demonstration

Figure 55: Alternative Energy Systems Consulting - Smart*DER (37)

Project/Technology Development/Product	Issues	Strategy	Expected Results
A 3-year effort to produce a controller and demonstrate the ability of a group of controllers to operate through a neural network to provide a smart, technologically sophisticated, but simple, efficient, and economic solution for aggregating a community of small DER units into a virtual single large generator able to sell power internally or externally to a utility, ISO, or other entity.	•Can it be made easier for consumers to maximize their investment in DER? •Do we understand how DER will interact with other DER and the grid in real-time? •Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services)?	Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)	Energy integration product for residential, commercial and industrial distributed generation applications

Funding/Source	Participants	Point of Contact
Currently in the first year of a 3-year project ($500k) DOE	Orion Engineering Corporation and University of Massachusetts at Lowell	Herb Sinnock, (617) 625-3953 Tom Regan, (978) 337-1352 Orion Engineering Corporation 40 Marion Street, Somerville, MA 02143

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Control Systems, Dispatching	Emerging	Development

Figure 56: DENNIS (38)

Project/Technology Development/Product	Issues	Strategy	Expected Results
RealEnergy is developing the Pleasanton Power Park, an industrial park in Pleasanton, CA. A variety of DER technologies will be installed to allow the park to generate its own electricity. Silicon Energy's Enterprise Energy Management software will manage the deployment, aggregation, and control of the DER units.	•Can it be made easier for consumers to maximize their investment in DER? •Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	•Demonstrate aggregation and control of DER •Develop low cost communications and control •Develop software to optimize DER in response to market price signals	Optimize costs by collecting and processing data that will allow a central control system to manage the park's energy demand and resources

Funding/Source	Participants	Point of Contact
Project is cost-shared between CEC & DOE ($1.7MM for solar installation), RealEnergy, and Silicon Energy	CEC, DOE, RealEnergy and Silicon Energy	Steven Greenberg Real Energy 300 Capitol Mall, Ste 120, Sacramento, CA 95814 (916) 325-2500 x108 sgreenberg@realenergy.net

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Control Systems, Dispatching	Key/Pacing	Development/ Demonstration

Figure 57: Pleasanton Power Park (39)

Project/Technology Development/Product	Issues	Strategy	Expected Results
In the summer of 2000, Sixth Dimension and New West Energy implemented an internet-based solution to curtail peak-power loads and bid sheddable loads into real-time energy markets through California's Independent System Operator (ISO).	• Can it be made easier for consumers to maximize their investment in DER? • Can we aggregate and remotely operate and control DER to better respond to market signals (e.g., energy capacity, ancillary services, and transmission and congestion)?	• Demonstrate aggregation and control of DER • Develop low-cost communications and control • Develop software to optimize DER in response to market price signals	Allowed internet-based communication of real-time, on-site meter readings and dispatch signals between California energy service providers, energy users, and the California ISO. Sixth Dimension's secure internet network (6D iNET™) coupled with its Aggregated Load Curtailment Service Package provided the ISO a 4-second snapshot of power usage at connected sites.

Funding/Source	Participants	Point of Contact
Project is complete	Sixth Dimension, New West Energy, Cal-ISO	Wade Troxell Sixth Dimension 1201 Oakridge Drive, Suite 300 Fort Collins, Colorado 80525 (970) 267-2021

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Control Systems, Dispatching	Key/Pacing	Demonstration/ Commercial

Figure 58: Sixth Dimension (40)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Analysis of the feasibility–both economically and practically–of grid connected electrical drive vehicles (EDVs) as a resource for distributed electric power in California. Infrastructure needed to make such activities feasible is also examined.	• Can it be made easier for consumers to maximize their investment in DER? • Could participation costs be reduced?	• Reduce costs by creating critical mass through a demonstration program • Assess requirements for tariffs or rates	The technologies required to make connecting EDVs to the grid feasible are either in production or in the prototype state. It is not economical to use EDVs in baseload power, but EDVs could profitably play a role in peak power and ancillary services (i.e., spinning reserves and regulation services).

Funding/Source	Participants	Point of Contact
California Air Resources Board, California Environmental Protection Agency, Los Angeles Department of Water and Power-Electric Transportation Program	University of Delaware, Green Mountain College, AC Propulsion, University of California, Davis	Willett Kempton University of Delaware (302) 831-0049 willett@udel.edu

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Policy, Control	Pacing	Demonstration

Figure 59: Vehicle-to-Grid Power (41)

Project/Technology Development/Product	Issues	Strategy	Expected Results
Funded through CEC as part of the DOE's State Energy Program (SEP), this is a multi-part study that analyzes 1) the transmission-level services provided by DER; 2) the benefits and pricing strategies for distribution services provided by DER; and 3) engineering and institutional limitations to DER providing T&D services.	• Can we aggregate and remotely operate and control DER to better respond to market signals? • Do we understand what benefits DER can provide to the power system? • Do we understand DER's impact on the grid?	• Assess current wholesale market rules for applicability to DER • Assess requirements for tariffs or rates • Develop models to understand system impacts	Different types of transmission services are defined and guidelines and challenges identified. 3 different pricing mechanisms were evaluated for distribution application to different DER services. Technical and policy barriers to the development of DER to provide T&D services are identified.

Funding/Source	Participants	Point of Contact
CEC and DOE	Energy and Environmental Economics, Inc.	Snuller Price snuller@ethree.com

Project Area	Project Focus	Technology Characteristic	Project Type
Market Integration	Wholesale, Policy, Metering/Settlement, IT	Base	Demonstration

Figure 60: Distributed Generation Services for Transmission and Distribution (42)

Overall Current Activity

As seen when the seven private sector categories and the 42 public projects are plotted, there is a significant amount of overall current activity (Figure 61). The private sector activity tends to fall in the later stages of the technology development; while publicly sponsored research is scattered focused on research and development of emerging and pacing technologies and demonstration and commercialization of key and base technologies.

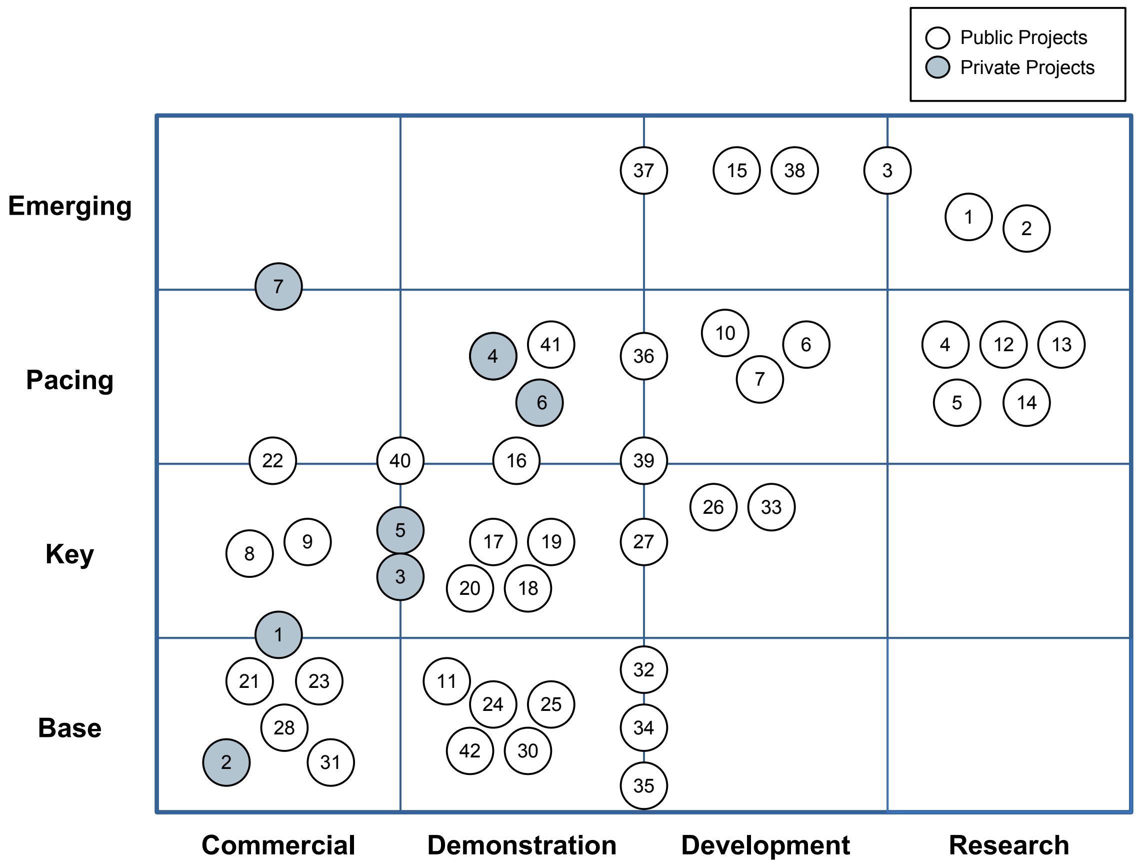


Figure 61: Development and Competitive Status of Public and Private Projects

Chapter 4: Strategy Mapping

To better understand the characteristics of the strategies outlined in Chapter 2, graphic representations were created for strategies in each of the areas: interconnection, grid effects, and market integration. The strategies were plotted by their stages of technology development (research, development, demonstration, and/or commercialization) and competitive impact (base, key, pacing or emerging). The position of the strategy indicates its balance of technical risk from its technology development stage and market risk from its competitive impact (Figure 62).

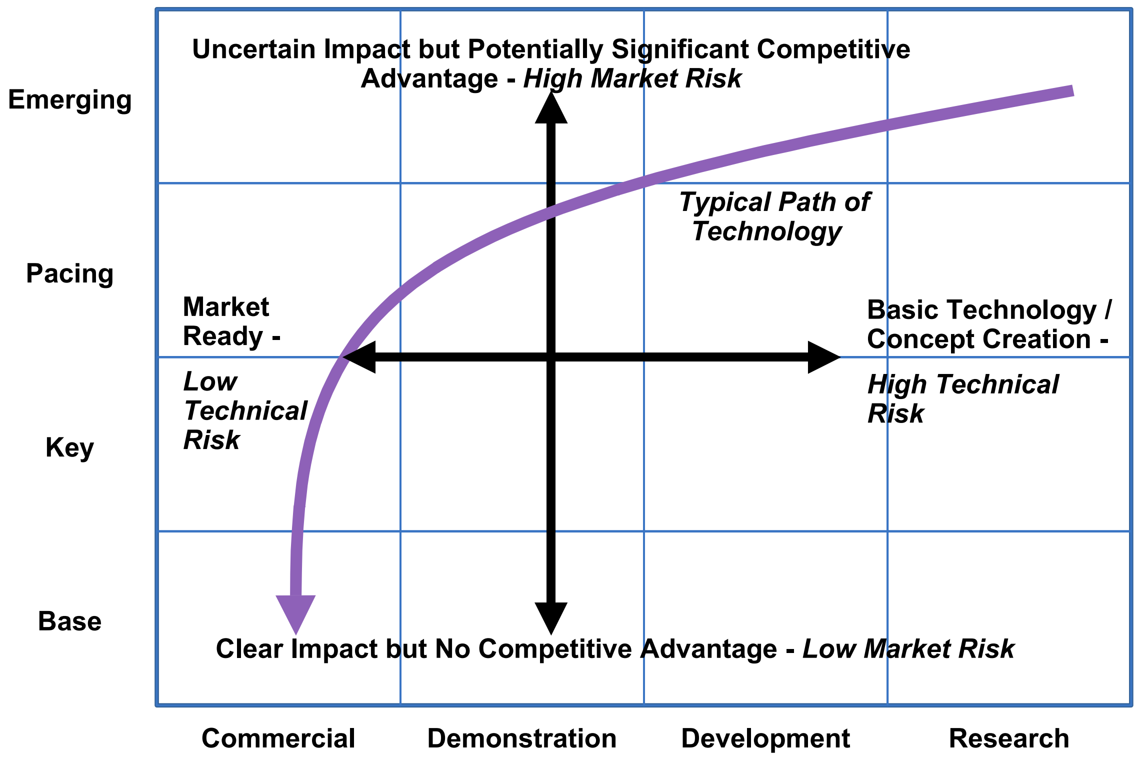


Figure 62: Strategy Map

Note that not every potential strategy is currently being pursued; also, there are areas on the strategy map where no strategies exist.

Interconnection

- With respect to interconnection, most of the strategies in the three strategic thrusts fall in the demonstration stage and concern either key or base technologies (Figure 63). No interconnection strategies in the research stage were found. Many interconnection technologies have been commercially available for decades and have been widely used in customer self-generation projects. Strategies that are characterized as base are not likely to give any one competitor significant advantage but are essential to the overall success of all interconnection suppliers. Many strategies relying on key technologies are being pursued that could lead to some competitive advantage in the short term.
- ***Standardization and Adoption of New Requirements and Processes*** – Strategies in this thrust are focused on base technologies, as there will be little competitive advantage to be gained by any one company with the development and adoption of new standards.
- ***Cost Reduction and Product Improvement*** – Most of the strategies in cost reduction and product improvement are focused on key technologies in the commercial stage that are likely to yield competitive advantage for the companies engaged in the7se activities.
- ***Compatibility*** – The two strategies in compatibility are key technologies in the demonstration stage.

Interconnection

Can a substantial amount of DER be interconnected in both radial and networked distribution systems?

Strategies

Standardization and Adoption of New Requirements and Processes

1. Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions
2. Understand impact of and adopt new interconnection requirements
3. Standardize designs around new requirements
4. Initiate type-testing and certification of interconnection solutions
5. Develop guidelines and best practices for interconnection
6. Modify standardized requirements and standardized designs based on modeling, testing and field experience
7. Educate stakeholders on new requirements, contracts and processes
8. Develop standardized products for small DER

Cost Reduction and Product Improvement

9. Reduce costs of interconnection components
10. Improve reliability and performance of interconnection components (e.g., power electronics)
11. Integrate interconnection functions with other DER functions
12. Turnkey solutions that integrate DER functions
13. Develop new technologies that would eliminate or reduce some requirements or costs of interconnection

Compatibility

14. Develop test protocols for compatibility and power quality testing of DER
15. Test and understand compatibility and power quality issues

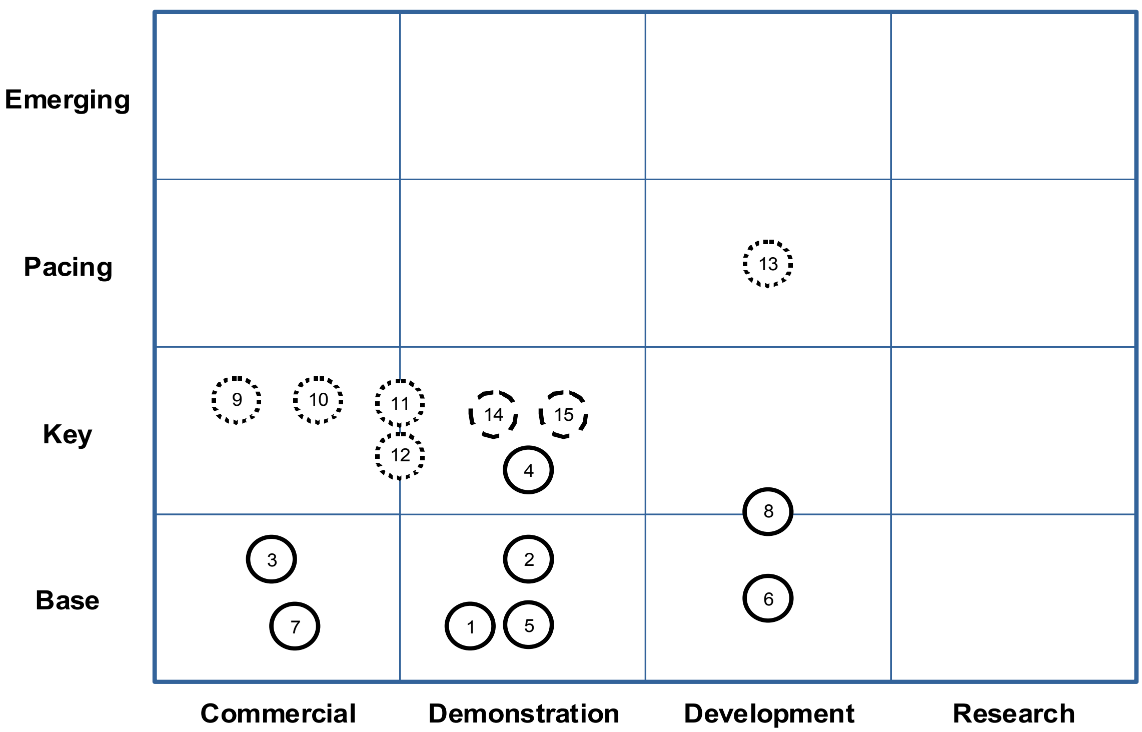


Figure 63: Strategies Addressing Interconnection Issues

Grid Effects

The four strategic thrusts in the grid effects area span all technology development stages from research to commercial (Figure 64). The strategies within each of the thrusts are related and need to be done sequentially in most cases. Much of the current work focuses on research and development. However, these technologies will eventually progress to demonstration and commercialization.

The competitive impact of these strategic thrusts is in the pacing and/or emerging areas. ***Modeling and Testing, System Impact Studies*** and ***Wires Companies Information Needs*** are pacing technology development. Although they are not fully embodied in current products, they may, if successfully applied, have a substantial impact on the basis of competition in the reasonably near future. Understanding penetration limits and changing the distribution system design approach to allow for DER could certainly lead to a change in the competitive structure of the industry and perhaps even a paradigm shift in how electricity is generated and distributed. However, the ultimate impact is uncertain. Likewise, the impact of the ***Microgrids*** thrust could be very similar; however, the ultimate impact is even less certain, thus making it an emerging technology.

