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FINAL PROJECT REPORT

MICROGRID ASSESSMENT AND RECOMMENDATION(S) TO GUIDE FUTURE INVESTMENTS

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PREPARED BY:

Primary Author(s):
Sudipta Lahiri
Olof Bystrom
Richard Fioravanti
Nellie Tong

DNV GL
155 Grand Avenue, Suite 500
Oakland, CA 94612
Phone: 510-891-0446
http://www.dnvgl.com

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Prepared for:

California Energy Commission

David Chambers
Agreement Manager

Fernando Piña
Office Manager
Energy Systems Research Office

Laurie ten Hope
Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

Robert P. Oglesby
Executive Director

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- Mr. Byron Washom, University of California, San Diego;
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PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

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- Transportation

Microgrid Assessment and Recommendation(s) to Guide Future Investments is the final report for the Microgrid Assessment and Recommended Future RD&D Investments project work contract number 500-11-029, work authorization number KEMA-11-017 conducted by DNV GL. The information from this project contributes to Energy Research and Development Division's Energy Technology Systems Integration program area.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

ABSTRACT

This report provides an assessment of microgrids in California and offers recommendations for future RD&D Investments for the State of California. DNV GL conducted research surveys and facilitated meetings and workshops among key stakeholders. This report summarizes the findings from those activities and provides suggestions to address existing barriers and future investment needs in planning, development, construction, interconnection, operation, and commercialization of microgrids. This report is intended to identify research, development, and demonstration gaps to guide future investments by the California Energy Commission, the Department of Energy, and the Department of Defense in microgrid technologies and demonstrations.

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS ..... **i**

PREFACE ..... **ii**

ABSTRACT ..... **iii**

TABLE OF CONTENTS ..... **iv**

LIST OF FIGURES ..... **iv**

LIST OF TABLES ..... **v**

EXECUTIVE SUMMARY **1**

CHAPTER 1: Introduction **3**

CHAPTER 2: Stakeholder Survey **4**

2.1 Introduction 4

2.2 Survey Design 4

2.3 Survey Results 6

2.3.1 Survey Participant Background 6

2.3.2 Microgrid Functionality 7

2.3.3 Microgrid Barriers 8

2.3.4 Discussion 13

CHAPTER 3: Stakeholder Workshop **15**

3.1 Lessons Learned from RD&D 16

3.2 Microgrid Barriers 17

3.3 Success Stories 18

CHAPTER 4: Conclusions and Recommendations **20**

GLOSSARY **23**

APPENDIX A: Microgrid Assessment and Recommended Future RD&D Investments Survey **A-1**

LIST OF FIGURES

Figure 1: Industry Background of Participants Who Completed the Survey 6

LIST OF TABLES

Table 1: Participant Background Related to Microgrids 7

Table 2: Barriers by Category as Indicated by All Participants and by Participants Categorized by Industry Background (5 Highest Barrier, 1 Lowest Barrier) 9

Table 3: Top Ten Barriers to Microgrid Commercialization as Indicated by Survey 10

Table 4: Top Three Barriers by Participant Group, and Relative Importance of Those Barriers to Overall Population 11

EXECUTIVE SUMMARY

Microgrids coordinate Distributed Energy Resources (DER) to provide reliability over sections of the electric grid during grid outages, provide higher efficiency in utilization of energy, and allow higher penetration of renewable resources than would otherwise be possible. Lower cost DER is now available to facilitate the implementation of microgrids. However, existing interconnection technology, communication and control technology, and regulatory constructs hinder the planning, development and deployment of microgrids

The purpose of this report is to:

- Provide an assessment of microgrids in California and outline the lessons learned from operational microgrids.
- Identify key barriers in planning, development, construction, interconnection, operation, and commercialization of microgrids.
- Identify research, development, and demonstration gaps and provide recommendations to guide future investments by the California Energy Commission, the Department of Energy, and Department of Defense in microgrid technologies and demonstrations.

The goals of this effort were to:

- Identify technical, economic, regulatory, market and commercialization barriers, and requirements for rapid microgrid implementation including interconnection standards, control and communication technologies, market rules, and tariffs.
- Identify regulatory issues to assist the prioritization of legislative agendas to influence the adoption of microgrids that support resiliency and achieving the State of California's energy goals.
- Provide recommendations that will help the California Energy Commission to prioritize demonstration projects.

DNV GL supported the California Energy Commission by conducting research and facilitating meetings and a workshop among key stakeholders. The findings are based on two main sources of inputs – a survey that was conducted during January and February 2015 and a stakeholder workshop that was conducted by the California Energy Commission in Sacramento on March 6, 2015. The online survey had 119 participants, of which a majority had practical experience in microgrid deployment and operations, as developer, equipment vendor, or site host. The remainder of the participants was from utilities, academic institutions, government agencies, consulting firms, industry associations, environmental groups, and national labs, encompassing a wide spectrum of engagement in microgrid activities. The stakeholder workshop comprised of presentations on the challenges, benefits, and lessons learned from currently operational microgrids in California, and an open forum for discussion on the avenues to address existing barriers.

Key barriers identified from the survey and stakeholder workshop are:

- Difficulty in interoperability of microgrid technologies and components.
- Lack of clarity on the value of reliability and grid support services that a microgrid can offer.
- Cost and complexity of interconnection regulations.
- Existing tariffs and prohibition to wholesale market participation do not allow full monetization of microgrid services.

Key recommendations of this study include:

- Identify the location on the distribution or transmission systems where microgrids may have the maximum benefit to ratepayers and to the grid.
- Improve interoperability standards and operational guidelines for microgrids.
- Improve dissemination of information on microgrids to help electric systems operators, planners, and the public understand the values (tangible and intangible) that microgrids provide.
- Develop policy, markets, or other means to capture and quantify values provided by microgrids, such as improved reliability, islanding capability, lower emission production, and reducing electrical losses.