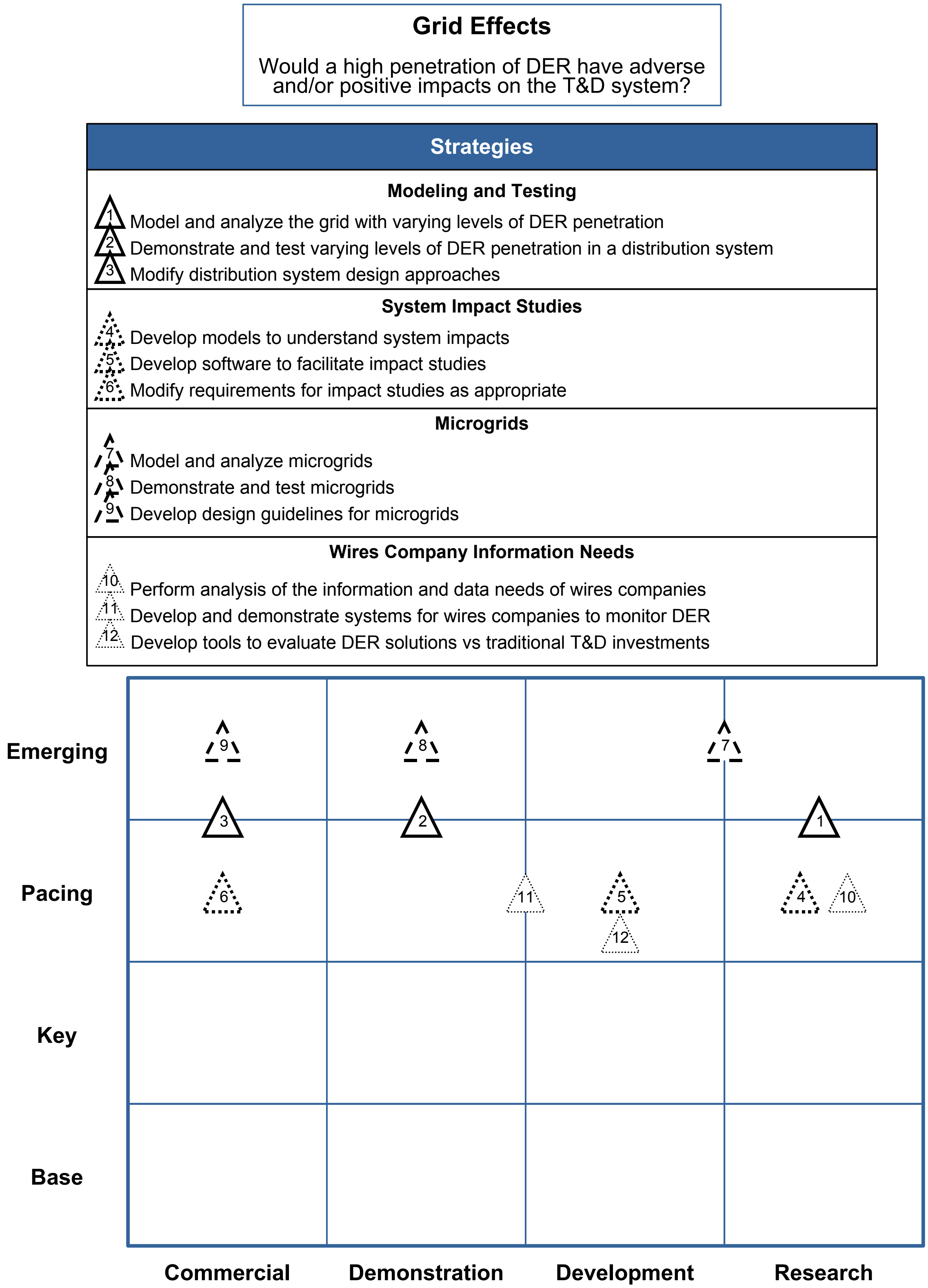


Figure 64: Strategies Addressing Grid Effects

Market Integration

There are market integration strategies at different stages of technology development (Figure 65). These strategies involve more regulatory and policy development initiatives than do the other two areas, interconnection and grid effects. However, technology could play a major role in achieving any policy changes, particularly for strategies in the research, development and demonstration areas.

- ***Current Market –*** Many of the strategies in this thrust fall in the pacing category, having the potential to change the entire basis of competition in this industry. Strategies in the commercial area represent the "low-hanging fruit" that would increase the level of DER penetration in the short term. They involve changing rates, tariffs and market rules and require little technology development.
- ***Advanced Market Concepts –*** Strategies in this thrust are mostly in the research and development stages, and are emerging technologies that could bring about a major shift in the industry and make DER a major electricity resource for California. The strategies to create a new market are related and would have to be done sequentially.
- ***Enabling Technologies –*** Enabling technologies include communications, control, metering, storage and software. These strategies are more focused on bringing about seamless customer DER response to real-time electricity prices and prices for additional benefits associated with some DER technologies such as CHP. All of the strategies in this thrust are in the demonstration phase and most have key/pacing competitive impacts. They are not yet fully embodied in commercial products, but they are likely to have a substantial impact on the basis of competition in the future. Most of the technology necessary to deploy these strategies will be commercial shortly. The technical challenges arise in the integration of these technologies.

Market Integration

Can DER access robust markets or be exposed to price signals that will maximize benefits to customers and the power system?

Strategies

Current Market

1. Assess current wholesale market rules for applicability to DER
2. Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER
3. Reduce costs by creating critical mass through a demonstration program
4. Integrate the required technologies to reduce costs of participating in markets
5. Assess requirements for tariffs or rates
6. Develop market mechanisms to capture and monetize additional DER benefits (e.g., T&D, reliability, environmental, CHP, etc.)

Advanced Market Concepts

7. Launch a new market for DER that captures all value generated
   - a Start from scratch, develop the best market structure for DER now and in the future
   - b Assess the system requirements for communications, control, metering, software for billing and settlement
   - c Pilot and then launch
8. Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)

Enabling Technologies

9. Demonstrate aggregation and control of DER
10. Develop low-cost metering
11. Develop low-cost communications and control
12. Develop software to optimize DER in response to market price signals
13. Develop standards/protocols for communications/control
14. Develop advanced storage to optimize DER in response to market price signals

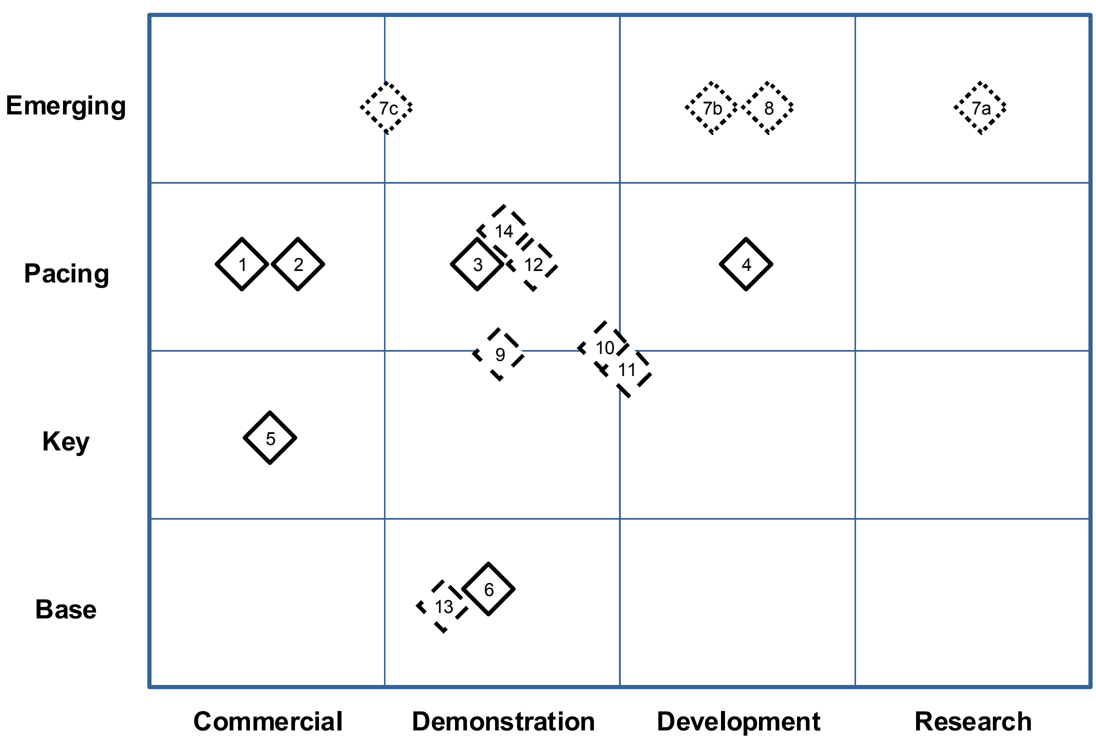


Figure 65: Strategies Addressing Market Integration

Chapter 5: Gaps in Strategies

Approach

In this chapter, gaps are identified for each of the strategies found in Chapter 2, based on the current projects noted in Chapter 3. Gaps are defined as disparities between the current level of private/public activity for a strategy and the level of activity needed to ensure that strategy has a reasonable chance of resolving the issue it is addressing. Interviews with researchers and company representatives working on these strategies provided the baseline information for assessing gaps.

In Chapter 4, strategies were plotted by their technology development stage (research, development, demonstration and/or commercialization) and their competitive impact (base, key, pacing or emerging). The magnitude of the gap for each strategy is based on the amount and thoroughness of the research pursuing a particular strategy. The following framework was used:

- *Significant gap* – Few companies or entities are adequately pursuing this strategy at a level that will likely ensure it has a reasonable chance of helping resolve the issue it is addressing. This could indicate an area that has been overlooked or is just emerging as a viable strategy.
- *Moderate gap* – There are several companies and/or entities pursuing this strategy, or it is not feasible or appropriate to pursue this strategy. Continued *and* additional activity is likely required to ensure the strategy has a reasonable chance of helping resolve the issue it is addressing. A "moderate gap" rating was also given to strategies that are deemed not appropriate or feasible to pursue at this time.

Little or no gap – There are many companies and/or entities pursuing this strategy. The current level of activity is likely appropriate to ensure the strategy has a reasonable chance of helping resolve the issue it is addressing. Little additional work beyond what is currently funded is necessary.

Results

The gaps were evaluated by separately examining the private and public activities identified in Chapter 3, and then combined for an overall view for each of the three areas: interconnection, grid effects and market integration.

Interconnection

Private companies are deploying strategies that are associated with adopting new requirements and developing products that will reduce the cost of interconnection (Figure 66). Ongoing commercial work has been addressing cost reductions through reducing cost of components, turnkey solutions, and integrating functions. This activity has been pursued only moderately as the technical requirements are still under development. The private sector work is mostly in the commercial stage of technology development. Companies are deploying base strategies to remain competitive while focusing on key technologies for a longer-term competitive advantage.

Interconnection

Can a substantial amount of DER be interconnected
in both radial and networked distribution systems?

Strategies

Standardization and Adoption of New Requirements and Processes

1. Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions
2. Understand impact of and adopt new interconnection requirements
3. Standardize designs around new requirements
4. Initiate type-testing and certification of interconnection solutions
5. Develop guidelines and best practices for interconnection
6. Modify standardized requirements and standardized designs based on modeling, testing and field experience
7. Educate stakeholders on new requirements, contracts and processes
8. Develop standardized products for small DER

Cost Reduction and Product Improvement

9. Reduce costs of interconnection components
10. Improve reliability and performance of interconnection components (e.g., power electronics)
11. Integrate interconnection functions with other DER functions
12. Turnkey solutions that integrate DER functions
13. Develop new technologies that would eliminate or reduce some requirements or costs of interconnection

Compatibility

14. Develop test protocols for compatibility and power quality testing of DER
15. Test and understand compatibility and power quality issues

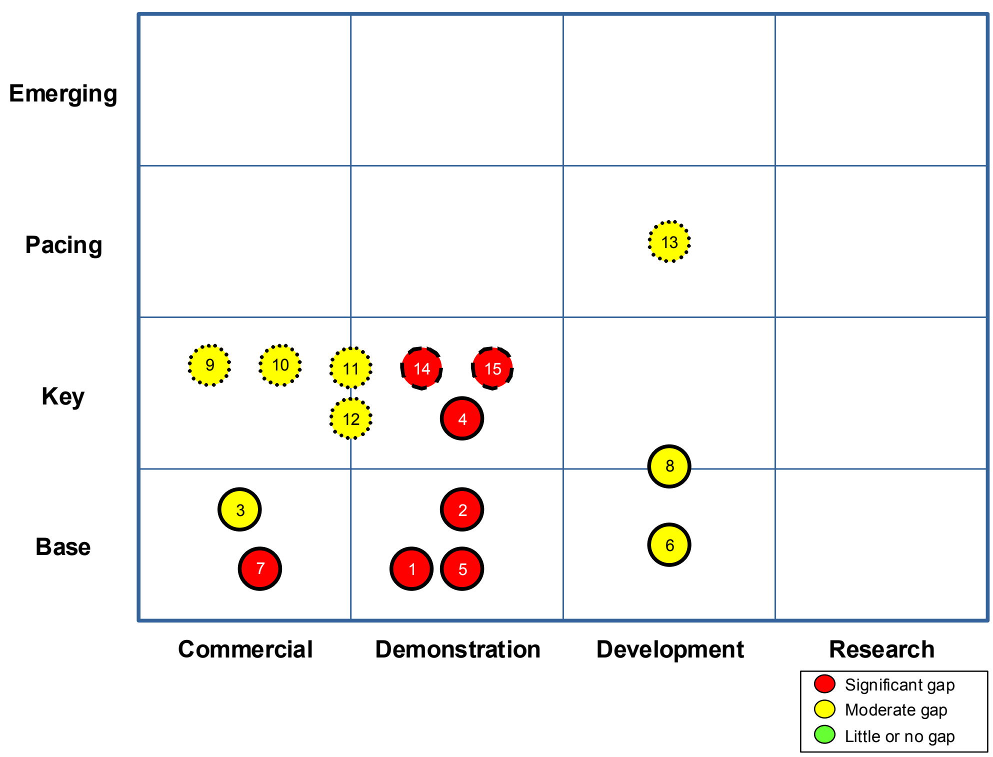


Figure 66: Private Activity Deploying Interconnection Strategies

Other strategies such as the modification and adoption of new requirements require a collaborative approach supported by public or nonprofit entities (Figure 67). This would include the development of standards such as the IEEE P1547 and Rule 21 efforts. The consensus opinion from the interview process was that, while there was still work to be done in the development of standards, level of effort and current standards in California adequately cover this area. Many interviewed expressed that it was time to start focusing beyond the development of these standards to their adoption. There is already some activity in this base/commercial area. Other government/nonprofit activity is found in the key/base area where entities such as EPRI are working through testing and demonstration to understand the impact of DER on other end-use equipment. There is also activity in the pacing/development area that would develop new technologies.

Strategies

Standardization and Adoption of New Requirements and Processes

1. Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions
2. Understand impact of and adopt new interconnection requirements
3. Standardize designs around new requirements
4. Initiate type-testing and certification of interconnection solutions
5. Develop guidelines and best practices for interconnection
6. Modify standardized requirements and standardized designs based on modeling, testing and field experience
7. Educate stakeholders on new requirements, contracts and processes
8. Develop standardized products for small DER

Cost Reduction and Product Improvement

9. Reduce costs of interconnection components
10. Improve reliability and performance of interconnection components (e.g., power electronics)
11. Integrate interconnection functions with other DER functions
12. Turnkey solutions that integrate DER functions
13. Develop new technologies that would eliminate or reduce some requirements or costs of interconnection

Compatibility

14. Develop test protocols for compatibility and power quality testing of DER
15. Test and understand compatibility and power quality issues

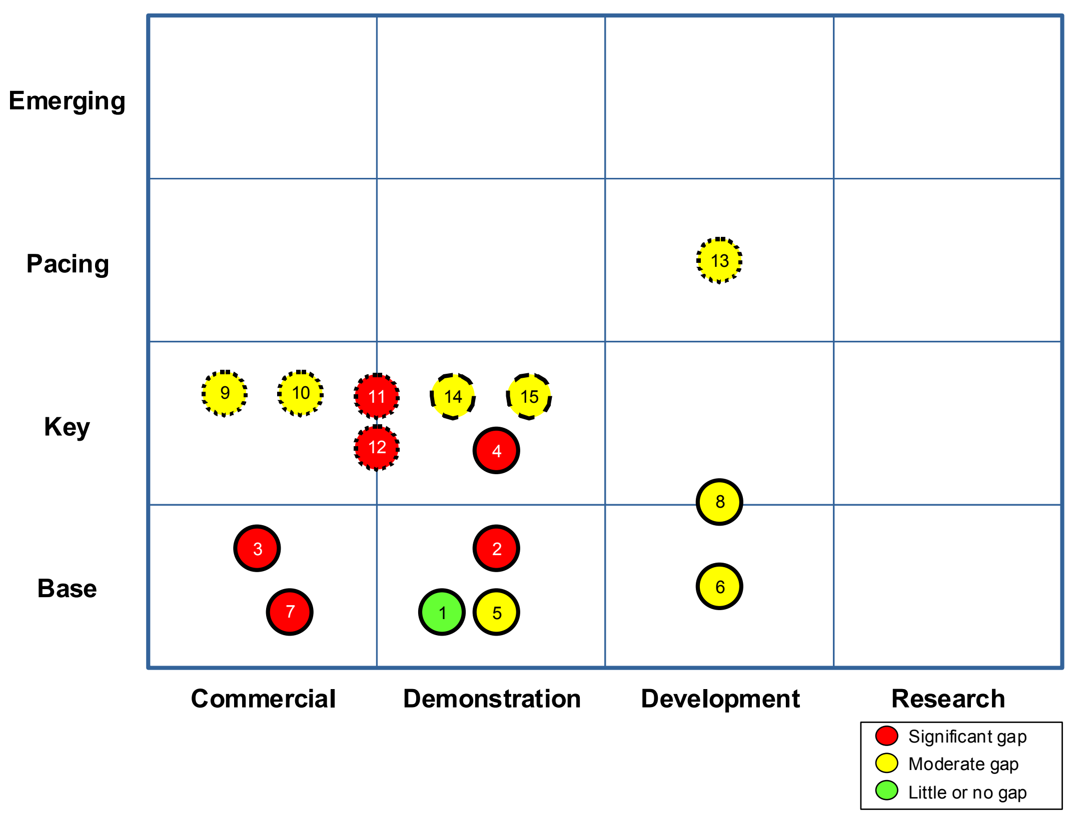


Figure 67: Public/Nonprofit Activity Deploying Interconnection Strategies

By combining the overall public and private activity, the following observations can be made concerning gaps in the three strategic thrusts (Figure 68):

- ***Standardization and Adoption of New Requirements and Processes*** – Strategies in this thrust are focused on base technologies, as there will be little competitive advantage to be gained by any one company with the development and adoption of new standards. There has been a significant amount of activity in California and on a national level in developing standards in the past and going forward, leaving virtually no gap. There are, however, some significant gaps in the strategies that will adopt and refine these standards. Significant gaps also exist in type testing and certification, as well as developing guidelines and best practices for interconnection. While there are a few private sector efforts in developing standardized products for small DER, efforts in this area may not be feasible to pursue on a large scale at this time.
- ***Cost Reduction and Product Improvement*** – Most of the strategies in cost reduction and product improvement are focused on key technologies that are likely to yield competitive advantage for the companies engaged in these activities. There are some private and government-funded activities in this area, but moderate gaps still exist. While it is premature to significantly fund development of truly breakthrough technologies that could lead to substantial cost reductions, a preliminary study into where some progress can be made in the near term may be warranted.

Compatibility – Strategies in compatibility are being pursued exclusively by EPRI PEAC. These activities are just getting under way and additional activity is likely to be required to make such strategies viable to pursue.

Strategies

Standardization and Adoption of New Requirements and Processes

1. Standardize technical requirements, processes and contracts for interconnection (including networked systems and power export) that allow for innovative solutions
2. Understand impact of and adopt new interconnection requirements
3. Standardize designs around new requirements
4. Initiate type-testing and certification of interconnection solutions
5. Develop guidelines and best practices for interconnection
6. Modify standardized requirements and standardized designs based on modeling, testing and field experience
7. Educate stakeholders on new requirements, contracts and processes
8. Develop standardized products for small DER

Cost Reduction and Product Improvement

9. Reduce costs of interconnection components
10. Improve reliability and performance of interconnection components (e.g., power electronics)
11. Integrate interconnection functions with other DER functions
12. Turnkey solutions that integrate DER functions
13. Develop new technologies that would eliminate or reduce some requirements or costs of interconnection

Compatibility

14. Develop test protocols for compatibility and power quality testing of DER
15. Test and understand compatibility and power quality issues

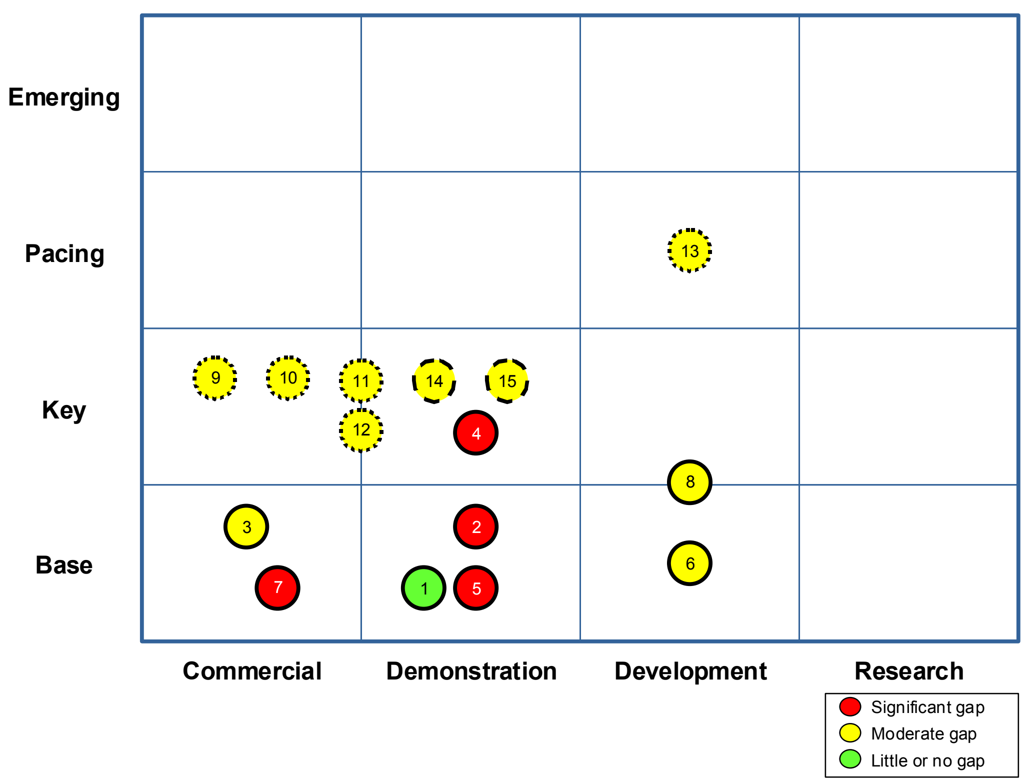


Figure 68: Overall Activity Deploying Interconnection Strategies

Grid Effects

Most of the past and current work in this area falls under pacing and emerging technologies in the research and development areas of the technology development pathway (Figure 69). These projects are mostly conducted or supported by government, nonprofit or collaborative organizations.

The following observations can be made regarding gaps in the four strategic thrusts:

- ***Modeling and Testing –*** Private companies and EPRI have done work in developing models and analyzing DER's impact on the electric power system. There is still a moderate gap in this area to evaluate these models for their applicability to DER. The next step in development where there is a significant gap is in the field demonstration and testing. The Distributed Utility Integration Testing Program at the Nevada Test site will pursue this strategy. However, it is still in the planning phase. Only with such efforts well under way can we begin to contemplate modifying distribution system design approaches.
- ***System Impact Studies –*** There is a moderate gap in developing models to understand system impact and to develop software that will facilitate impact studies. With more progress on these efforts, activities to modify requirements for impact studies may need to be examined.
- ***Microgrids –*** There has been a significant amount of work on modeling and analyzing microgrids through government-supported efforts such as CERTS. The next step, where there is a significant gap, is to demonstrate and test microgrids. UCI and CERTS are poised to do this type of work. As a follow-on to such work, design guidelines for microgrids may need to be created.
- ***Wires Company Information Needs –*** EPRI has completed work to understand the information needs of utilities with DER in their systems. EPRI has developed a prototype system to be deployed in 2001 with follow-on demonstrations in 2002. There is a moderate gap in demonstrating such a system. Many utilities have evaluated DER investments versus traditional transmission and distribution (T&D) investments. However, the tools they have used to do this are reinvented each time and the analysis process is lengthy.

Strategies
Modeling and Testing
1 Model and analyze the grid with varying levels of DER penetration
2 Demonstrate and test varying levels of DER penetration in a distribution system
3 Modify distribution system design approaches
System Impact Studies
4 Develop models to understand system impacts
5 Develop software to facilitate impact studies
6 Modify requirements for impact studies as appropriate
Microgrids
7 Model and analyze microgrids
8 Demonstrate and test microgrids
9 Develop design guidelines for microgrids
Wires Company Information Needs
10 Perform analysis of the information and data needs of wires companies
11 Develop and demonstrate systems for wires companies to monitor DER
12 Develop tools to evaluate DER solutions vs traditional T&D investments

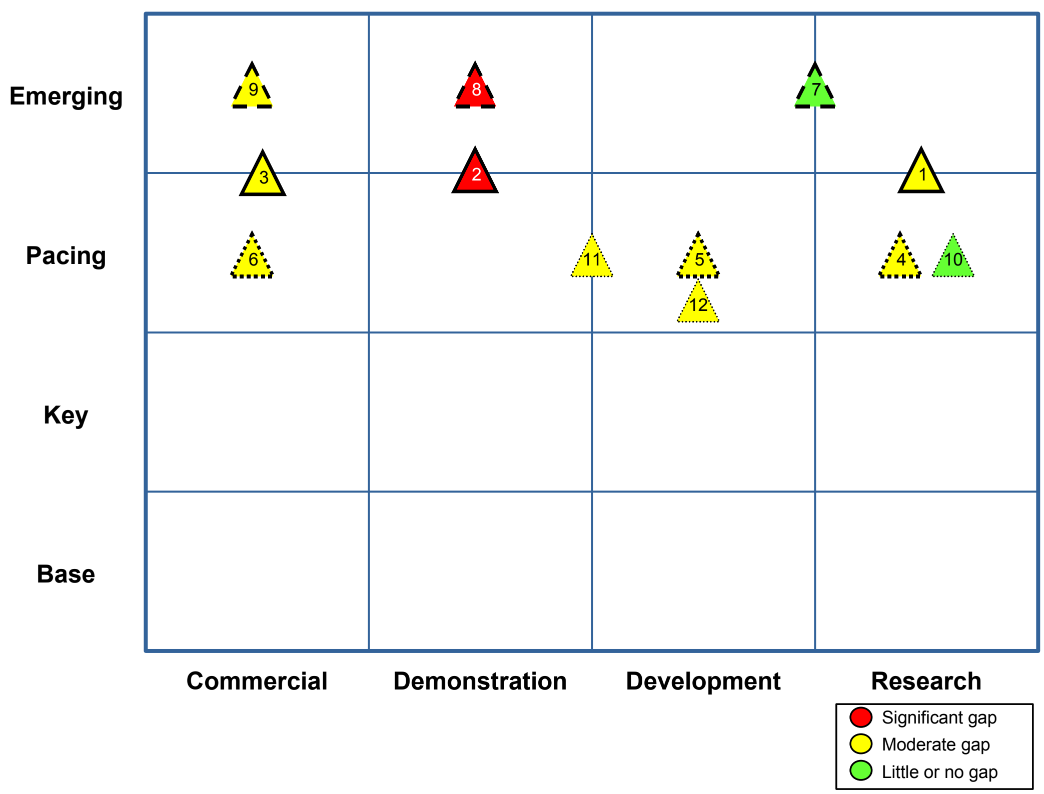


Figure 69: Overall Activity Deploying Grid Effects Strategies

Market Integration

With the exceptions of low-cost metering and assessing rates and tariffs, private and public/nonprofit organizations are working on the same strategies (Figure 70 and Figure 71).

Strategies

Current Market

1. Assess current wholesale market rules for applicability to DER
2. Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER
3. Reduce costs by creating critical mass through a demonstration program
4. Integrate the required technologies to reduce costs of participating in markets
5. Assess requirements for tariffs or rates
6. Develop market mechanisms to capture and monetize additional DER benefits (e.g., T&D, reliability, environmental, CHP, etc.)

Advanced Market Concepts

7. Launch a new market for DER that captures all value generated
   - a Start from scratch, develop the best market structure for DER now and in the future
   - b Assess the system requirements for communications, control, metering, software for billing and settlement
   - c Pilot and then launch
8. Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)

Enabling Technologies

9. Demonstrate aggregation and control of DER
10. Develop low-cost metering
11. Develop low-cost communications and control
12. Develop software to optimize DER in response to market price signals
13. Develop standards/protocols for communications/control
14. Develop advanced storage to optimize DER in response to market price signals

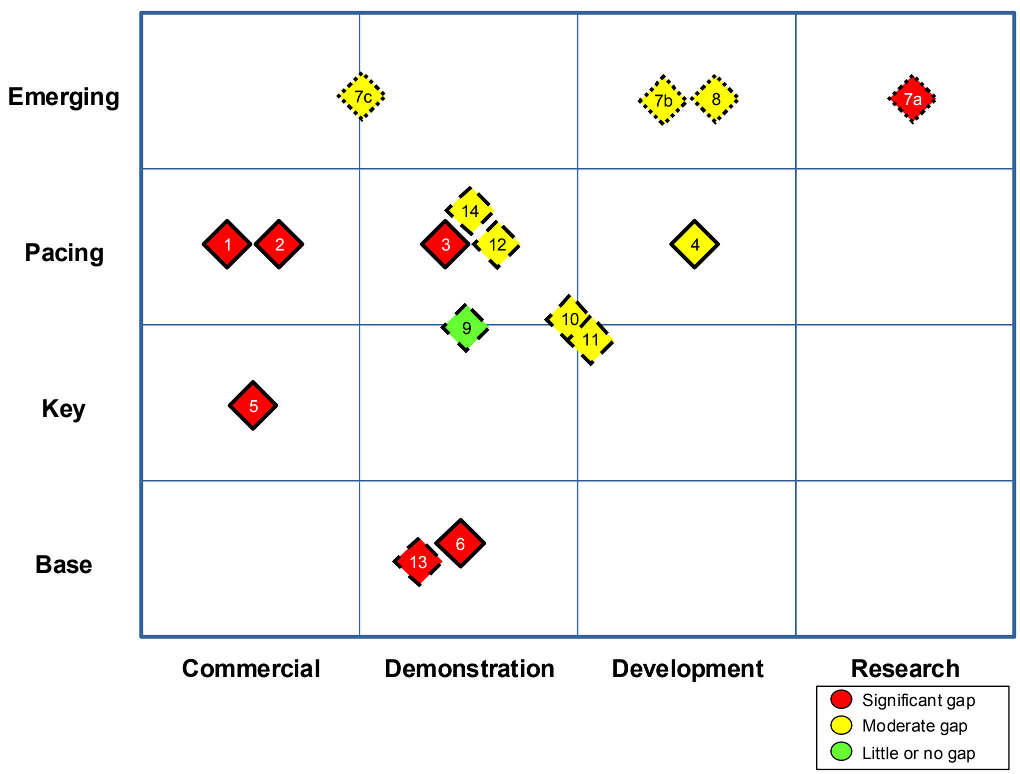


Figure 70: Private Activity Deploying Market Integration Strategies

Strategies

Current Market

1. Assess current wholesale market rules for applicability to DER
2. Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER
3. Reduce costs by creating critical mass through a demonstration program
4. Integrate the required technologies to reduce costs of participating in markets
5. Assess requirements for tariffs or rates
6. Develop market mechanisms to capture and monetize additional DER benefits (e.g., T&D, reliability, environmental, CHP, etc.)

Advanced Market Concepts

7. Launch a new market for DER that captures all value generated
   - a Start from scratch, develop the best market structure for DER now and in the future
   - b Assess the system requirements for communications, control, metering, software for billing and settlement
   - c Pilot and then launch
8. Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)

Enabling Technologies

9. Demonstrate aggregation and control of DER
10. Develop low-cost metering
11. Develop low-cost communications and control
12. Develop software to optimize DER in response to market price signals
13. Develop standards/protocols for communications/control
14. Develop advanced storage to optimize DER in response to market price signals

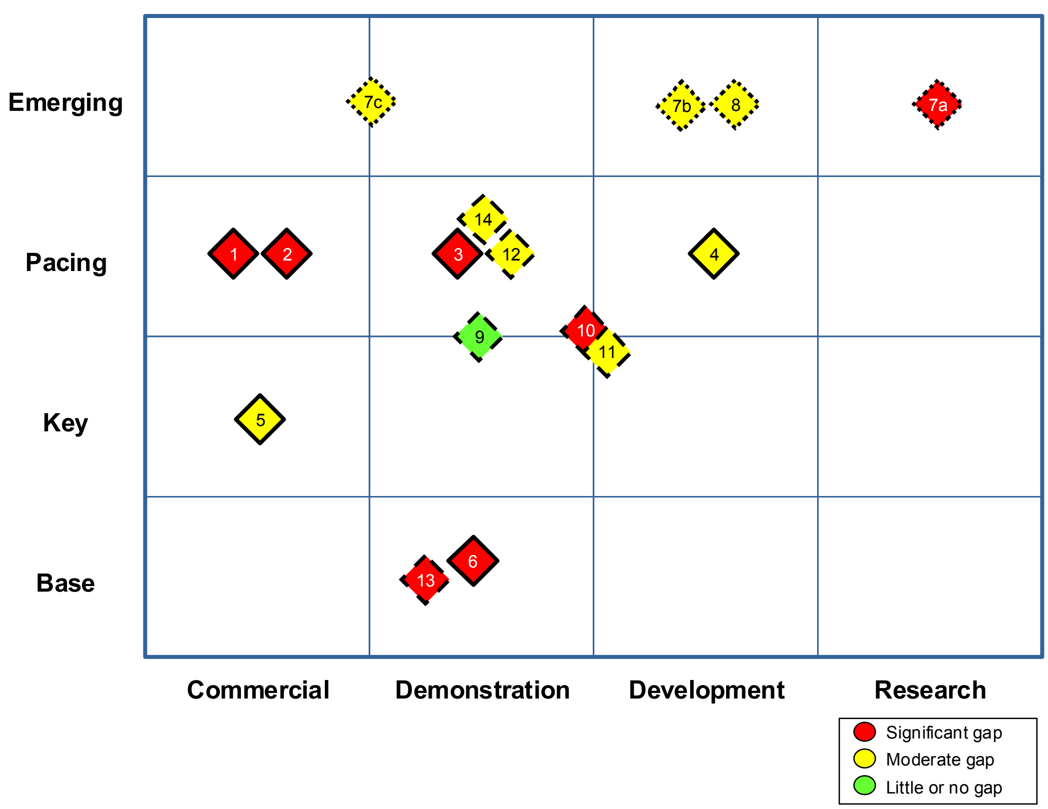


Figure 71: Public/Nonprofit Activity Deploying Market Integration Strategies

Combining the private and public sector activities, gaps can be identified (Figure 72) The following observations can be made regarding gaps in the three strategic thrusts in market integration:

- ***Current Market –*** Many of the strategies in this area fall in the pacing category, having the potential to change the entire basis of competition in this industry. There are significant gaps in many of these strategies, particularly those that involve changing rates, tariffs and market rules without requiring significant technology development. Although it falls in the base technology category, developing market mechanisms to capture additional benefits associated with various forms of DER is of great importance and has not seen significant activity thus far.
- ***Advanced Market Concepts –*** Strategies in this thrust are in the research and development stages, and are emerging technologies that could bring about a major shift in the industry and make DER a major electricity resource for California. There is a significant gap in understanding the best market structure for DER. It is still too early to take some actions associated with the creation of a new market (e.g., conducting systems assessments or pilot programs); therefore there is a moderate gap in this area.
- ***Enabling Technologies –*** Most enabling technology strategies have key/pacing competitive impacts. Not yet fully embodied in commercial products, they are likely to have a substantial impact on the basis of competition in the future. Enabling technologies include communications, control, metering, storage, and software. Overall, there is a moderate gap in this thrust. While there has been a significant amount of activity designed to aggregate and control DER, moderate gaps remain in developing low-cost metering, low-cost communications and control, optimization software, and advanced storage. There is also a significant gap in developing standards and protocols for communications and control.