As proposed next steps, it is suggested that a microgrid roadmap is developed that maps out specific policy, regulatory, technical, and commercial barriers that exist for microgrids and how the California stakeholders, including regulatory agencies, the California systems operator, utilities, and microgrid owners and developers, can address these.

Expansion of microgrids in California supports California's legislative and regulatory goals as microgrids can reduce greenhouse gas emissions, support reliability and resiliency, and facilitate higher levels of distributed generation. This study provides benefits to California ratepayers, stakeholders and policy makers by summarizing the experience to date of implementing microgrids as well as the perceived barriers to further development. The report also recommends actions to remove such barriers and provide a better understanding of values provided by microgrids.

CHAPTER 1: Introduction

Microgrids offer resiliency over a geographic area during grid outage events, provide cost saving opportunities, and can deliver additional societal benefits; such as reduced carbon footprint and higher penetration levels of renewable resources than would otherwise be possible. Lower-cost Distributed Energy Resources (DER) are now available to facilitate the implementation of microgrids. However, interconnection technology, communication and control technology, and regulatory constructs hinder the planning, development, and deployment of microgrids.

The operation of DER and coordination of loads with the California Independent System Operator (CAISO) is becoming more complex. Therefore, it is critical to identify and develop research that will address technical, economic, regulatory, and market issues for renewables-based microgrids to provide lower-cost energy, grid stability, increased reliability, and adaptation for climate change impacts.

This report provides an assessment of microgrids in California and offers recommendations for future RD&D Investments for the State of California. DNV GL supported the Energy Commission by conducting research and facilitating meetings and workshops among key stakeholders. This report summarizes the findings and provides suggested next steps to address existing barriers and future investment needs in planning, development, construction, interconnection, operation, and commercialization of microgrids. The work is intended to identify research, development, and demonstration gaps to guide future investments by the California Energy Commission, the Department of Energy, and the Department of Defense in microgrid technologies and demonstrations.

The findings presented in this report are based on two main sources of inputs: a survey that was conducted during January and February 2015 and a stakeholder workshop that was conducted by the California Energy Commission in Sacramento on March 6, 2015. Section 2 of the report presents the survey, its design, and its findings. Section 3 provides a summary of the microgrid workshop, its presentations, and the stakeholder discussions. Section 4 provides recommendations and next steps. The Energy Commission envisions that this work effort will provide a useful starting point for a more comprehensive microgrid policy roadmap in the future.

CHAPTER 2:
Stakeholder Survey

2.1 Introduction

DNV GL organized a stakeholder survey that was open to the public. Key stakeholders were identified based on user lists and listservers maintained by the California Public Utilities Commission and the Energy Commission on issues such as microgrids, energy storage, and distributed generation. Members of these lists were invited to participate in the survey and the survey was publicly available through the Energy Commission website and on https://www.surveymonkey.com/s/MicrogridRDD. The online survey notice was sent out to stakeholders in January 2015 and was completed in March 2015. The purpose of the survey was to gather information about issues that can support further commercialization of microgrids, and challenges that the microgrid community encounters, with a specific focus on technology development, cost, codes, and standards.

2.2 Survey Design

The survey was designed to gather key information about the respondent's microgrid experience; barriers encountered or perceived, and detailed information about each respondent to understand their perspective. Two main categories were used in the survey: participant background and microgrid barriers. In the background section, participants were asked to select among a range of choices. In the section on microgrid barriers, participants were asked to rank listed barriers on a scale of 1 to 5, where 5 is the highest and 1 is the lowest barrier[1]. In addition, every question had a field where the participants were encouraged to provide comments pertaining to the topic of concern. The survey is presented in Appendix A and the categories are described in further detail below:

- Respondent profile and microgrid background: Organizational profile of the participant, their experience in the microgrid area, and whether their microgrid experience was in California. There were four questions in this category.
- Microgrid capabilities: Participants were asked to list the most important functional and technological capabilities of a microgrid. The queries were as follows: primary purpose, end users, capabilities, and technologies deployed in a microgrid. There were five questions in this category.
- Technology barriers: Participants were asked to rank barriers with respect to the maturity of three technology classes: microgrid controls; building automation controls; demand response, and load management controls. There were three questions in this category.

[1] One of the choices included the null response option in the form of 'Don't Know'.

- Technical knowledge barriers: This section focused on the understanding of technologies that enabled microgrid deployment and operation. The questions pertained to standardized microgrid design, interoperable equipment, microgrid operations in parallel and islanded mode, and the interplay of technologies enabling operation in different modes and transition between modes. Further questions included understanding of protection and relaying requirements, cyber security issues, end user behavior as related to load management and frequency control, load forecasting and weather forecasting. There were nine questions in this category.
- Training barriers: This section sought to identify the barriers related to training and awareness around the microgrid concept and consisted of the following questions: experienced microgrid designers and operators, utility understanding of microgrid impacts and benefits, and behind-the-meter end user awareness. The final question asked whether lack of specific regulatory policies around microgrids was hindering commercialization. There were five questions in this category.
- Standards barriers: This section had questions asking the participants to quantify perceived barriers in lack of interoperability standards for microgrid components, safety and reliability standards around microgrid equipment and operation, and codes for siting and permitting microgrids. There were three questions in this category.
- Economic barriers: This section had questions pertaining to barriers in monetization, financing, and cost-effectiveness of microgrids. The questions related to the cost of microgrid isolation and stability controls, cost of distribution automation technologies, cost of communication infrastructure, and utility rates for standby services or other penalizing tariffs for departing load. Other questions asked whether existing retail energy tariffs allowed microgrid benefits to be equitably monetized, whether lack of wholesale market access was a barrier, and whether government-financing assistance was required. The final questions pertained to lack of standardized methods to evaluate microgrid financial benefits for different categories of stakeholders, standardized contracting and standardized risk assessment for microgrids. There were ten questions in this category.
- Interconnection barriers: The questions in this category asked the participants about the cost and complexity of current interconnection regulations. There were three questions in this category.
- Market Rules: The questions in this category asked about utility franchise rights as a barrier to microgrid deployment, lack of service and billing rules for non-utility microgrids, and lack of clearly defined roles and responsibilities between the utility and the microgrid. There were three questions in this category.