Strategies

Current Market

1. Assess current wholesale market rules for applicability to DER
2. Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER
3. Reduce costs by creating critical mass through a demonstration program
4. Integrate the required technologies to reduce costs of participating in markets
5. Assess requirements for tariffs or rates
6. Develop market mechanisms to capture and monetize additional DER benefits (e.g., T&D, reliability, environmental, CHP, etc.)

Advanced Market Concepts

7. Launch a new market for DER that captures all value generated
   - a Start from scratch, develop the best market structure for DER now and in the future
   - b Assess the system requirements for communications, control, metering, software for billing and settlement
   - c Pilot and then launch
8. Develop advanced control and optimization approaches and technologies (including neural networks and intelligent software agents)

Enabling Technologies

9. Demonstrate aggregation and control of DER
10. Develop low-cost metering
11. Develop low-cost communications and control
12. Develop software to optimize DER in response to market price signals
13. Develop standards/protocols for communications/control
14. Develop advanced storage to optimize DER in response to market price signals

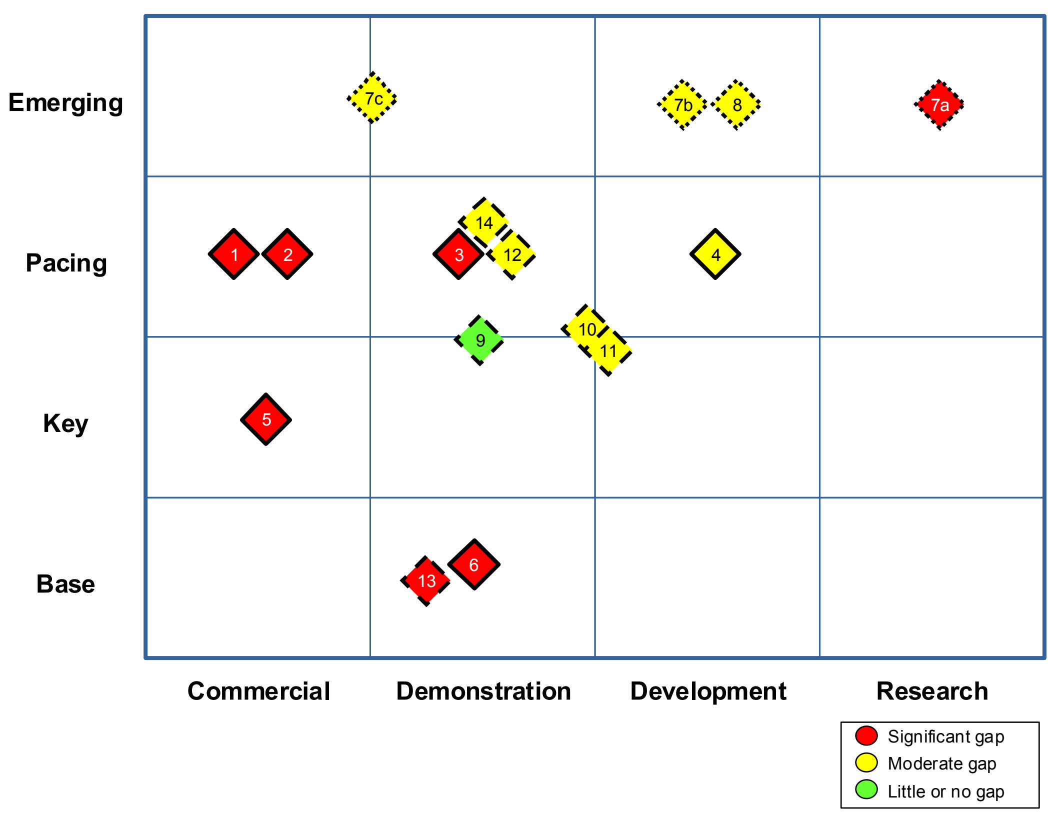


Figure 72: Overall Activity Deploying Market Integration Strategies

Chapter 6: Conclusions

General Observations

Interconnection – "We have just seen the tip of the iceberg"

Since Californians formed the California Alliance for Distributed Resources in 1995, much has been accomplished to improve the environment for DER. Most notable are the tremendous collaborative efforts to streamline interconnection requirements and processes. Many feel that while progress has been made there is a long way to go before "plug and play" interconnection solutions based on universally excepted standards are ubiquitous. Bi-directional power flow and interconnection into network distribution systems are still key challenges facing this nascent industry. As Joe Iannucci from Distributed Utility Associates stated during the August 28 workshop, "At this point, we have just seen the tip of the iceberg."

Grid effects rather than grid impacts

Understanding the impact that DER will have on the power system, particularly at high penetration levels, has also been an area of concern for many years. Equally important is an understanding of the benefits that DER can provide to the power system. Without a clear understanding of grid effects, development of a business model, regulatory changes, and future technology development needs will remain uncertain.

Microgrids – The new, new thing?

Recently, microgrids have emerged as a potentially attractive alternative to the central plant model and the distributed generation model. Microgrids could be viewed as a hybrid of the central plant and distributed generation paradigms – a sort of mini power grid controlled, perhaps in a similar manner to the central power plant dispatch models but using small power units as the generation sources. The benefits, operation and control of these systems is still unclear; indeed, there is not a generally accepted definition of a microgrid or a clear agreement on whether a definition is needed.

Apple or Microsoft?

Over the past year, there have been opportunities created for DER in California from high electricity costs and customers' reliability concerns. However, a robust DER market still has not developed. The DER industry is still in an embryonic phase. As Scott Castelaz stated during the August 28 workshop, "The stage this industry is in right now is similar to the computer industry in the early 1980s and we are just being exposed to this industry's VisiCalc." In addition, the long-term success of DER will rely on relationships and interactions between suppliers, operators and customers that are highly integrated. This may require major changes in a regulated industry that, by its nature, is slow to change and embrace major innovations. Given this uncertainty, it is still too early to tell which business models will ultimately be successful. However, the lack of a clear successful business model:

- prevents significant private industry investment,
- obscures a clear path for technology development,
- and creates difficulty in understanding and prioritizing necessary regulatory changes

Breaking DER out of this cycle may be possible by developing and analyzing several business models and encouraging the most attractive from a public policy perspective. Developing these business models would require answering the following questions:

What is the role of the utilities – active participant or innocent bystander?

- Should DER be controlled centrally or locally?
- How does DER create value for the power system? How is DER compensated for that value?
- What does the customer value? How is DER providing that value? How is the customer paying for that value?
- How is risk allocated in this business model?

It's the Policy, Stupid!

It is clear that regulatory and policy developments are as important as technology development in the area of DER. Some in the industry believe that most of the technology required can be "pulled off the shelf" and the challenge is more technology integration and policy debates rather than technology development. Of course, many more, while agreeing that regulatory and policy developments are critical, would point out that there is still technology research, development and demonstration that needs to be carried out.

Without a clear understanding of the possible business models and the stakeholder benefits derived from each business model, it is difficult to understand what long-term policy/regulatory changes are required and should be encouraged. However, changes in regulations that allow DER to compete on a more level playing field would probably create short-term opportunities for DER.

Integration/Optimization/Operation

DER integration, optimization and operation are vital to realizing extensive penetration. However, understanding the requirements for integration, optimization and operation may not be possible until a clear business model emerges. For example, the requirements for the DER communications systems for operation vary by the amount of information that must be transferred, the timing of the information and control needs, and the entities that require the information and control functions.

Priorities for Public Funding

The priorities for public funding of DER technology development should be driven by where there are significant gaps in the strategies and where it is appropriate for public funding to be invested. The appropriateness of a given strategy for public funding is driven by its stage of technology development and its competitive impact (Figure 73). The following strategies are most appropriate for public funding of technology development:

- Those in the base technology area, as these do not provide any one company with a competitive advantage; and emerging and some pacing technologies, as it is still too early to tell if they are a source of competitive advantage and more likely to need public funding to remove these uncertainties.
- Strategies in the research, development, and demonstration phases of the technology development chain; the commercial area should be avoided unless special circumstances exist where private funding is constrained.
- Strategies that involve technology rather than policy development and strategies that require collaborative efforts.

The gap analysis revealed strategies with significant gaps in each of the three areas of analysis: interconnection, grid effects, and market integration (Figure 74). These strategies all offer a program such as California Energy Commission PIER Strategic opportunities to make a significant impact in areas that have not been explored in great detail thus far.

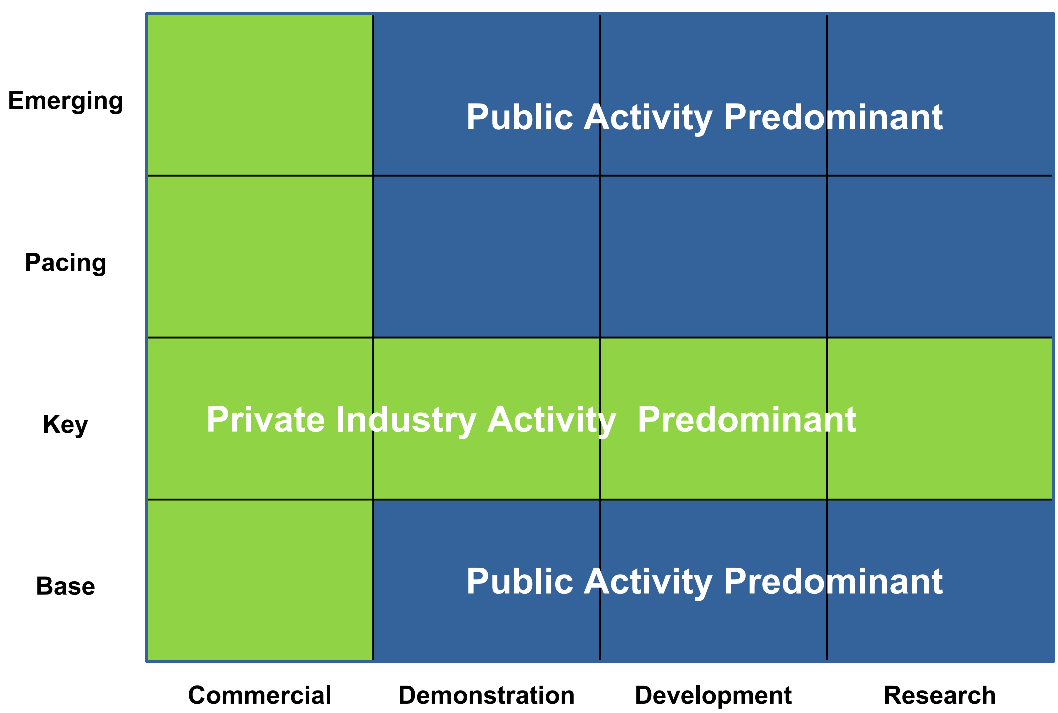


Figure 73: Public versus Private Funding

Strategies

Interconnection

- (2) Understand impact of and adopt new interconnection requirement
- (4) Initiate type-testing and certification of interconnection solutions
- (5) Develop guidelines and best practices for interconnection
- (7) Educate stakeholders on new requirements, contracts and processes

Grid Effects

- △2 Demonstrate and test varying levels of DER penetration in a distribution system
- △8 Demonstrate and test microgrids

Market Integration

- ◇1 Assess current wholesale market rules for applicability to DER
- ◇2 Modify market rules as appropriate to reduce the participation costs (fees, metering, process) for DER
- ◇3 Reduce costs by creating critical mass through a demonstration program
- ◇5 Assess requirements for tariffs or rates
- ◇6 Develop market mechanisms to capture and monetize additional DER benefits (e.g., T&D, reliability, environmental, CHP, etc.)
- ◇7 Launch a new market for DER that captures all value generated
  a. Start from scratch, develop the best market structure for DER now and in the future
- ◇13 Develop standards/protocols for communications/control

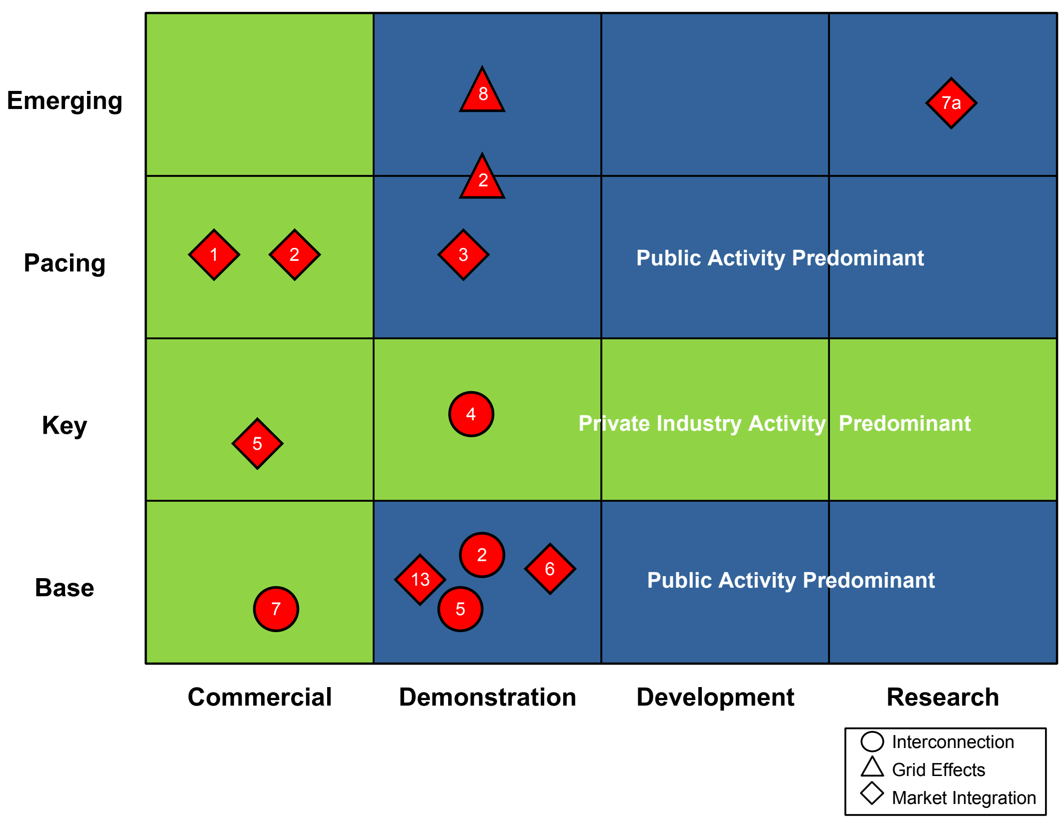


Figure 74: Strategies with Significant Gaps

Interconnection

Interconnection strategies with significant gaps are found in the *Standardization and adoption of new requirements and processes* thrust. There is general consensus that there is a need to support the adoption of new interconnection requirements by industry, customers and utilities. Specifically, these strategies are:

- Understand impact of and adopt new interconnection requirement
- Initiate type-testing and certification of interconnection solutions
- Develop guidelines and best practices for interconnection
- Educate stakeholders on new requirements, contracts and processes

All of these strategies are in the demonstration phase, with the exception of educating stakeholders. With the exception of type-testing, they are all base technology strategies. Type-testing and certification would provide competitive advantage to individual companies, particularly in the short run, as some companies have type tested and/or certified products and others do not. However, there is a collaborative aspect of doing type-testing and certification that would be appropriate for public funding. For example, a publicly funded lab or government agency could run the type-testing and certification labs and activities. Public funding could also be used to analyze and develop approaches for type-testing and certification.