Apart from contact details, participant response was solicited for seven questions related to microgrid background, experience and understanding and, 36 questions related to specific barriers in the commercialization of microgrids.

2.3 Survey Results

2.3.1 Survey Participant Background

In total, 119 participants responded to at least one question of the survey. Figure 1 shows the breakdown of participants according to industry background. Of the participants, 49 participants or 42 percent had experience in California, while 70 participants or 58 percent had experience outside of California, including a few participants with experience outside of United States.

Figure 1: Industry Background of Participants Who Completed the Survey

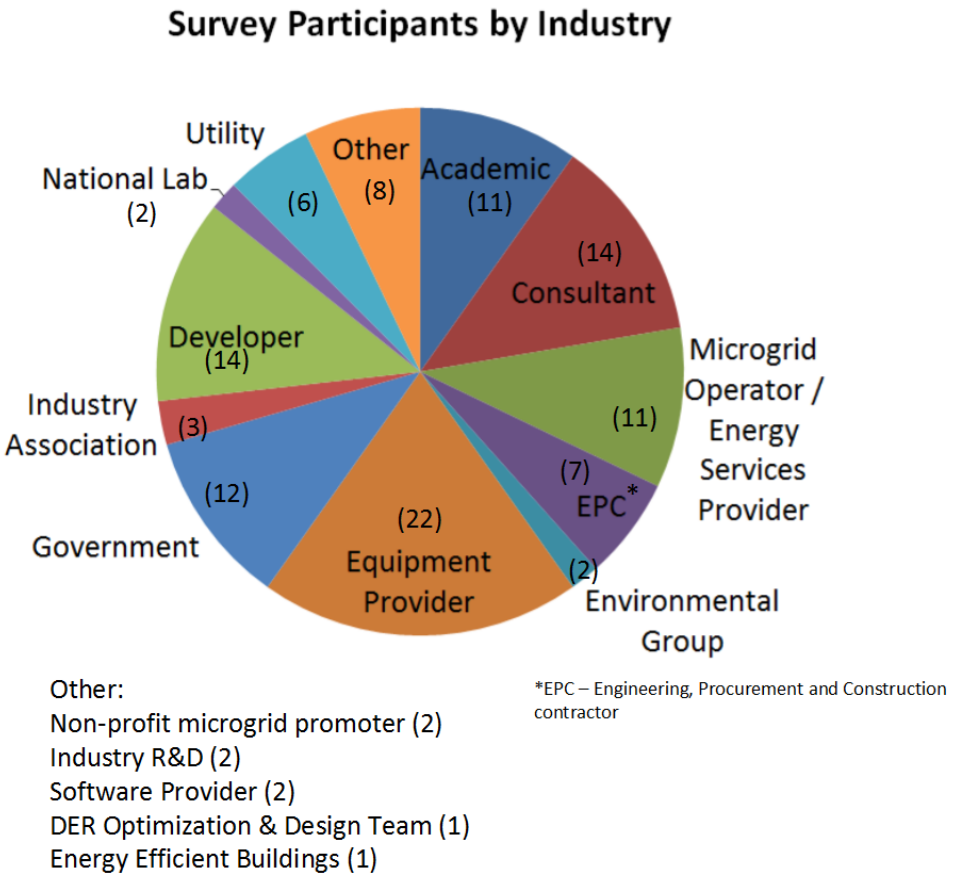

Table 1 shows the backgrounds of the participants in the microgrid area. A majority of the respondents (59%) had practical experience related to microgrids, as a developer, vendor, or site host. 30 percent of the respondents described themselves as having good theoretical expertise in microgrids and 11 percent of the respondents had a basic understanding of microgrid-related concepts.

Table 1: Participant Background Related to Microgrids

Stated Experience in Microgrids	Number Of Participants	Percentage Of Participants
Participated in microgrid design, development, financing and/or operation	41	34%
Equipment supplier to presently operational microgrid or a microgrid under development	24	20%
Site host of an existing microgrid	6	5%
Theoretical understanding of microgrids, but not participated in a project	33	28%
Supplier interested in microgrids but not participated in a project	2	2%
Just beginning to understand microgrids	13	11%

2.3.2 Microgrid Functionality

The participants were asked to rank microgrid functionality by order of importance. Seventy eight percent of the participants responded that the primary purpose was to enhance reliability of local loads during abnormal grid conditions. The functions of a microgrid to the local campus or load, in order of importance, as determined from the survey are:

1. The reliability benefit, increase reliability of local loads.
2. The economic benefit, lower facility energy costs.
3. The sustainability benefit, reduced emissions of GHG, or other pollutants. .

An important societal benefit of microgrids was stated as the integration of renewables within the electrical system. Microgrids offer local control and smoothing of intermittent renewables, thus allowing higher overall penetration within the electric grid.

The respondents were asked to specify which generation and storage technologies were important to a microgrid, with more than one selection allowed. The results of this query, ranked by the percentage of participants, are as follows:

1. Integrated solar photo-voltaic, 88 percent.

2. Electric energy storage, 81 percent.
3. Fossil fuel based turbine generators, 57 percent.
4. Wind turbine generator, 41 percent.
5. Fuel cells, 36 percent.
6. Thermal energy storage, 29 percent.
7. Electric vehicles, 26 percent.