Grid Effects

Two strategies in the grid effects area present significant gaps:

- Demonstrate and test varying levels of DER penetration in a distribution system
- Demonstrate and test microgrids

Modeling and analysis of DER's effect on the grid is already under way, but demonstrating and testing DER in a distribution system has barely begun. Unless the benefits and impacts of high degrees of DER penetration are understood through real- world demonstration and testing, concerns may not be credibly addressed and modification of distribution system design approaches cannot begin. It was the consensus during the workshop that this area would provide the greatest leverage to the ultimate success of DER. While microgrids have received increased attention of late, much of that work has focused on modeling and analysis. Without demonstrating and testing microgrids, potential stakeholders cannot begin to develop and design guidelines for their operation and understand their value. Both these emerging technology strategies are in the demonstration stage and may well require a collaborative element, making them candidates for public funding.

Market Integration

There are significant gaps in strategies in the three market integration thrusts. The strategies with significant gaps in the *Current Market* thrust are:

- Assess current wholesale market rules for applicability to DER
- Modify market rules as appropriate to reduce participation costs (fees, metering, process) for DER
- Reduce costs by creating critical mass through a demonstration program

- Assess requirements for tariffs or rates
- Develop market mechanisms to capture and monetize additional DER benefits (e.g., T&D, reliability, environmental, CHP, etc.)

Significant work is needed to alter current markets to accommodate DER participation. The first steps are to assess current wholesale market rules and then modify these rules and possibly tariffs and rates as well. After these steps are complete development of market mechanisms to capture the unique benefits provided by various forms of DER can begin to take place. Most of these strategies are in the commercial stage of technology development, with responsibility for pursuing them falling primarily on regulatory bodies. Therefore, they could not be a prime focus for public technology development funding. However, there might be a research component to understanding how market rules, tariffs and rates ought to be modified. This effort could be done in a collaborative manner supported by public R&D funding. There is also research and analytical work required on DER benefits to better understand their value and how they might be captured. This strategy is a base/demonstration strategy, making it well-suited for public funding. A large-scale demonstration program can help validate concepts and benefits in parallel with the development of new rules and market mechanisms. This demonstration program may also serve to jumpstart the market for DER in California; however, it is a pacing strategy where the ultimate competitive impact is still unknown.

There was one strategy with a significant gap in the Advanced Market Concepts *thrust:*

Launch a new market for DER that captures all value generated – start from scratch, develop the best market structure for DER now and in the future

Ultimately, launching a new market would require regulatory and perhaps legislative action. However, before this market is even piloted, there is a lot of research and analytical work that would need to be done in a collaborative fashion. The ultimate competitive impact of this research is still uncertain, making it an excellent area for public funding.

There was one strategy with a significant gap in the Enabling Technologies *thrust:*

Develop standards/protocols for communications/control

Creating standards and protocols for communication and control equipment is essential to integrating DER into the current power markets as well as creating opportunities in new markets. This strategy is base, not providing any competitive advantage. It would also require a collaborative effort, making it a good opportunity for public funding.

This report provides an understanding of where there are current gaps in technology development and provides a basic prioritization of these gaps for public funding. However, the ultimate public funding will also be driven by the funding agency's objectives, budget, timing for results, and overall portfolio balancing.

Appendix I: 8/28/01 Workshop — Current World Session Comments

Interconnection

1. S.C. Bhatt (EPRI): Problem is integration ($600K project for testing underway). There are different perspectives and priorities.

2. Joe Iannucci (Distributed Utility Associates):

a) Operational issues: when, where, how?

b) Planning methods

c) Benefits maximization

d) Storage (dispatch strategy)

3. Ross Fernandes (Southern California Edison): Integration and dispersed storage

-Reliability

-Response Characteristics

-Impact on transmission

4. Rita Norton (SVMG): Increase stakeholder involvement. Get institutional representatives to review and assist with barriers. Engage institutional barrier representatives as stakeholders in standards development.

5. Dan Rastler (EPRI):

-How much DER is considered substantial? Are we talking Gigawatts? 20 percent of total generating capacity? The quantity in question will drive the nature of projects.

-What is the time horizon? 5-10 years or 10-20 years?

-Defining these items will help in prioritizing strategies

6. Richard Ely (ADM Associates): Top-down approach is being assumed. Assume distributed control. If islanding is considered part of the system, the whole approach would change. That would be a real game changer.

7. Edan Prabhu (Reflective Energies): Look at the fuels. What are the benefits and downsides?

8. Chris Marnay (Berkeley Lab): CHP technology and societal benefits need to be made more explicit. Integrate CHP concerns into system design.

9. Fred Schwartz (AFS Trinity): Distinguish between utility grade interconnection and industrial grade interconnection for low-cost interconnect.

10. Richard Ely (ADM Associates): Plugging in a generator should be more economical than a load of the same size.

11. Susan Gardner (ABB): Economics make things difficult. California is subsidizing the utilities right now so the market is not equal. A level playing field is needed.

Grid Impacts

1. Ted Bronson (GTI): Can we quantify the benefits to the grid?

2. Ed Vine (GIC/CIEE): Why not do a bottoms-up analysis to see what customers want and penetration?

3. Robert Wichert (US Fuel Cell Council): Do site-specific studies rather than generic, unnecessary ones.

4. Joe Iannucci (Distributed Utility Associates): How do these things interact in real-time? Is there a limit to the amount o DG on the grid? Maybe 30 percent? Dynamic versus a static answer.

5. Jim Skeen (SMUD): More tools to assess modeling impacts are needed…for many sources rather than just 1 or 2.

6. Rita Norton (SVMG): Forecast for the grid after 10-20 years to address meeting demand of the future.

7. Chris Marnay (Berkeley Lab): Think of a more decentralized power system. Can the power system or the expansion thereof be built around microgrids?

8. Gary Nakarado (NREL): There is a status quo bias where the utility decides. Politics need to be discussed to find out what is in the public interest.

9. Mike Iammarino (San Diego Gas and Electric): Not enough test information is available on the interaction between the power system and DER.

10. Catherine Mohr (Aerovironment): The effect of storage on grid impacts is significant.

Market Integration

1. Name Not Available: Timeline for role and purpose of grid (to see how its role changes)

2. Rita Norton (SVMG): High reliability requirements

-Can that be reflected?

-Market integration would be where it belongs

3. Dave Hawkins (CAISO): Dispatching for environmental reasons

-market credits

-look at it from an environmental perspective

4. Ron Hoffman (RHC): Baselining the system below substation to understand what is the market. With baseline, the benefits can then be calculated.

5. Bob Yinger (Southern California Edison): What does the customer want? CHP? Premium power? At what price?

6. Richard Ely (ADM Associates): Look at where the risk flows

-Risk assignment

-Risk analysis in strategic planning

-Storage as a buffer, particularly for wind and solar (CA is encouraging more renewables)

7. Name Not Available: Look at storage as an enabling technology

8. David Hawkins (CAISO): A task force to look at market rules for intermittent power may be needed along with new tariffs.

9. Richard Ely (ADM Associates): Show stoppers are institutional in nature.

10. Dan Rastler (EPRI): A pilot program for market participation may be helpful to develop market participation mechanisms

11. Name Not Available: Examine power quality in the digital world.

12. S.C. Bhatt (EPRI): Resources are limited and those limitations will drive which items get addressed.

Appendix II: 8/28/01 Workshop — Top Game Changers

Group 1

Facilitator: Robert Shelton

Energy Internet (energy transactions)

Distributed control networks (autonomous control)

Ubiquitous plug and play DER (plug into grid)

Complete redesign of grid into bi-directional system

Real-time marginal pricing (location-based)

Energy star type compliance for DER (system level engineering)

Motor vehicles integrated into grid

10 percent DER portfolio mandate for California (10 percent of all power in CA must be from DER)

California Energy Commission support for pilot microgrid project

Large scale support for storage technologies

Group 2

Facilitators: Jose Luis Contreras / Warren Wang

Universal certification standards for interconnection and environmental performance

Address (ratify or reject) outstanding policy issues-(e.g., clarify rules for participation in DER markets)

DMV-like entity for home/small scale applications for DER (one-stop shopping for approval)

Streamline the regulatory process

Focused research on transition from centralized to decentralized power

Group 3

Facilitator: David Walls

Standardize interfaces of grid interconnection

R&D should be market value driven

- -based on real-time pricing
- -research on playing field: regulatory, economic, and environmental

R&D into distributed control across all levels such that it is less top-down (e.g., virtual grid)

Selling DG back to the balancing authority – services (ancillary, voltage support, etc.)

Other Ideas

More focus on cooling CHP

Focus on demonstrations and pilot programs

Create clear market penetration targets – geographic, timing, types, etc.

R&D into reliability and power quality in terms of customer needs, market value…etc.

Science of Demand Side Management (DSM)/ DG/ CHP – optimization at facility level

Group 4

Facilitator: Stanley Blazewicz

Moratorium on pollutants such as CO_2 (e.g., Kyoto Accord)

Digital society needs (e.g., power quality)

Assign dollar values to DER related items such as environmental impact, reliability, and cost

True real-time pricing

Pricing signals for reliability

Appendix III: 8/28/01 Workshop — Game Changer Group Notes

Group 1

Facilitator: Robert Shelton

Mental Models

Large scale

Revolutionary

Systemic

Out of box

Change of authority (control of power)

Necessary

Futuristic-forward looking fundamental shifts

Starts today ➜ Future impacts

Market enablers

Super fast-tracking

Disruptive

Leadership

Results-fast (Lower risk of R&D)

New direction of technology

New market structure

Bottom-up control instead of top-down

Paradigm shift

Brainstorming Ideas

Distributed generation requires decentralized utilities (control)

From aerobic to anaerobic (water management)

Energy Internet (energy transactions) financial, contractual

Islanding as an element of design (now anathema)

All regulated investments accomplished by outsourcing (market based or led)

Commissions understand benefits

Removing utility controls

Many networks-devices, informational

Distributed control networks (autonomous controls)

Intelligent devices

Choice vs. programs

Ubiquitous plug and play (plug into grid) DER

More information on devices (readiness, dispatchability, location, pedigree)

Intelligent cooperative power centers, internet model.

Redesign better bidirectional power system

Real-time marginal pricing

Integrated information flow bottom-up and top-down

Liability and risk management (change the model). Local Liability? Utilities not responsible for what is in the wires.

Telco analogy: separate content from wires

Individual responsibility

Highest EE end use responsibility (regulation); Mandated high efficiency standards; Ultra-low emissions; Environmentally friendly power sources; High quality power

Whole system engineering – Energy Star Distributed Power

Individual choice on all issues and responsibilities

All distribution systems totally automated

Equiv. of manufacturing plant

Motor vehicles integrated into grid

Proper large scale funding

Outside force that change energy supply (e.g., global warming)

Game changer that voids current contracts being signed

California Energy Commission mind-shift regarding DER leverage from Technology to Policy

Nationally coordinated agenda for DER

Completely redesigned infrastructure for bidirectional power flow

No new transmission lines

Avoiding transmission constraints through DER

Local retail wheeling

Develop one integrated standard for interconnect (national standard)

Different levels of performance based rate-making and give right to do it myself

Integrated aligned industry

Shift responsibility for power quality to customer (including choice)

Apply riparian rights to electricity

10 percent renewable DER portfolio mandate

Standardized air quality regulations throughout the state

Minimal performance levels (mandated)

Support pilot microgrids (California Energy Commission)

Include megawatts as DG (megawatt exchange or hub)

Mandated minimum criteria for DER

Large scale support for storage

Group 2

Facilitators: Jose Luis Contreras and Warren Wang

Desired Outcomes

Faster commercialization

No need to connect to utilities

Large percent of DG in the power generation mix

No additional money to operate the grid

Elimination of subsidies

Creation of market for DER power

Decentralization of control

Reduced environmental impacts

Plug and play interconnection

Increased penetration of renewables

Reduced costs

Logical ownership structure for generation

Mental Models

Grid infrastructure is based on central power

Siting and permitting issues (economics don't make sense)

Land use planning process

Economies of scale is important

Variations of environmental review based on the size of DER being installed

Electric system stability under four operating conditions: peak shaving, grid isolation, net exporter and merchant

In a free market, investors demand rapid return on investment, which may play against DER becoming more widespread

Customers are looking for simplicity and do not wish to become experts

Implementation of DER is not widespread

A community among DER electricity producers doesn't exist

Brainstorming Ideas

Remove the ability of companies to deduct gas and electricity expenses from federal and state taxes that are essentially acting as a subsidy

Pilot project with a participant in an area of California that is experiencing a lot of pain with a negative impact on small users nearby

Universal certification standards for interconnection and environmental performance

Penalty taxes for pollution that exceed acceptable levels

Common communication protocol

More market research to understand consumer preferences

Incentives for small commercial DER

Address (ratify or reject) outstanding policy issues-(e.g., clarify rules for participation in DER markets)

Streamline the regulatory process

Protect the ratepayer so they are not penalized for growth in DER resulting in a shrunken user base relying on traditional utility supplied power

Standardize the process of how standards are created

Transaction forum or market for DER power

Centralized monitoring with decentralized control

DMV-like entity for DER installation in homes and small scale use that offer one-stop approval

Look to Europe (e.g., Netherlands) for model of separation between distribution from generation

Public education program for those who wish to sell DER power and potential users

Focused research on the what is needed for a transition from centralized to decentralized power and identifying what are the consequences

Group 3

Facilitator: David Walls

Definition of Game Changer Idea

Free energy storage

Mother of invention

End run around obstacles

Fear and crisis (as an incentive)

New perspective-customer centric

Rethinking public utilities as primary source

Value proposition-quick return on investment

Cell phone-interconnection

PCs as an example

Blank paper-redesign of the power grid

Services for sale and customer choice vs. obligation to serve

Remove obstacle to goals (new strategies)

Mental Models

Utility-centric views

Standard view of DER as a problem, not as a benefit

Universal quality of service

Entrenched utility accounting system

Averaging of power prices, services, etc…

Working solution through reverse engineering

What is the grid?

What does it take to handle bi-directional power flow?

Status quo cost

Joint energy system optimization

Increased DER

Power “gridlock”-create controls

Public places for demonstrations (state facilities)

Brainstorming Ideas

Identify target goals for DER penetration around geography or time frame, custom types, etc.

Easy relocation of DER to optimize applications for industrial and society needs

DER selling service back to balancing authority (ancillary service, voltage support)

Research reliability and quality in terms of customers and markets

Research study on the "playing field" (we don't currently understand it): economic, regulatory, and environmental

Virtual grid-power generation, distribution without lines

Science of Demand Side Management/DER/CHP – all together

R&D becomes market-value driven and real-time pricing drives R&D needs

Integrate CHP into building design

DER is "parasitical" in society

More distributed control across all levels (less top-down control)

Standardization of macro/micro grid interconnection and standardize interfaces

Focus on demonstrations/pilots

Energy system optimization at the facility level

Energy system optimization at society level

Research into aggregation of unique customers as well as suppliers (e.g., wind, solar)

Virtual grid designs

Group 4

Facilitator: Stanley Blazewicz

Mental Models

Existing tariffs (fixed price/kWh) does not allow DG to be paid for real value

There are no existing tariffs for different levels of reliability

Ability to move/flexible reliability

Lack of grid flexibility and economic communications

Utilities not motivated for DER

Driven by kW passed through

Incentives counter to DER

In the driver's seat

Varied market-dynamic; technical (3rd World) vs. regulatory (U.S.)

Lack of cost-effective and environmentally benign DER

Lack of clean fuel infrastructure

Lack of good operational data to assess environment, economic benefit, and customer risk

Must consider systemic impacts (diesel trucks and diesel DG)

Separation of critical and non-critical loads + non-critical loads + communication system implications (can be interactive, real-time, etc.)

Existing power system problems may be short-lived and be resolved by solutions other than DER

Brainstorming Ideas

Digital society needs such as power quality

Monetize other DER values such as environmental impact, reliability and cost

Absolute deregulation with an open market where anyone can buy or sell – a free for all

Move to total system design and develop technologies to improve CHP and other waste heat recovery

Regulatory change and revised tariff to accommodate CHP

Address export power regulations

Develop DER that can determine all incentives and benefits based on location (zip code)-self optimization

BTU Bank – convert natural gas to electricity and electricity to e-storage (e.g., H_2)

Incentives and disincentives based on benefits achieved and impacts avoided

True real-time pricing

DER ISO

Pricing signals for reliability, T&D constraints, environmental incentives, T&D stability, and ancillary services

Lower grid reliability to minimum requirement and let customers that need high reliability pay for it

Moratorium on construction of central power plants >50 MW

Moratorium on pollutants such as CO_2 (e.g., Kyoto Accord)

Lots of cheap nuclear power ➜ need for storage

Development of clean fuel infrastructure (e.g., LNG, H_2)

Better understanding of power markets by customers and ease of participation

Help customers understand problems to be solved

Appendix IV: 8/28/01 Workshop — Panel Discussion Notes

Interconnection

Q: Is the 80/20 rule applicable to DER interconnection (i.e., 20 percent of effort yield 80 percent of returns)?
Joe Iannucci: (No) The answer would be "yes" if we knew what is the right area to research. But we've only seen the tip of the iceberg, so "no".

Tom Dossey: (No) I agree with Joe. Simple interconnection rules need to be built upon. Option of selling and exporting power needs to be expanded.

Scott Castelaz: (No) It is still early in the game, much like the transition from mainframe computers to PCs in 1982. Significant work needs to be done.

Wade Troxell: (No) DG is still flying blind. Information networks need to be developed.

Audience: Is standby power & price/reliability charges the correct path to take?

Joe Iannucci: It is too early and immature to tell.

Tom Dossey: Work is being done and utilities are balancing charges, but it is still early.