From the response above, solar PV and electric storage are stated as the most widespread technologies providing local generation support.

Similarly, the respondents were asked to select microgrid control and integration technologies of importance, with more than one selection allowed. The responses are shown in order of percentage of participants selecting a particular technology:

1. Microgrid management system, 83 percent.
2. Building energy management system, 59 percent.
3. Smart inverters for individual devices, 57 percent.

2.3.3 Microgrid Barriers

The results for the survey questions specific to microgrid barriers have been drawn from 112 completed responses. In aggregate, the participants provided a response to 75 percent of the queries on microgrid barriers and 25 percent of the response fields were left blank or attributed 'Don't Know'. To streamline the delivery of results and enhance the understanding of barriers within a broader context, the 36 questions were grouped into to four major categories as follows:

- Technical: Includes all questions within technology and technical knowledge categories. The total number of questions is 12.
- Economic: Includes the 10 questions under the economic category.
- Policy and Regulatory: Includes questions on interconnection, market rules, and regulations specific to microgrid development, totaling to seven questions.
- Training and Standards: Includes the questions under the categories of training and technical or safety standards, totaling to seven questions.

Table 2 shows the average score within the barrier categories for all participants, as well as the participants grouped by background.

Table 2: Barriers by Category as Indicated by All Participants and by Participants Categorized by Industry Background (5 Highest Barrier, 1 Lowest Barrier)

Participant Background	Barrier			
	Policy and Regulatory	Economic	Training and Standards	Technical
All participants (112)	3.8	3.3	3.3	2.9
Academic (11)	3.9	3.4	3.3	2.8
Consultant (14)	3.5	3.4	3.3	3.0
Microgrid Operator / Energy Service Provider (11)	3.9	3.1	2.9	2.70
Engineering / Procurement / Construction contractor (7)	4.2	3.9	3.9	2.8
Environmental (2)	5	N.A	N.A.	N.A.
Equipment Provider (22)	3.5	2.9	2.9	2.7
Government Agency (12)	3.7	3.7	3.5	3.5
Industry Association (3)	4.8	3.8	2.7	3.3
Developer (14)	3.9	3.2	3.3	2.8
National Lab (2)	4.0	3.4	2.7	4.3
Utility (6)	3.6	3.2	3.5	3.0
Other (8)	3.7	3.4	3.7	3.1

Table 2 suggests that technical barriers have the lowest score, while regulatory barriers have the highest score. The overall scores for economic barriers and training and standards barriers are very close, and they may be considered equal in importance. It is to be noted that a majority of the survey respondents are involved in innovation and technical development of micro grids. This may be a contributing factor to why technical barriers are perceived as less significant than other categories of barriers.

Table 3 describes the ten highest scoring barriers, as rated by the entire population of survey participants. Table 3 suggests that the most significant barrier is lack of specific policies or regulations that promote microgrid development. Even though some policies exist that focus on individual components of microgrids, such as solar PV, storage, combined heat and power, there are no specific incentives that specifically support aggregation and integration of these resources to support reliability or cost savings.

Other key regulatory barriers that emerge from the survey are the cost and complexity of interconnection requirements and utility franchise rights. Key economic barriers include the customer tariffs not valuing the range of services that the microgrid can provide and the lack of direct wholesale market access to provide grid related services.

Table 3: Top Ten Barriers to Microgrid Commercialization as Indicated by Survey

Barrier	Rank	Average score (5 highest, 1 lowest)
Lack of policies or regulations that enable microgrids	1	4.1
Interconnection rules impose limitations on microgrids	2	4.0
Utility franchise rights inhibit microgrid deployment	3	4.0
Existing retail tariffs do not allow all microgrid benefits to be monetized	4	3.9
High cost of meeting interconnection requirements	5	3.8
Lack of direct access to wholesale markets do not allow all microgrid benefits to be monetized	6	3.7
Lack of utility understanding of the impacts of end user microgrids to the utility	7	3.6
Adequacy of IEEE technical standards to address integration and operation of microgrids	8	3.5
Lack of clearly defined roles and responsibilities between utility and microgrids	9	3.5
Lack of standardized method to establish cost and value of microgrids to various stakeholders	10	3.5

Table 4 shows the top three barriers by participant group as scored by individual industry groups. Note that the groups 'National Labs', 'Environment Groups', and 'Industry Associations' have not been included in this list, due to the small number of participants within these groups and the large percentage of unanswered survey questions by the participants. The barriers as denoted in this table generally reflect the top ten barriers as indicated in Table 3.

In addition, a few other barriers of note emerge:

- Lack of standardized contracts makes financing microgrid projects difficult.
- Lack of understanding in how generation, storage, and building management system work to increase overall energy efficiency.
- Lack of government assistance to reduce first mover risk in initial contract years.

- Lack of experienced operators of microgrids.
- Lack of maturity and interoperability of microgrid system controls.
- Cost of microgrid isolation and stability controls.

Table 4: Top Three Barriers by Participant Group, and Relative Importance of Those Barriers to Overall Population

Participant Background (# of participants)	Barrier	Average score within industry group (5 highest, 1 lowest)	Average score for all participants (5 highest, 1 lowest)	Overall Rank by Importance (1 highest ranked barrier)
Academic (11)	Lack of policies or regulations that enable microgrids	4.3	4.1	1
	Lack of standardized contracts make financing projects difficult	4.3	3.2	20
	Existing retail tariffs do not allow all microgrid benefits to be monetized	4.2	3.9	4
Consultant (14)	Lack of understanding in how generation, storage and building automation technologies work together while in parallel with the larger grid	3.9	3.1	26
	Lack of policies or regulations that enable microgrids	3.9	4.1	1
	Lack of direct wholesale market access do not allow all microgrid benefits to be monetized	3.9	3.7	6
Microgrid Operator / Energy Service Provider (11)	Interconnection rules impose limitations on microgrids	4.4	4.0	2
	High cost of meeting interconnection rules	4.3	3.8	5
	Lack of government assistance to reduce first mover risk for initial contract years	4.2	3.4	14
Engineering / Procurement	Utility franchise rights inhibit microgrid deployment	4.7	4.0	3