Q: What are the customers' biggest concerns involving interconnection?
Dan Rastler: 1) Customers are not educated and don't want to be bothered, 2) would like to see closure on IEEE standard development and 3) energy provider should take care of interconnection issue

Chris Marnay: Customers ask what are the benefits and at what cost

Joe Galdo: Unnecessary requirements and delays in processing request

Joe Iannucci: Environmental issues

Audience: Are standards ready to be applied in the field?

Dan Rastler: Yes, it's being done in field tests.

Tom Dossey: IEEE isn't ready, but efforts are underway using existing standards. The number of units out there is still not sufficient.

Audience: Are results good?

Tom Dossey: Minimum standards have been met.

Q: What are the next steps for California Energy Commission on standards?
Wade Troxell: Encourage market development. In a true market, customer oriented entities will provide products of great value.

Scott Castelaz: Create value, not so much a technology issue. California Energy Commission should focus on making things simpler.

Joe Galdo: Lots of testing and validation remains to be done; IEEE addressing networks in a minimal way and California Energy Commission may work on that a little more

Dan Rastler: Education for end users with a platform to inform stakeholders of good, bad and the ugly. Network Issues need to be addressed and R&D is needed.

Audience: Anything that California Energy Commission could do to encourage 1547 would be appreciated.

Audience: What about islands as a system of design?

Chris Marnay: More research into positives and negatives is still needed to understand how to deal with islands

Tom Dossey: We are putting together a microgrid at a university, but we'll need regulatory changes to go along with the technology.

Joe Iannucci: Islanding shows the good and bad side of DER, but no one is looking into the central station concept. We're not ready for beneficial islanding.

Chris Marnay: We need to make a system that makes sense from an EE perspective and prevent unintentional islanding.

Q: How effective are strategies to reduce costs? How should California Energy Commission participate?
Wade Troxell: Benefits and costs become clear from large projects…perhaps a large scale pilot involving 1,000 to 1,500 units would reveal true benefits.

Joe Galdo: Long term approach would help guide California Energy Commission.

Dan Rastler: There's a lot of work from large companies, but the California Energy Commission could help sponsor a pilot to drive a large-scale project.

Joe Iannucci: The free market will take care of hardware development.

Dan Rastler: Type testing is still needed.

Audience:

-No one can optimize the grid properly right now.

-Pilot testing in a field experiment involving transitional controls is needed.

-Look to off-shore rigs and military DER that may provide insights into civilian DER.

-If pilot projects go through RFP, they may not be responsive to customer needs. Establish entity that provides monetary resources to customers to expand DER usage.

Grid Effects

Q: What is the next logical step for microgrids?

Tom Dossey: We utilities have not used DER significantly, but we're doing research in microgrids with UCI. Regulatory issues become complicated when there are multiple end user entities on a microgrid.

Scott Castelaz: Some universities and mining operations are already like small grids; pilot testing is needed

Dan Rastler: We're trying to understand microgrids and how it complements the existing infrastructure. We need to see if it could it be a new model to serve the digital economy. Getting a coordinated effort together is a major gap.

Chris Marnay: Existing demonstrations are built on local needs. Look at the fundamental economics of what a microgrid is. Lots of projects in microgrids are trying to meet local needs. Microgrids are very appropriate candidates for California Energy Commission assistance. CHP is a key economic driver. Look at the social science aspect such as noise pollution (not found in draft report).

Audience: Impacts have negative bias. Begin to define where the benefits are.

Joe Iannucci: We don't have good models and data for benefits. Don't call them impact or benefits, but call it effects.

Wade Troxell: More system modeling on intelligent grid is needed.

Tom Dossey: We must distinguish between premium power vs. cobbling together some DER (grid effects)

Joe Iannucci: Of course there are benefits, but more modeling and data is needed.

Audience:

-Wind power and storage cannot be ignored.

-There is an interest in high quality, inexpensive power with low environmental impact, so multiple pilot studies will be helpful.

Q: If California Energy Commission could only fund grid impacts, where would you put your money?
Scott-Have to home in on what Chris said earlier about microgrids.

Audience: Microgrids vary dramatically, so categorizing them or defining them is meaningless.

Q: Are there any missing gaps?
Tom Dossey: I tend to be more in favor of education and consumer advocacy.

Q: What is the role of a distribution company?
Tom Dossey: Anything and everything…particularly a facilitation role.

Joe Iannucci: DUIT is trying to answer a lot of these questions of diverse DER interacting with each other and the grid.

Joe Galdo: There isn't one distribution system out there…testing and validation is needed.

Audience: Power quality should be examined.

Joe Iannucci: We are doing it in DUIT.

Audience: Congestion doesn't seem to have been a focus so far.

Stan: It is addressed in market integration, but perhaps we may also include it in the grid impact section.

Market Integration

Q: Grid side benefits are:
a) a red herring
b) limited to exceptions
c) substantial

d) none of the above
Wade Troxell: c) substantial; grid constraints can be significantly reduced with DER; DER fundamentally enhances the grid

Joe Galdo: potentially substantial benefits since there are still many if's…may require grid redesign

Scott Castelaz: potentially substantial benefits; many things need to be addressed

Q: Are grid side benefits
a) difficult to monetize and not worth the effort
b) impossible to monetize and not worth the effort
c) difficult to monetize but critical to DERs success
d) none of the above

Dan Rastler: They are difficult to monetize but critical to DER's success. One utility is trying to quantify the benefits. Small gas turbine supporting transmission might be appropriate.

Tom Dossey: Gas turbines can be a temporary solution. Some may not define 20 MW as DER.

Chris Marnay: Installation of microgrids will reveal the benefits. The benefits are found where the system is growing. Microgrids make you think about both sides of the coin.

Joe Iannucci: Grid-side benefits are exceptions but frequently occur. Portability and storage are some benefits.

Audience: Has DG been targeted geographically in CA?

Chris Marnay: GIS is perfect for this and identify where benefits can be found

Joe Iannucci: You need to know where you're overbuilt; uncertainty of the growth

Audience: Isolated load centers such as SF would be very interested.

Audience: Central Business Districts (CBDs) have generally been excluded from DG benefits.

Dan Rastler: Networks in these areas are prevented from 2-way power flow and are barriers to DER adoption.

Audience: We need to understand the time and location impact of power quality and outage.

Audience: Grid regulations could be modified to allow for better DER participation

Q: How important is it for DER to participate in wholesale power markets?
Chris Marnay: CA has bracketed the problem, small DER's low voltages won't make them effective in the bulk power markets (skeptical)

Joe Iannucci: Less skeptical than Chris; people will sell their excess power if they can

Wade Troxell: Part load curtailment and part export is being done.

Chris Marnay: Autonomous agents modeling could be an opportunity.

Q: How important are the enabling technologies? Are they appropriate for public funding?
Scott Castelaz: Collaboration and competition is good. These technologies are important.

Wade Troxell: This is a critical area. There can be a large number of participants. Costs will be driven down. Large-scale demonstration effort is recommended.

Tom Dossey: Communication and monitoring is needed if DER is going to be significant.

Wade Troxell: Intelligent equipment allow for less scaling needs at control points. It's an application but not demonstrated on a large scale.

Audience:

-How we put together the building blocks is a key area to explore. It's the application of existing technology.

-California is behind in DER because it has too much regulation.

Q: Where do you think the California Energy Commission should play a role in market integration?
Dan Rastler: Creating a platform where market integration is core…maybe a pilot for how DER participates in the market. One on one customer programs.

Joe Galdo: I agree with the draft report chart for this area in terms of where California Energy Commission can play a role; an assessment of tariffs and rates is also needed

Chris Marnay: Environmental questions haven't come up much.

Audience: consumption of methane should be considered

Joe Iannucci: I need to know where the playing field is in economic, environmental, and regulatory terms.

Wade Troxell: Its an informational network…control at the unit and global/aggregated level are all issues

General Questions

Q: What can be done to make working with the California Energy Commission more attractive?
General response: This is a tough question to answer.

Q: What should be the priorities for the California Energy Commission?
Scott Castelaz: 1) Regulatory process, 2) protocols for aggregating and communicating with ISO, 3) field testing 1547, 4) heterogeneity of microgrids

Joe Iannucci: 1) Sharpen the concept of benefits and quantify them, 2) leveling the playing field, 3) play a leadership role and leverage it to get more partners

Joe Galdo: 1) support implementation of IEEE interconnection standard, 2) look at tariffs and rules to get benefits back to owners of DG, 3) playing field: what does it look like

Chris Marnay: 1) find the benefits, 2) testing (e.g., environmental impacts), 3) CHP and control system

Wade Troxell: 1) value-stream identification and measurement technologies, 2) smart communication and interface, 3) large-scale pilot demonstration

Tom Dossey: consumer incentives and education

Dan Rastler: 1) applications (T&D grid support, CHP premium power), 2) CHP, 3) premium power; California Energy Commission should integrate programs with national coordinated activities

Audience:

-Talk about premium power suggests that some people will get low quality power.

-Hands-on field testing for DG impacts to validate models.

-Become as coupled as possible with consumer-based efforts by assisting with engineering or $

-Support use of DG that doesn't qualify on a commercial basis

-Support IEEE 1547 as CA standard

-Improve understanding of benefits from location and availability based on pilot.

-Continue support for technology development

-Increase funding support.

-Support enabling technologies, including storage.

Appendix V: 8 /28/01 Workshop Attendees

Name	Company / Affiliation	Telephone	Mailing Address	Email Address
Sue Scott	ABB	562-716-7765	7067 Skyline Blvd. Oakland, CA 94611	sue.scott@us.abb.com
Robert Anderson	ABB	510-982-4503	101 Myrtle St. Oakland, CA 94602	robert.w.anderson@us.abb.com
Susan Gardner	ABB-Catalyst Power	760-431-5159	2131 Palomar Airport #300, Carlsbad, CA 92009	sgardner@catalystpower.com
Alec Brooks	AC Propulsion	909-592-5599	441 Borrego Ct. San Dimas, CA 91773	abrooks@acpropulsion.com
Richard Ely	ADM Associates	916-363-8383	3239 Ramos Circle, Davis CA 95827	dick@davis.com
Adam Szczepaneu	Aerovironment	626-357-9983 ext. 505	825 S. Myrtle Ave. Monrovia, CA 91016	szczepaneu@aerovironment.com
Catherine Mohr	Aerovironment	626-357-9983 ext. 351	825 S. Myrtle Ave. Monrovia, CA 91016	mohr@aerovironment.com
Charlie Botsford	Aerovironment		825 S. Myrtle Ave. Monrovia, CA 91016	botsford@aerovironment.com
Fred Schwartz	AFS Trinity	415-499-1589		fschwartz@afstrinitypower.com
Angela Chuang	ALSTOM ESCA	408-467-3152	226 Airport Pkwy Suite 250 San Jose, CA 95110	angela.chuang@esca.com
George Williams	ASCO	209-472-7186 ext. 217	2291 W. March Lane, Suite A200, Stockton, CA 95207	gwilliams@asco.com
Chris Marnay	Berkeley Lab	510-486-7028	90-4000 1 Cyclotron Road Berkeley, CA 94720-8061	c.marnay@lbl.gov
David Hawkins	CAISO	916-351-4465		dhawkins@caiso.com
Bob Andvuszkienicz	CalEnergy.org	831-426-9431	738 Chestnut St. Santa Cruz, CA 95060	bob@calenergy.org
Scott Cronk	CalEnergy.org	707-546-6919	P.O. Box 4352, Santa Rosa, CA 95402	scott@calenergy.org
David Chambers	CEC	916-650-7067	1516 9th St. Sacramento, CA 95814	dchambers@energy.state.ca.us
Joseph Diamond	CEC	916-654-3877	1516 9th St. MS 40 Sacramento, CA 95814	jdiamond@energy.state.ca.us
Scott Tomashefsky	CEC	916-654-4896	1516 9th St. MS 31 Sacramento, CA 95814	stomashe@energy.state.ca.us
Jairam Gopal	CEC	916-654-4880	1516 9th St. MS 23 Sacramento, CA 95814	jgopal@energy.state.ca.us
Jamie Patterson	CEC	916-657-4819	1516 9th St. Sacramento, CA 95814	jpatterson@energy.state.ca.us
Mignon Marks	CEC	916-654-4732	1516 9th St. MS 31 Sacramento, CA 95814	mmarks@energy.state.ca.us
Kirm Avery	Chevron	925-842-5489	6001 Bollinger Canyon Road San Ramon, CA 94580	kmav@chevron.com
Scott Edwards	Chevron USA	925-892-5867		sedw@chevron.com
John Dutcher	Consultant	707-421-8411	3210 Corte Valencia Fairfield, CA 94533	ralf24la@cs.com
Kirk Bracht	CPUC	415-355-5556	505 Van Ness Avenue San Francisco, CA 94102	kwb@cpuc.ca.gov
John Galloway	CPUC	415-703-2565	505 Van Ness Avenue #4A San Francisco, CA 94102	jhg@cpuc.ca.gov
Anthony Mazy	CPUC/ORA	415-703-3036	505 Van Ness Avenue San Francisco, CA 94102	amazy@cpuc.ca.gov
Don Smith	CPUC/ORA		505 Van Ness Avenue San Francisco, CA 94102	dsh@cpuc.ca.gov
Joe Iannucci	Distributed Utility Associates	925-447-0624	1062 Concannon Blvd. Livermore, CA 94550	joe@dua1.com
Joe Galdo	DOE	202-586-0518	1000 Independence Ave. SW Washington, D.C. 20024	joseph.galdo@hq.doe.gov
Scott Castelaz	Encorp	312-925-2277	1512 S. Prairie Ave. Unit F Chicago, IL 60605	scott.castelaz@encorp.com
Chuck Whitaker	Endecon Engineering	925-552-1330	347 Norris Ct. San Ramon, CA 94583	chuckw@endecon.com
Keith Davidson	Energy Nexus Group	760-710-1712	701 Palomar Airport Rd. Suite 200 Carlsbad, CA 92009	kdavidson@energynexusgroup.com
Herman P. Miller	Environmental Developers	209-948-3111	P.O. Box 1769 Stockton, CA 95201	
Maria Miller	Environmental Developers	209-948-3111	P.O. Box 1769 Stockton, CA 95201	
S.C. Bhatt	EPRI	650-855-8751	3412 Hillview Ave. Palo Alto, CA 94303	sbhatt@epri.com
Tom Boyd	EPRI	704-547-6033	1300 Harris Blvd. Charlotte, NC 28031	tboyd@epri.com
Tom Key	EPRI PEAC	865-218-8082	16600 Summit Ct. Knoxville, TN	tkey@epri-peac.com
Dan Rastler	EPRISolutions	650-855-2524	3412 Hillview Avenue Palo Alto, CA 94304	drastler@epri.com
David Packard	EVI	530-823-8077	11839 Industrial Ct. Auburn, CA 95603	dpackard@evii.com
Jan McFarland	Fairhaven Institute	443-336-1402	P.O. Box 26 Tracys Landing, MD 20779	jmcfarland@att.net
Frank Lambert	Georgia Tech/NEETRAC	404-675-1855	62 Lake Mirror Road Forest Park, GA 30297	flambert@ece.gatech.edu
Ed Vine	GIC/CIEE	510-486-6047	c/o LBNL, Building 90-2000 Berkeley, CA 94720	edward.vine@ucop.edu
Cecilia Arzbaecher	Global Energy Partner	916-731-5948	2500 5th Avenue Sacramento, CA 95818	carzbaecher@gepllc.om
Ted Bronson	GTI	847-768-0637	1700 South Mount Prospect Road Des Plaines, IL 60018-1804	ted.bronson@gastechnology.org
Howard G. Carpenter	Kite Electricy Development Co.	209-957-9282	9667 Kelley Dr. #13 Stockton, CA 95207	hkgc2@hotmail.com
Alan Lamont	LLNL	925-423-2575	Box 808 Livermore, CA 94550	lamont1@llnl.gov
Peter James	Loop Center	530-824-1477	4530 Alfareta Ln. Corning, CA	peterjames8@hotmail.com
Mike Merlo	Mesa Verde	714-840-9947	3712 Aquarius St. Huntington Beach, CA 92649	mmerlo@mesaverdeassoc.com
Gary Nakarado	NREL	303-275-3719	NREL 1517 Cole Blvd. Golden, CO 80401	gary_nakarado@nrel.gov
Jim Perkowski	NREL	303-384-7524	NREL 1517 Cole Blvd. Golden, CO 80401	joe_perkowski@nrel.gov
Crisman Cooley	Overdomain, LLC	805-683-0938	599 Via El Cuandro, Santa Barbara, CA 93111	ccooley@overdomain.com
Jeff Deal	PG&E	916-386-5100	5555 Florin Park, Sacramento CA 95628	jld4@pge.com
Dylan Savidge	PG&E	415-973-2628	Mail Code B8M P.O. Box 770000 San Francisco, CA 94107	dxsg@pge.com
Eric Stroh	Power Measurement	661-733-0400	27637 Woodfield Pl. Valencia, CA 91354	eric_stroh@pml.com
Bill Westbrock	Power Measurement	415-457-9040	1099 D St. #208 San Rafael, CA 94901	bill_westbrock@pml.com
Linda Mott-Jones	RCRC	916-447-4806	801 12th St., Sacramento, CA 95814	lindam@rcrcnet.org
Edan Prabhu	Reflective Energies	949-380-4899	22922 Tiagua, Mission Viejo, CA 92692	edanprabhu@home.com
Ron Hofmann	RHC	510-547-0375	847 Mountain Blvd. Oakland, CA 94611	caron10@aol.com
Rita Norton	Rita Norton & Associates (representing SVMG)	408-354-5220	18700 Blythswood Drive, Los Gatos, CA 95030	Rita@ritanortonconsulting.com