Participant Background (# of participants)	Barrier	Average score within industry group (5 highest, 1 lowest)	Average score for all participants (5 highest, 1 lowest)	Overall Rank by Importance (1 highest ranked barrier)
Construction contractor (7)	Lack of policies or regulations that enable microgrids	4.6	4.1	1
	Lack of service and billing rules for non-utility microgrid	4.5	3.5	12
Equipment Provider (22)	Utility franchise rights inhibit microgrid deployment	3.9	4.0	3
	Existing retail tariffs do not allow all microgrid benefits to be monetized	3.9	3.9	4
	Interconnection rules impose limitations on microgrids	3.8	4.0	2
Government Agency (12)	Lack of direct access to wholesale markets do not allow all microgrid benefits to be monetized	4.3	3.7	6
	Lack of experienced operators of microgrids	4.2	3.2	23
	Maturity and interoperability of microgrid system controls	4.0	3.3	19
Developer (14)	Lack of policies or regulations that enable microgrids	4.8	4.1	1
	Interconnection rules impose limitations on microgrids	4.4	4.0	2
	Utility franchise rights inhibit microgrid deployment	4.1	4.0	3
Utility (6)	Utility franchise rights inhibit microgrid deployment	4.7	4.0	3
	Cost of microgrid isolation and stability controls	4.2	3.3	17
	Lack of policies or regulations that enable microgrids	4.2	4.1	1
Other (8)	Interconnection rules impose limitations on microgrids	4.4	4.0	2

Participant Background (# of participants)	Barrier	Average score within industry group (5 highest, 1 lowest)	Average score for all participants (5 highest, 1 lowest)	Overall Rank by Importance (1 highest ranked barrier)
	Lack of interoperability standards for microgrid components	4.1	3.5	11
	Costs of meeting interconnection requirements	4.0	3.8	5

About 50 percent of the participants, (54 out of 112), belong to the microgrid developer, vendor, equipment provider, EPC, or service provider community. The barriers articulated by this community follow a similar vein and are related to the difficulties perceived during microgrid deployment. The principal concerns are in the regulatory areas related to complexity of interconnection, utility jurisdiction, and tariff structures not realizing the complete range of microgrid benefits. It is interesting to note that the most important barrier as noted by the participants from the utility community is that utility franchise rights often prevent cohesive deployment of multi-user customer microgrids.

Key technical barriers that emerge from the survey are the lack of interoperability of vendor-specific microgrid components, open standards for communication and data-interchange, and standards for islanding and reconnection of microgrids.

2.3.4 Discussion

A major technical barrier that has emerged from the survey is the difficulty in interoperability of microgrid technologies and components. Some issues noted with current integration platforms are vendor specificity, lack of standard control and communication protocols, and the difficulty in integrating legacy components. Another point of note is that microgrid system operation does not leverage the full benefits from building efficiency, automation, and load management measures. A reason cited is that existing building management system platforms are opaque, proprietary, and not designed to be integrated with on-site generation and storage. Several participants have pointed out that every microgrid site needs to be customized to fit the goals of the end-user. This results in high cost and complexity of deployment. However, some of this complexity may be mitigated with open, vendor neutral communications and control platforms that offer the full range of microgrid functionality and a high degree of customization capability.

One of the most important regulatory barriers is the time, cost, and complexity of interconnection. Among the economic barriers, lack of access to wholesale markets, and inability to receive remuneration for excess generation at retail or bundled rates have been mentioned as important issues. Several participants have mentioned during the survey that the

financial calculations performed during the design phase are rarely realized during the operational phase. There is a need to publish data from operational microgrids that derive financial performance from operational data. The survey has also brought to light the need for comprehensive and consistent standards for interoperability of components within the microgrid and interconnection with the larger grid. These standards may be an extension and refinement of existing IEEE 1547.4 guidelines and is a work in progress. In addition, communication standards and operational guidelines need to be crystallized for the interaction between the microgrid and the macrogrid.

At a higher level, a central theme that emerges from the survey and the participant comments is the call for greater financial incentives or regulatory reform that is specific to microgrids. Participants have cited the need for programs similar to California Self Generation Incentive Program for renewable generation and storage, as related to microgrids. However, counter-points presented to this suggestion are as follows: incentives on renewable generation and storage are embedded within the capital outlay of microgrids. While early adopters have demonstrated reliability of local loads, the full range of services to the larger electric grid is yet to be demonstrated or verified on a consistent basis. Further discussions on this topic were conducted in the stakeholder workshop and this point has been elaborated in Chapter 3.

CHAPTER 3:
Stakeholder Workshop

As part of the California Energy Commission's effort to map out and assess microgrid barriers and opportunities, a stakeholder workshop was held at the California Energy Commission's offices in Sacramento on March 6, 2015. The purpose of the workshop was to solicit public input to help identify research development and demonstration (RD&D) gaps and provide recommendations to guide future RD&D investments by the California Energy Commission in microgrid technologies and demonstrations. Specifically the workshop sought to identify investments that address technical, economic, market and commercialization issues to better enable stable microgrids that can potentially provide better and more reliable service to energy customers while improving the stability of the larger grid. The workshop informed the stakeholder community of recent developments in microgrid RD&D, and provided insight and knowledge sharing from California stakeholder with experience in the operation, design, and regulation of microgrids. The workshop also presented and discussed the survey results shown in Chapter 2 of this report. Meeting participants provided their perspective experience and recommendations with a view to help the California Energy Commission's future research and development investments in microgrids in California.