Name	Company / Affiliation	Telephone	Mailing Address	Email Address
David Rohy	Rohy Consulting	619-461-7547	8639 Warmwell Dr. San Diego, CA 92119	rohy@cts.com
Tom Bialek	San Diego Gas and Electric	858-654-5795	9316 Century Park Ct., CPSZE San Diego, CA 92123	tbialek@sdge.com
Mike Iammarino	San Diego Gas and Electric	858-850-6166		miammarino@sdge.com
Kevin Spinks	San Jose Airport	408-501-7729	1732 N. First St. Suite 600 San Jose, CA 95112	kspinks@sjc.org
Max Takaki	San Jose Airport	408-501-0467	1732 N. First St. Suite 600 San Jose, CA 95112	mtakaki@sjc.org
Gerome Torribio	SCE	626-302-9669	2244 Walnut Grove Rosemead, CA 91770	torribgg@sce.com
Marianne Walpert	Schott Applied Power Corp.	650-592-7772	2819 San Ardo Way, Belmont CA 94002	mwalpert@schottappliedpower.com
Mary Turley	Sempra Energy	619-696-4298	101 Ash St. San Diego, CA 92101	mturley@sempra.com
Robert Shelnutt	Shasta College	530-245-7362	11555 Old Oregon Trail Redding, CA 96049	bshelnutt@shastacollege.edu
Linda Kehoe	Shasta College-Economic Development	530-225-3965	115 Old Oregon Trail Redding, CA 96059	lkehoe@shastacollege.edu
Chris Forbes	Siemens Westinghouse	412-256-2022	1310 Beulah Rd. Pittsburgh, PA 15235	christian.forbes@swpc.siemens.com
Wade Troxell	Sixth Dimension, Inc.	970-267-2021	1201 Oakridge Drive Suite 300 Fort Collins, CO 80525	wade@6d.com
Bud Beebe	SMUD			bbeebe@smud.org
Jim Skeen	SMUD	916-732-5305	Box 1850 Sacramento	jskeen@smud.org
Henry Mak	SoCal Gas	213-244-5323	P.O. Box 513249 GTI5E3 Los Angeles, CA 90051-1249	hmak@socalgas.com
Scott Lacy	Southern California Edison	909-357-6589	7951 Redwood Ave. Fontana, CA 92336	lacysr@sce.com
Bob Yinger	Southern California Edison	626-302-8952	P.O. Box 800 Rosemead, CA 91770	robert.yinger@sce.com
Ross A. Fernandes	Southern California Edison	626-302-8607	2244 Walnut Grove Rosemead, CA 91770	ross.fernandes@sce.com
Tom Dossey	Southern California Edison	626-302-8242		dosseyt@sce.com
Rick Martin	Thomson Technology, Inc.	888-888-0110	9087A 94th Ave. Langley, BC, Canada	rmartin@thomsontechnology.com
Rob Williams	UC Davis	530-752-6623	Dept. Bio & Agr. Engineering, University of California 1 Shields Ave. Davis, CA 95616	lbwilliams@ucdavis.edu
Bryan Jenkins	UC Davis	530-752-1422	Dept. Bio & Agr. Engineering, University of California 1 Shields Ave. Davis, CA 95616	bmjenkins@ucdavis.edu
Robert Wichert	US Fuel Cell Council	916-966-9060	P.O. Box 117 Citrus Heights, CA 95621	wichert@fuelcells.com

Appendix VI: Contact Information from Literature Search and Interviews

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
ABB	Jaime Trevino; Tim La Berteaux	Trevino: Electric Systems Technology Inst.; La Berteaux: Distributed Generation Manager ABB Power T&D Company		1021 Main Campus Dr. Raleigh, NC 27606	Trevino: 919-856-3851 La Berteaux: 919-856-2330	Large supplier of an array of DG equipment ranging from basic interconnect components to technology that allows for the connection and control of a range of power units to the grid at a single point, incorporating a web server and IT.
AeroVironment				1610 s. Magnolia Dr. Monrovia, CA 91016	Tel: 626-357-9983 Fax: 626-359-9628	Produces control systems such as iPower which combines electronic power conversion with intelligent control systems.
Alpha Power Systems	Dana Sears	Vice President-Engineering and Sales	alphapower@earthlink.net	8626 Xyllon Court North, Suite 101 Minneapolis, MN 55445	763-315-1899	Paralleling switchgear, engine controls, remote monitoring and control of multiple sites from a single remote location. DG product - Dispersed Generation Paralleling Switchgear-(DGPS)
Alternative Energy Systems Consulting, Inc. (AESC)	Gerald L. Gibson; Ronald Ishii	Vice Presidents (both)		Gibson: 4715 Viewridge Avenue, Suite 200, San Diego, CA 92123; Ishii: 1945 Camino Vida Roble, Suite A, Carlsbad, CA 92008	Gibson: 858-560-7182; Ishii: 760-931-0517	AESC is active in intelligent software agents and is working with Reticular Systems to identify utility industry applications.
American Wind Energy Association (AWEA)	Jim Caldwell	Policy Director	jcaldwell@awea.org	122 C Street, NW, Suite 380 Washington, DC 20001	General line: 202-383-2500	Involved in various efforts using wind technology, primarily small wind and distributed wind.
Apogee Interactive	Joel Gilbert	CEO		2100 East Exchange Place Tucker, Georgia 30084	770-270-6504	Apogee produces peak load management software (The Demand Exchange), ebusiness solutions and business simulation software.
ASCO (Automatic Switch Co.)	George L. Williams	Marketing Manager Western Region Distributed Power	gwilliams@asco.com	2291 W. March Lane, Suite A200, Stockton, CA 95207	Tel: 209-472-7186 ext. 217; Fax: 209-472-1389	ASCO manufactures power control system, communication and transfer switches for critical power, peak shaving, utility interconnection.
California Independent System Operator (Cal ISO)	John Counsil; Dave Hawkin	Counsil: Senior Contract Analyst/ Engineer; Hawkin: Operations	jcounsil@caiso.com, dave.hawkins@gov.ca.gov	151 Blue Ravine Road, Folsom, CA 95630	Counsil: Tel: 916-608-5921; Fax: 916-351-2487	The ISO has received proposals from some entities that desire to implement and evaluate DER on a pilot project basis.
Cannon Technologies	Joe Cannon	Vice President	joel@cannontech.com	1212 East Wayzata Blvd. Wayzata, MN 55391	800-827-7966	Offers control and metering technology applicable to distributed generation.
Capstone Turbine Corp.	Joel Wacknov	Vice President-Power Electronics	jwacknov@capstoneturbine.com	21211 Nordhoff St. Chatsworth, CA 91311	Tel: 818-734-5549; Fax: 818-734-5382	Manufacturer of microturbines and related control technology
Celerity	Brad Hodges	V.P. and Project Manager	bhodges@celerityenergy.com		505-797-3408	Network Distributed Resource (NDR) Proprietary technology which provides synchronization, control, protection and power monitoring for DG

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
CERTS-Lawrence Berkeley Laboratory	Joe Eto; Chris Marnay		jheto@lbl.gov, c_marnay@lbl.gov	Lawrence Berkeley National Laboratory 1 Cyclotron Road, MS 90-4000 Berkeley, CA 94720	Tel: Eto 510-486-7284, Marnay 510-486-7028; Fax: 510-486-6996	The LBL maily focuses on the customer adoption of microgrids. Current research is focused on modeling more complex integrated microgrid scenarios and determining locations for the field testing of microgrids.
CERTS-non-LBL	Robert Lasseter; Robert Yinger; Abbas Akhil; Jeff Dagle; Sachis Meliopolos	Lasseter: Univ. Wisconsin, Yinger: SoCal Edison, Akhil: Sandia National Labs, Dagle: Pacific NW Lab, Meliopolos: Georgia Tech			Lasseter: 608-262-0186,Yinger: 626-302-8208, Akhil: 505-844-7308, Dagle: 509.375.3629, Meliopolos	CERTS organizes its research activities under four major areas to improve reliability, power quality, and other power needs. One major focus is the development of the microgrid. - Reliability Technologies and Issues for the energy grid of the 21st century to meet reliability needs in the restructured electricity industry - Real Time System Control to improve reliability of the interconnected T/D grid - Interconnection and Integration of Distributed Energy Resources - Reliability and Markets
Cummins Onan	Dan Erickson	Product Manager, Networks and Switchgear		1400 73rd Avenue NE Minneapolis, MN 55432	763-574-5228	Large manufacturer of power generation equipment
Distributed Power Services, Inc.	Kon McQuiston	President		2111 Business Center Drive Suite 100 Irvine, CA 92612	949-428-2560	Software
Distributed Utility Associates	Joseph Iannucci	Principal	dua@ix.netcom.com	1062 Concannon Blvd. Livermore, CA 94550	Tel: 925-447-0624; Fax: 925-447-0601	Presented work on the Distributed Utility Integration Test at the DOE Distributed Power Program Review at beginning of the year.
DTE Energy Technologies	Ronald Fryzel; Mark Fallek; Murray Davis	Fryzel: Manager-Market Development; Fallek: Chief Marketing Officer	Fryzel: fryzelr@dteenergy.com; Fallek: fallekm@dteenergy.com	37849 Interchange Drive Suite 100 Farmington Hills, MI 48335	Tel: Fryzel 248-427-2241; Fallek 248-427-2233, Fax: 248-427-2265; Davis: Tel: 248-427-2221, Fax: 248-427-2295	Energy monitoring, microgrid systems, application engineering and studies, DG technology sales
Eaton Corporation (Cutler Hammer)	John Wafer	Director of Technology-Electrical Distribution Products	johnawafer@eaton.com	170 Industry Dr. RIDC Park West Pittsburgh, PA 15275	Tel: 412-787-6520; Fax: 412-494-3417	Automatic transfer switches, power control panels
Electrotek Concepts	Howard Feibus, Jeff Smith	Feibus: Vice President	howardf@electrotek.com	Feibus: One Colonial Place 2111 Wilson Blvd. Suite 323 Arlington, VA 22201; Smith: 408 N. Cedar Bluff Rd Suite 500, Knoxville, TN 37923-3641	Feibus: 703-351-4492 ext. 124; Smith: 865 470-9222	Involved in a project with NYSERDA in the Aggregated Distributed Generators project. Active in research, consulting, software related to power quality and monitoring of electrical systems.

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
ENCORP	Scott Castelaz	Vice President-Marketing and Strategic Planning	castelaz@rcnchicago.com	1512 S. Prairie Ave. Unit F Chicago, IL 60665	312-945-3036	Offering paralleling switchgear and energy automation software
Endecon Engineering	Chuck Whitaker				925-552-1330	Offers technical expertise and is supporting several projects in DER
Enercon Engineering	Larry Tangel	Vice President and General Manager	ltangel@enercon-eng.com	1 Altorfer Lane, East Peoria, IL 61611	309-694-1418	Enercon provides switchgear and parallel link controls for reciprocating engine gensets and turbines
Enermetrix	Jeff DeWeese	Co-Founder		3 Clock Tower Place, Maynard, MA 01754	978-461-0505	Transaction network/exchange and software
Engage Networks	Greg Andrews	National Account Executive		316 North Milwaukee St, Suite 410, Milwaukee, WI 53202	414-273-7600	Develops energy management techniques through SCADA and IP interface cards (web-enabling of GE meters)
EPRIsolutions	Dan Rastler			EPRI: 3412 Hillview Ave., Palo Alto, CA 94304	650-855-2521	
Gas Technology Institute (GTI)	Ted Bronson; William Liss	Bronson: Associate Director-Distributed Energy; Liss:	ted.bronson@gastechnology.org	1700 South Mount Prospect Road Des Plaines, 60018-1804	Tel: 847-768-0637, Fax: 847-768-0501; Liss: 847-768-0753	Industry backed nonprofit organization involved that has been active in distributed generation issues with several relevant projects underway.
GE Corporate R&D	Dr. Richard Zhang	Project Leader and Electrical Engineer	zhangr@crd.ge.com	Building K1, Room 2C33 Niskayuna, NY 12309	Tel: 518-387-5313; Fax: 518-387-7592	The research arm of General Electric is active in DER technology development and is leading a DOE cofunded project called "Predictive Modeling, Grid Interconnection Issues, Communications".
GE Distributed Power	Paul McGuire; Wayne Elmore	Senior Business Manager-GE Distributed Power (both)	McGuire: paul.mcguire@ps.ge.com; Elmore: wayne.elmore@ps.ge.com	McGuire: 3633 E. Inland Empire Blvd., Suite 800 Ontario, CA 91764; Elmore: 20 Technology Park Suite 300 Norcross, GA 30092	McGuire: Tel: 909-477-5789, Fax: 909-477-5748; Elmore: Tel: 770-662-7024, Fax: 770-447-7793	Large manufacturer of power generation equipment.
GE Industrial Systems	Daniel Klenke; Tom Mc Gibbon	Klenke: Manager, Ener.ge Program; McGibbon: Business Development Manager	daniel.klenke@indsys.ge.com; patrick.mcgibbon@indsys.ge.com	Klenke: 12101 Woodcrest Executive Drive St.Louis, MO 63141; McGibbon: 350 Humboldt Dr. North Henderson NV 89014	Klenke: Tel: 314-579-7025, Fax 314-579-7070; McGibbon: Tel: 702-433-6396, Fax: 702-433-6396	Produced control and protection equipment.
GE Zenith Controls	David Leslie		david.leslie@indsys.ge.com	GE Zenith Controls 1 Oak Hill Center, Westmont, IL 60559	773-299-6928	GE Zenith Control manufactures transfer switches, paralleling switchgear, and communications systems.
Generac	Eric Neitzke	Engineering Inquiries; VP of Sales & Marketing	eneitzke@generac.com	P.O. box 8 Waukesha, WI 53187	262-544-4811 ext. 2777	Develops transfer switches, paralleling switchgear, and GenLink software program for remote monitoring control panels.

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
Honeywell Sensing and Control	Louis Warren	Electrical Engineer		Honeywell Power Systems Albuquerque, NM	505-798-6031	Developed embedded sensors and controllers, ATRIUM an Internet-based service that can monitor and integrate equipment, operations, and energy information from multiple sites.
Illinois Institute of Technology- Grainger Power Lab	Dr. Alexander J. Flueck			3301 South Dearborn Street Electrical and Computer Engineering Department Illinois Institute of Technology Chicago, IL 60616-3793 USA	Phone: 312-567-3625 Fax: 312-567-8976	Focuses on congestion management research with transmission of power.
Intellution (Emerson Electric)	Rob Davidson; Greg Maciel; Lillian Allen	Davidson: Inside Sales Allen and Maciel: Part of **BM2Solutions**		325 Foxborough Blvd. Foxborough, MA 02035	General Number: 508-698-3322; Davidson: 800.526.3486 x7607; Maciel: 949.364.9090x 11; Allen: 949.364.9090x 16	
Invensys Controls				Carlisle Place, London SW1P 1BX	44 (0) 20 7834 3848	Invensys is developing an Internet-based energy management and monitoring solution, and plans to integrate Capstone MicroTurbine generation into its demand side management solutions
Itron	Dennis A. Shepherd	VP and General Manager, Energy Information Systems			919-876-2600	Advanced metering
Johnson Controls				3655 Northpoint Parkway Suite 200 Alpharetta, GA 30005	678-297-4100	Facility Management and Building Control Systems
Kelso Starrs and Associates	Tom Starrs	Principal	kelstar@nwrain.com	14502 SW Reddings Beach Road, Vashon WA 98070	Tel: 206-463-7571; Fax: 206-463-7572	Conducting a survey to interview a representative sample of DG facility developers and owners to determine interconnection problems and obstacles.
Kinectrics (formerly Ontario Power Technologies)	Blake Morrison	Director of Business Development	Blake.Morrison@kinectrics.com		954-659-9282	Third party company that provides consulting services through science and engineering to the energy markets. They conduct equipment testing and demonstrations on products such as fuel cells and microturbines.
Kohler Power Systems	Mark Siira	Director of Business Development-Generation Division	siiramar@kohlerco.com	444 Highland Drive, MS 072, Kohler, WI 53044-1541	920-803-4949	Manufacturer of generation equipment.
Los Angeles Department of Water and Power (LA DWP)	Bill Glauz	Manager of Distributed Generation	wglauz@ladwp.com	111 N. Hope St. Room 1004, Los Angeles, CA 90012	Tel: 213-367-0410; Fax: 213-367-0777	Municipal utility serving the city of Los Angeles

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
MIT Energy Laboratory	Marija D. Ilic; Stephen R. Connors ; J. Cardell, R. Tabors, Jefferson Tester	Illic: Principal Investigator; Connors: Support Investigator	Illic: ilic@mit.edu; Connors: connorsr@mit.edu; Tester: testerel@mit.edu		Ilic: 617-253-4682, Connors: 617-253-7985	The energy laboratory does a variety of work regarding distributed generation including predictive modeling, cost reduction, price and regulatory analysis, and quality of service.
National Renewable Energy Laboratory (NREL)	Richard DeBlasio	Technology Manager-Distributed Power Programs	deblasid@tcplink.nrel.gov	1617 Cole Blvd. Golden, CO 80401	Tel: 303-275-4333; Fax: 303-275-3835	The DOE distributed power program supports numerous technology development and demonstration projects in distributed power; It is also actively supporting the formulation of new standards.
National Rural Electric Cooperative Association (NRECA)	Edward Torrero	Senior Program Manager-Cooperative Research Network	ed.torrero@nreca.org	4301 Wilson Blvd. SS9-204 Arlington, VA 22203	Tel: 703-907-5624; Fax: 703-907-5518	Evaluation of the field performance of fuel cells and microturbines to better understand potential benefits and barriers
NEISO	N/A					Also pursuing methods to reduce load during peak capacity; also has two classes of interruptible loads: Class 1 (following a Contingency Loss) and class 2 (price-responsive, notification sent when forecasted that the ECP will exceed $100/MWhr)
NiSource Energy Technologies	Pete Disser	Vice President of Strategy	ptdisser@nisource.com	801 E. 86th Ave. Merrillville, IN 46410	Tel: 219-647-6070; Fax: 801-749-1605	Leading the DOE cofunded project "System Integration of Distributed Power for Complete Building Systems"
North Carolina Solar Center	Shawn Fitzpatrick		safitzpa@eos.ncsu.edu	N.C. Solar Center, Campus Box 7401, NCSU, Raleigh, NC 27695	Tel: 919-515-7147	Developed a "Guide to PV Interconnection Issues" along with Interstate Renewable Energy Council (IREC); Endecon Engineering, Kelso Starrs & Associates
Northern Power Systems	Lawrence Mott; Chach Curtis	Mott: Director-Special Projects	ccurtis@northernpower.com	182 Mad River Park One North Wind Road P.O. Box 999 Waitsfield, VT 05673-0999	General line: 802-496-2955	Engine Control System (ECS) is a line of generator set controls and switchgear. RemoteViewTM software allows remote monitoring and control of power systems.
NYISO, NYSERDA, Competitive ESCOs	N/A					Load reduction programs
Oak Ridge National Laboratory	Mike Karnitz					Coordinating numerous projects involving industrial DG.
Omnimetrix	Kent Heuser		akheuser@omnimetrix.net	Atlanta, GA	770-209-0012	Remote monitoring and notification of emergency generator conditions to cell phone, pager, etc.
Omnion (S&C Power Electronics Division)				2010 Energy Drive, East Troy, WI 53120	262-642-7200	Grid-parallel inverters
Orion Engineering Corporation	Dr. Thomas Regan; Herb Sinnock			Herb Sinnock, 40 Marion Street, Sommerville, MA 02143	Herb Sinnock, 617.625.3953 Tom Regan, 978.337.1352	Beginning a three-year development effort to produce a household generation controller and demonstrate the ability of a group of controllers to operate through a neural network to provide a smart, technologically sophisticated, but simple, efficient and economic solution for aggregating a community of small distributed generators into a virtual single large generator capable of selling power internally or externally to a utility, ISO or other entity, in a coordinated manner.