The partners for the workshop hosted by the California Energy Commission were California Public Utilities Commission (CPUC), Department of Energy (DOE), Department of Defense (DOD), and Naval Facilities Engineering Command (NAVFAC). The workshop included the following presentations:

- DOE/OD Integrated Microgrid R&D Plan, FY 2015 – 2016, by Jim Reilly, consultant to DOE/OE
- Microgrids – A Regulatory Perspective, by J. David Erikson, CPUC
- Microgrid Developments at Marine Corps Installations Command, by Robert Gilleskie, MCI West
- Military Microgrids: Initiatives, Perspectives and Challenges, by Laura Baker, NAVFAC
- Microgrid Initiatives, Impact and Lessons Learned at University of California San Diego (UCSD), by Byron Washom, UC San Diego
- SMUD Energy R&D Program Microgrid Demonstration – Lessons Learned, by Katarina Miletijev, Sacramento Municipal Utility District
- Current and Future Role of Microgrids, by Thomas Bialek, San Diego Gas and Electric

The results of the microgrid barriers survey were presented and a general discussion was solicited based around the following key points:

- Performance metrics to evaluate microgrids, for example, what makes a microgrid project successful?

- Value of a microgrid to the end user and to the larger electrical system
- Strategies for successful commercialization of microgrids?
- Recommended future investments and strategies to promote commercialization of microgrids.

The presentations made during the workshop and the discussions around key issues have been condensed into the sections presented below. Section 3.1 presents the lessons learned from deployment and operation of existing R&D microgrids. Section 3.2 outlines the main barriers articulated over the survey and during discussion at the workshop. Section 3.3 presents the areas in which microgrid R&D has had meaningful impact in improving the efficiency and reliability of the electric grid.

3.1 Lessons Learned from RD&D

The presentations and subsequent discussion among workshop participants suggest that there are a number of lessons learned from the microgrid experience gathered by users and regulators so far, including the following:

- Microgrid demonstrations and RD&D efforts have led to general advancement of energy generation and control technologies and energy management infrastructures and have stimulated development of technical standards for integration of energy assets into the larger electric grid.
- Microgrids offer end user customers the ability to manage local loads effectively and efficiently – making end users major stakeholder in the generation and delivery side of the energy ecosystem. This has spurred tremendous ingenuity among end users, stimulated innovation in the energy area and generated visibility on state and national goals for a cleaner electric grid.
- The microgrid concept requires some customizability in system design to suit the needs of the end user. This has resulted in numerous conflicting management and controls infrastructures and vendor specific platforms, resulting in high cost of deployment. The cost and complexity of integrating legacy and new assets with sophisticated management systems presents one of the biggest technical challenges.
- Field demonstrations of innovative microgrids have proven efficiencies in energy procurement and use, and increased reliability of local loads. The performance data of existing RD&D microgrids need to be made widely available to demonstrate the viability of technologies and architectures and promote widespread adoption of the concept.
- RD&D efforts have clearly demonstrated two models of microgrid deployment – customer owned and operated and utility owned and operated. The benefit of both structures in offering efficiency and reliability benefits to end users within their purview has been demonstrated. However, there exist technical and economic barriers in leveraging these benefits for the larger grid in a systematic way.

- Current efforts have enhanced the state-of-art microgrid planning for cost-effective deployment. Sizing microgrid assets to critical loads and installing basic management systems to enhance the efficiency of these assets is a key principal in achieving cost-effectiveness. In addition, energy efficiency measures, basic load monitoring, and forecasting technologies offer high returns and may 'subsidize' the installation of more expensive interconnection, islanding, and protection equipment.
- Electrical energy storage is a critical asset in microgrids, enabling efficient energy use, and providing fault ride-through, long duration backup, demand, and energy charge management.

3.2 Microgrid Barriers

Workshop participants and presenters also identified a number of barriers that they perceive as preventing wider adoption of microgrids and a deeper commercialization of microgrids, including:

- Cost and complexity to enable interoperability of legacy and new microgrid assets. Presently, energy management platforms and associated technical standards are in a nascent stage of maturity and commercialization. There is a lack of off-the-shelf open and configurable platforms that can handle microgrid customization and operational needs in:
    - Stability, islanding, and reconnection.
    - Relaying and protection.
    - Forecasting, optimization, and scheduling,
    - Integration with Building Management Systems (BMS) and load management technologies.
    - Communications with bulk electric grid.
- Reliability and enhanced efficiency are the key benefit areas of a microgrid. One barrier is the lack of clarity on the value of enhanced reliability. Work has been done to assess this value as a function of economic loss for individual microgrid customers. However, in most cases, this value is intangible from a cash flow perspective and may not be used to acquire financing. In addition, there is no clarity on the value of reliability or grid support benefits that a microgrid may provide.
- Efficient microgrid deployment may require islanding of assets separated by public roads. Assets may also be electrically connected through the utility distribution system. Furthermore, customer loads / buildings within a microgrid location may be separately interfaced to the utility distribution system. In such circumstances, utility right-of-way regulations prohibit microgrid deployment by the customer.
- Interconnection requirements vary according to the location (transmission or distribution system) of the microgrid and by the type and size of assets. These

requirements impose a heavy burden in cost and complexity. Another issue raised, is the queuing problem for interconnection studies. Initial projects require less analysis, and as the number of projects build up on a particular distribution feeder, the complexity of analysis increases, leading to longer hold-ups for subsequent projects.