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
Overdomain, LLC	Crisman Cooley	Managing Member	ccooley@overdomain.com	599 Via El Cuadro Santa Barbara, CA 93111	Tel: 805.683.0938; Fax: 253.276.3206	Distributed Energy Neural Network Integration System (DENNIS)
Pacific Gas & Electric	Sun Chase; Jeff Goh				Chase: 415-973-2223; Goh: 415-973-0260	Major investor owned utility serving northern California.
PJM	N/A					Load Response Program - In order to reduce demands on Load-Serving Entities, a limited number of participants are given two options: compensation for end use customers who help reduce load during an emergency or work through the market participants to reduce load, who will then share the savings with the end-users (economic).
Power Measurement				2195 Keating Cross Rd., Saanichton, BC Canada V8M 2A5	1-250-652-7100	Performance MeteringTM Solutions -ION® web-ready software and intelligent electronic meters, software and communications (including internet)
Power Technologies Inc.	P.P. Barker	Senior Consultant		1482 Erie Blvd, P.O. Box 1058, Schenectady, NY 12301-1058		Provides power system simulation and modeling software as well as generation optimization software
PowerWeb Technologies	Lothar Budike	President and CEO				Omni-link® Internet Energy Platform - Multifunctional, internet-based enterprise energy information software
Public Utility Commission of Texas	Ed Ethridge	Electrical Production Engineer	ed.ethridge@puc.state.tx.us	1701 N. Congress Ave. PO Box 13326 Austin, TX 78711-3326	Tel: 512-936-7340; Fax: 512-936-7361	The state of Texas has established rules and technical standards for DER interconnection .
RealEnergy	Steven Greenberg		sgreenberg@realenergy.com	300 Capitol Mall, Ste 120, Sacramento, CA 95814	916-325-2500 x108	Independent power producer with equipment operating at site of power consumption
Reflective Energies	Edan Prabhu		edanprabhu@home.com		Tel: 949-380-4899	Reflective Energies is assisting with Focus I
Regulatory Assistance Project	Cheryl Harrington		rapmaine@rapmaine.org			RAP is involved in a DOE cofunded project identifying regulatory options for DER.
Resource Dynamics Corporation	Richard Friedman	Chairman	nrf@rdcnet.com	8605 Westwood Center Drive, Ste. 410 Vienna, VA 22182	703-356-1300 x203; Fax: 703-356-2230	IEEE/P1547 - Electric Power Resources Interconnected with the Electric Power System
Retx.com				Plaza 400, Suite 180, 5883 Glenridge Dr, Atlanta, GA 30328-5339	888-228-RETX	This company offers online hosting and software for retail choice programs including transaction support, metering and settlement, and analysis.
Sacramento Municipal Utility District (SMUD)	Chris Trinidad	Principal Distribution System Engineer	ctrinid@smud.com	6001 S Street MS# D104 Sacramento, CA 95817-1899	Tel: 916-732-6969; Fax: 916-732-6556	SMUD is a municipal utility that has been active in PV technology.

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
Sandia National Lab	Akhil Abbas and Jerry Ginn	Abbas: Principal Member; Ginn: Senior Member of Technical Staff	Abbas: aaakhil@sandia.gov; Ginn: jwginn@sandia.gov	P.O. Box 5800 - MS 0704 (Abbas)/MS 0753 (Ginn), Albuquerque, NM 87185	Abbas: 505-844 7308 and Ginn: 505-845-9117	Akhil Abbas was a speaker at the CADER Conference: Market Deployment-The Microgrid Concept
SatCon Technology Corporation	L.E. Lesster	General Manager-Technology Center	lesster@satc.com	161 First St, Cambridge, MA 02142	Tel: 617-349-0927; Fax: 617-661-3373	Developing power electronics equipment and energy storage technology.
Schneider Electric (Merlin Gerin, Modicon, SquareD, Telemecanique)	Jim Giordano		giordanj@squared.com	1415 Roselle Rd Palatine, IL 60067	615-287-3583	Manufactures control and protection equipment
Sempra Energy (San Diego Gas and Electric)	Mark Ward		mward@sempra.com		Mark Ward 619-696-4014, Vic Romero 858-650-4084, Tom Bilaek 858-654-8795, Mike Iammarino 858-650-6166	Major investor owned utility serving the greater San Diego area.
Siemens Westinghouse Power Corp	Allan Casanova	Director of Business Development & Admin.-Stationary Fuel Cells	allan.casanova@swpc.siemens.com	1310 Beulah Road Pittsburgh, PA 15235	Tel: 412-256-2813; Fax: 412-256-1310	DEMS economic dispatch tool (control and optimization of decentralized DG)
Silicon Energy	Afshin Afshari	Product Manager, Distributed Energy Management	aafshari@SiliconEnergy.com	1010 Atlantic Ave, Alameda, CA 94501	877-749-2600, 510-263-2672	Offers network/platform and software for reporting and analysis of energy usage and cost management...also includes bill auditing and analysis features.
Sixth Dimension, Inc.	Wade Troxell; Ph.D.	President & COO		1201 Oakridge Drive, Suite 300 Fort Collins, Colorado 80525	970-267-2021	Produces software for DER with products such as 6D iNET Network, 6D PowerPortal, 6D PowerPak and Embedded Site Server.
Southern California Edison	Gerome Torribio		torribgg@sce.com		626-302-9669	Major investor owned utility serving southern California
Stanford University Energy-Energy Modeling Forum	Hillard Huntington	Executive Director	hillh@stanford.edu	Terman Engineering Center, Room 406 Stanford, CA 94305-4026	Phone:650-723-0645 Fax: 650-725-5362	Involved in large level modelling; DG has been very difficult to analyze-not very active
Thomson Technology	Rick Martin	Vice President of Sales and Marketing	rmartin@thomsontechnology.com	9087A - 198th Street, Langley, BC V1M 3B1, Canada	Tel: 604-888-0110 ext. 305; Fax: 604-888-3381	Manufactures control panels and switchgear, transfer switches, remote monitoring and control software.
Underwriters Laboratories Inc.	Tim Zgonena	Sr. Project Engineer	Timothy.P.Zgonena@us.ul.com	333 Pfingsten Rd. Northbrook, IL 60062	Tel: 847-272-8800 ext. 43051; Fax: 847-509-6298	UL1741 - The Standard For Inverters, Converters and Controllers For Use In Independent Power Production Systems

Company	Point of Contact Information					Relevant Activities / Products
	Name(s)	Title / Affiliation	Email	Address	Phone	
University of California, Irvine	Kim Bergland		kb@nfcrc.uci.edu, jb@nfcrc.uci.edu	National Fuel Cell Research Center University of California, Irvine Engineering Laboratory Facility Irvine, California 92697-3550	Tel: 949-824-1999; Fax: 949-824-7423	Involved in several DER projects.
Urban Consortium Energy Task Force	Roger Duncan	Vice President of Austin Energy	roger.duncan@austinenergy.com			Active as a resource for DG information to large cities and municipal utilities.
Wisconsin Electric Machines & Power Electronics Consortium (WEMPEC)	Dr. Giri Venkataramanan; Fernando Alvarado	Venkataramanan: Assistant Professor	giri@engr.wisc.edu; alvarado@engr.wisc.edu		Venkataramanan: 608.262.4479; Alvarado: 608-262-8900	Activities include inverter control technologies to increase reliability and reduce costs as well as DG pricing and locational models.
Woodward Industrial Controls	Paul Johnson	Marketing Manager	pajohn@woodward.com	PO Box 1525 Fort Collins, CO 80522	970-498-3562	EGCP-2 Control and synchronization of multiple units
Xantrex (Trace Engineering and Trace Technologies)	Ray Hudson	Vice President of Emerging Markets and Advanced Development	ray.hudson@xantrex.com	161 S. Vasco Rd, Suite G, Livermore, CA 94550	Tel: 925-245-5407; Fax: 925-245-1022	Grid-parallel inverters

Appendix VII: Definitions

Advanced Market Concepts: strategies to enable DER participation in electricity markets involving radical changes to the existing infrastructure and processes

Combined Heat and Power (CHP): the use of heat produced as a byproduct of power generation

Communications: the monitoring of the power equipment and system using advanced technologies

Compatibility: the interoperability of equipment and systems

Competitive Impact: a measure of how important a technology is to the way companies compete in a particular industry

Congestion: limitations of the transmission system to transfer electricity generated

Control/Dispatch: equipment enabling effective activation and deactivation of equipment to respond to market or system needs

Cost Reduction: opportunities to reduce the cost associated with providing electricity to end-users

Current Market: opportunities to bring about increased DER participation in electricity markets with minimal changes to the existing market infrastructure and processes

Enabling Technologies: technologies outside of the core power generation technologies that allow DER to be used in applications that unlock the intrinsic value of distributed energy (these technologies are needed for DER to reach its full potential)

Focus Areas: the three elements within DER under study in this report – interconnection, grid effects and market integration

Grid Benefits: the positive effects of distributed power on the power grid

Grid Effects: the impact of the equipment / systems on the power grid, whether positive or negative

Grid Impacts: the negative effects of distributed power on the power grid

Hardware: the physical equipment involved in DER at the component or system level

Independent System Operator (ISO) Procedures: instructions for the control and use of DER by centralized managers to support and supplement the power grid

Information Technology (IT): various technologies involved with transmission and processing of data

Intelligent Software Agents: embedded software coding paired up with advanced control and communications allowing for self-activated responses to market or system needs by DER equipment

Interconnection: the system required to connect a DER system to the power grid while it generates electricity (often used synonymously with "synchronized" or "parallel" operation)

Issue: a critical question facing the development of DER that is in need of an answer or solution

Market Integration: the absorption of distributed energy into the market infrastructure for energy

Metering/Settlement: technology to measure the amount of and assign dollar value to electricity or other benefits DER provides to customers or the power system

Microgrid: stand-alone network that mimics a power grid, but on a smaller scale (Note: a standardized definition of microgrids has yet to be developed)

Modeling: simulations conducted to increase understanding of how systems interact

Power Electronics: the branch of electrical/electronic engineering concerned with the research, development, design and application of switching power converters (power electronics are used in DER technologies that require conversion from direct current or high frequency alternating current to 60hz or 50hz alternating current)

Power Quality: describes the suitability of that electricity for servicing electrical loads, concerns the shape of voltage and current waveforms

Project: discreet efforts, primarily from non-profit and governmental entities, with a clear objective and dedicated resources that attempt to address issues of concern with the relevant strategies

Protocols/Software: standards in electronics or communications such that advanced technology equipment can effectively communicate with each other

Reliability: a measurement of the availability of electricity when demanded

Retail: the market level at which the power distribution companies or other providers sell electricity to end-users

Strategy: a pathway to a solution of a particular challenge or question (issue)

Strategic Thrust: a grouping of aligned strategies within each focus area

System Impact Studies: projects to examine the effects of DER equipment on the stability and operational characteristics of the power system as a whole

Type Testing and Certification: the acceptance of products based on prior testing and approval of applicable technology and functionality

Transmission and Distribution (T&D): the system of wires that transports electricity from the generation source to the end user

Wholesale: the market level at which power producers or traders sell electricity to retailers or distributors

Wires Company Information Needs: the requirements of companies that own and operate the physical transmission and distribution system, to understand the location and operating status of DER systems on their for system to ensure safety and overall system reliability, and in some cases maximize the locational benefits of the DER

Appendix VIII: Process Example

The process by which Arthur D. Little identified issues, strategies and gaps was not a linear one. Numerous iterations and pieces of information including interviews and the workshop were used to arrive at the final issues, strategies and gaps found in this report. To describe the process as clearly and as simply as possible, this appendix provides an illustrative example of this process for the following Market Integration strategy in the Advanced Market Concepts strategic thrust:

Develop advanced controls, optimization approaches and technologies (including neural networks and intelligent software agents)

I. Literature Search and Project Candidate Identification

The entire effort began with a literature search for information about efforts in Distributed Energy Resources (DER) research and development. At this stage, anything that was considered potentially relevant to DER R&D was captured. Project information was particularly important at this stage as subsequent contacts with those associated with the project often yielded significant insights into the state of technology and/or market development. Through an affinity analysis, common issues and strategies were identified for all the projects found during the literature search. A preliminary list of strategies and issues was created and was continually refined as interviews are held and more information is collected. Among the projects identified were three projects that appeared to share a common strategy in developing advanced controls and optimization. Preliminary profiles were completed for three projects relating to advanced control technologies applicable to market integration.

II. Confirmation and In-Depth Interview

In-depth interviews were held with representatives of organizations responsible for these projects:

Contact Name	**Organization**	**Project Name**
Pete Disser	NiSource	Advanced CHP Systems
Gerald Gibson	Alternative Energy Systems Consulting	Smart*DER
Herb Sinnock	Orion Energy Corporation	DENNIS

Details from the literature search were confirmed and additional insights were sought during these interviews. Information on the state of the project, applicability of the preliminary set of issues and strategies to the projects, expected insights, additional DER project activities, and funding source information were all sought during the interviews.

It became clear during the three interviews relevant to the "advanced controls" strategy that the projects were dealing with emerging technologies primarily in the development stage since there were significant uncertainties of what impact the technology may have. All the projects were still involved with proving the viability of concepts rather than true demonstration, although Smart*DER will begin to involve initial system prototypes.

III. Refinement of Strategies & Issues and Additional Feedback

During the interviews, the underlying strategies and issues applicable to each project became more visible. Although each of the three projects in "advanced controls" is unique and focuses on different aspects of the problem, the common bonds also became more obvious as details were collected. When the entire set of market integration strategies was put together, clear patterns began to emerge and redundancies among the strategies were removed.

Additional feedback from the audience at the workshop were also accepted and taken into consideration. For the "advanced controls" strategy, feedback came primarily during the Game Changer exercise where ideas of networked devices and various models for coordinated controls were brought up. Thoughts and comments from the workshop were fed back into the list of issues and strategies where modifications were made, where appropriate. After the workshop, a reevaluation of the issues and strategies led to the formation of strategic thrusts that grouped the strategies into logical clusters to be matched up with the appropriate issues.

IV. Mapping

All the strategies including ***Develop advanced controls, optimization approaches and technologies (including neural networks and intelligent software agents)*** were evaluated for their stage of technology development and competitive impact. The technology development stage was determined by looking at the projects that were identified to be pursuing this strategy. For this example strategy, all the projects had completed research on the concepts and were clearly in the development stage doing pilot scale testing. From interviews with the researchers it was clear that each of the concepts being pursued were well ahead of the current marketplace and that there was significant market risk that they would be successful. Therefore this strategy was characterized as emerging.

V. Gap Analysis

For the gap analysis, the viewpoints shared by the interviewees and relevant comments from the workshop were taken into consideration along with all the information that had been gathered in the literature search. Comparisons of what is needed to achieve a meaningful level of support for a strategy with the current level of activity showed that while there were clearly several active projects pursuing the "advanced controls" strategy, the many uncertainties that still exist offer significant opportunities for additional research and development activity. The three projects pursuing this strategy were relatively low levels of effort compared to other DER technology development. It was clear that much more work would need to be done in order to bring these concepts to commercialization. However, even with significantly more activity, these concepts could not be easily accepted into the DER industry given its current state of development. The gap was therefore characterized as moderate.

VI. Broad Perspective and Conclusions

When the entire body of information collected and analyzed was unified in the written report, insightful observations could be made about the state of DER development. Given the importance of integrating DER into the electricity markets in order for DER to reach its full potential, advanced controls and optimization approaches and technologies certainly has a critical role to play.