- Public safety concerns have the potential to slow down or stall microgrid penetration. As mentioned in the workshop, the lack of fire safety standards for Li-Ion storage requires approval from the Fire Marshall for citing and permitting of storage. There is also the concern of relay and protection systems not operating allowing a Distributed Generator (DG) to energize a section of the grid, jeopardizing public health and safety.
- Another technical challenge is the lack of clarity on the islanding requirements for microgrids and Distributed Energy Resources (DERs). There is an inherent conflict between a microgrid islanding securely, new stabilizing functions of advanced inverters, and the present distribution system standards requiring DER's to trip off on detection of abnormal grid conditions. Technologies on smarter islanding controls enabled through fast communications and related standards need to be expedited for adoption.
- Microgrids have the capability to provide services to the larger electric grid through participation in wholesale energy and ancillary service markets. Present regulations do not allow behind-the-meter resources direct wholesale access, thus depriving microgrids of a value stream the technology is capable of accessing.

3.3 Success Stories

Among workshop participants with direct experience in operating or designing microgrids, they reported several success stories that future microgrid initiatives should leverage:

- Microgrids provide control and integration capabilities for renewables at the local level. This shields the larger grid from the effects of renewable variability and enables high penetration of renewables within the electric power system. Active microgrids such as those at Borrego Springs, Santa Rita Jail, and UCSD have demonstrated system operation with very high renewable penetration levels.
- Microgrids have demonstrated increased resiliency of local electricity supply under grid outages. This is particularly true for communities or loads vulnerable to high restoration times, such as Borrego Springs, which is supplied by a single long feeder. For loads with stringent reliability requirements, such as at the Santa Rita Jail, the microgrid concept has proven higher outage ride through capabilities.
- Local generation and storage within microgrids have demonstrated peak load reduction in the distribution system feeder, thus increasing the carrying capacity of the distribution system. Several large microgrids such as UCSD, 29 Palms, and MCIWEST are active in utility demand response programs, contributing substantially to demand reduction during periods of system stress.

- In certain instances, microgrids have prevented catastrophic grid failure by voluntarily providing grid support through over-generation. While this has not been implemented and recorded on a consistent basis, initial demonstrations have shown that large-scale implementation and coordination of microgrids for grid support has considerable scope for reducing widespread cascading grid failures.
- Microgrids have demonstrated increased efficiency in energy supply to local loads through management and optimization of generation and storage resources for electric and thermal needs. This has resulted in substantial reduction in emissions as compared to supplying local loads solely from the larger electric grid.
- Current RD&D efforts have demonstrated the efficacy of novel generation and storage technologies, controls and management systems and infrastructure. It has provided end user customer, utilities, universities, and vendors with experience in planning, implementation, and operation of microgrids and has enabled a vast body of knowledge and experience to move the microgrid concept towards widespread adoption and rapid commercialization.

CHAPTER 4:
Conclusions and Recommendations

The survey on microgrid barriers and the discussions during the microgrid workshop provide guidance for how to continue building on the successes and challenges that California's first microgrids have experienced. This section provides suggested areas to focus R&D efforts to facilitate a wider deployment and commercialization of microgrids. The recommendations are intended to guide research needs, future investments, and help identify issues that should be resolved to pave the path to broader commercialization of microgrids.

1. To identify benefits to the larger electric grid, a key issue is identifying the location on the distribution or transmission systems where microgrids may have the maximum benefit, or conversely, customer microgrid operation will not degrade the performance of the existing system. The CPUC procedures on distribution system planning (R. 14-08-013) address the question of 'optimal' siting of microgrids within the distribution system. It requires load-serving entities to file distribution resource plans that contain Distributed Energy Resource integration capacity analysis and locational benefit analysis. While the need has been identified, methods for determining the most valuable microgrid locations are still being developed and would benefit from additional research.

2. As a first step in addressing barriers regarding interoperability standards and operational guidelines, the Institute of Electrical and Electronics Engineers (IEEE) P2030.7 standards for specification of microgrid controllers represent important work in progress and an effort of great interest to microgrid commercialization. It seeks to enable interoperability of controllers and interfaces and promote platform neutrality. The Priority Action Plan (PAP) 24 (http://www.sgip.org/PAP-24---Microgrid-Operational-Interfaces) will focus on deriving standards and protocols for microgrid interaction with the larger electric grid. Specific additional recommendations following from the survey and workshop include developing or improving standards for:

    - Microgrid interoperability.
    - Energy management platforms, controls, and communication.
    - Islanding and reconnection.

3. Survey respondents and participants in the microgrid workshop expressed a strong desire to make more information available on microgrids to help electric systems operators, planners, and the public understand the values (tangible and intangible) that microgrids provide. Stakeholders recommended the following information and regulatory efforts:

    - Improve dissemination and availability of data on operations and performance of RD&D microgrids to facilitate a more complete understanding of microgrid benefits to customers.

- Closely examine the business cases (ratepayer cases) for utility ownership of microgrids as a means to enhance reliability, prevent outages, and defer distribution system investments.
- Simplify rules for microgrids and behind the meter assets to gain direct access to wholesale markets. This will likely require changes to California Independent System Operator (CAISO) communications requirements and also require that procedures for determining net-load baselines and auditing be established.
- Develop public health and safety standards for microgrid assets, as well as guidelines and best practices for their deployment and operation.
- Training and outreach to promote the microgrid concept among energy end users towards the goal of transforming energy consumers into 'prosumers'.

4. The most frequently cited barrier for microgrid commercialization is economic. As highlighted below, many stakeholders express a need to capture values provided by microgrids, such as improved reliability, islanding capability, lower emissions, and lower losses. There are a couple of examples where microgrids have been successfully commercialized despite these perceived barriers. The first example is in Solar City that has launched a turnkey microgrid-as-a-service offering for campuses with reliability needs greater than that provided by the distribution system. The service combines solar PV, electrical batteries, and backup generators as the enabling technologies controlled through a management console. The service offers financing through a pay-as-you-go and upfront capital purchase schemes. The standardized contract offerings are of great interest and present a solution to a significant barrier in microgrid commercialization.
5. Another example that addresses risks of being a first mover is the New Jersey Energy Resilience Bank that offers financial assistance and uptake of risk involved in deployment of first mover microgrids specifically designed to enhance the resilience of communities against catastrophic events pertaining to large grid outages. The financial incentives are deeply tied to verifiable performance measures of the deployed microgrid. Similar initiatives are being pursued in several states in the Northeast, such as New York, Massachusetts and Connecticut in the aftermath of Hurricane Sandy. These initiatives provide a framework for first mover government-based financing for microgrids capable of demonstrating tangible benefits to the society. As a result of the stakeholder survey and workshop, the following additional recommendations were made to address economic barriers:
    - Quantify benefits in energy efficiency and reliability to local loads by customer owned and operated microgrids.
    - Demonstrate and quantify system benefits in grid reliability and resiliency provided by utility-owned and operated microgrids, which could include:
        - Distribution system support for renewable integration or enhancing the carrying capacity.

    - Outage reliability to loads on the other side of the meter.
    - Grid black start.
    - Direct ramping services for the Regional Transmission Operator (RTO).
- Quantify distribution system services provided, wholesale market value.
- Utilizing microgrid performance data of operational microgrids to derive costs and benefits realized by the end user as well as the larger electric grid. These results will help identify the gap between financial analysis performed during the design phase and actual realizable operational financial performance. This effort will help identify the areas of focus in technology and controls needed to maximize the benefits of microgrids within present regulatory constraints.

GLOSSARY

Term	Definition
BMS	Building Management Systems
CAISO	California Independent System Operator
DG	Distributed Generation
CPUC	California Public Utilities Commission
DER	Distributed Energy Resources
DOD	Deparment of Defense
DOE	Department of Energy
EPIC	Electric Program Investment Charge
IEEE P2030.7	Institute of Electrical and Electronics Engineers Standard for the Specification of Microgrid Controllers
Microgrid	A group of interconnected loads and distributed energy resources with clearly definied electrical boundaries that acts as a single controllable entity with respect to the grid and can connect and disconnect from the grid to enable it to operate in both gri-connected or island mode
NAVFAC	Navy Facilities Engineering Command
RD&D	Research, Development, and Demonstration
RTO	Regional Transmission Oeprator
SMUD	Sacramento Municipal Utility District
UCSD	University of California San Diego

APPENDIX A:
Microgrid Assessment and Recommended Future RD&D Investments Survey

Microgrid Assessment and Recommended Future RD&D Investments (MARFI) Survey

1. Introduction

25%

Thank you for contributing your opinions to the California Energy Commission's Microgrid Assessment and Recommended Future RD&D Investments survey. The survey intends to gather information about challenges that the microgrid community encounters with a specific focus on technology development, cost and codes and standards.

The survey takes 15-20 minutes to complete. **Please submit the survey by January 13, 2015.**

1. Please enter your contact information.

Please enter your contact information. Name

Organization

Position

Email

2. Check here if you want to be put on a mailing list to be informed of the development of the Energy Commission's Mircrogrid Assessment and Recommended Future RD&D Investments (MARFI) plan.

☐ Check here if you want to be put on a mailing list to be informed of the development of the Energy Commission's Mircrogrid Assessment and Recommended Future RD&D Investments (MARFI) plan. Yes

3. Select what best defines your organization.

☐ Select what best defines your organization. Academic

- ☐ Consultant
- ☐ Microgrid developer
- ☐ End user
- ☐ Energy services provider, microgrid operator
- ☐ Engineering, Procurement, Contractor
- ☐ Environmental group
- ☐ Equipment provider
- ☐ Government
- ☐ Industry association
- ☐ Military
- ☐ National lab
- ☐ Utility
- ☐ Other (please specify)

***4. What is your experience with implementing microgrids*?**

- ☐ What is your experience with implementing microgrids*? Participated in microgrid design, development, financing and/or operation
- ☐ Theoretical understanding of microgrids but not participated in a project
- ☐ A supplier not yet successful selling into a completed microgrid project.
- ☐ Just beginning to understand microgrids

*The Department of Energy (DOE) defines microgrid as "a group of interconnected loads and distributed energy resources (DER) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid [and can] connect and disconnect from the grid to enable it to operate in both grid connected or island mode."

Next

2. Microgrid description

50%

Please enter as much details regarding the microgrid project(s) you have been involved in.

5. Please choose what best describes your level of experience with microgrids.

	California	Outside of California
Owner and/or operator of one or more microgrids	☐	☐
Constructed at least one microgrid	☐	☐
Provided equipment and design only for an operational microgrid	☐	☐
Developed plans for a microgrid that has not yet been implemented	☐	☐
A participant in microgrid design and development	☐	☐

Other (please specify)

6. What is the primary purpose of the microgrid?

	Primary purpose	Secondary purpose	N/A
Increase reliability or power quality	☐	☐	☐

	Primary purpose	Secondary purpose	N/A
Lower facility energy cost	☐	☐	☐
Increase revenue by selling electricity or services to utility or wholesale markets	☐	☐	☐
Reduce T&D losses or defer T&D capacity investments	☐	☐	☐
Reduce emissions of GHG or other pollutants	☐	☐	☐
Experimental/ demonstration	☐	☐	☐

Other (please specify)

7. Who are the end users of microgrid?

☐ Who are the end users of microgrid? Commercial
☐ Industrial
☐ Residential
☐ Mixed-use
☐ Military base
☐ University
☐ Other (please specify)

8. What are the capabilities of the microgrid? (Check all that applies)

☐ What are the capabilities of the microgrid? (Check all that applies) Provides back-up for 100% of critical load and most of non-critical load
☐ Provides back-up for only 100% of critical load minimal

- ☐ Demand response participation
- ☐ Advanced control for network reconfiguration and load balancing in islanded mode
- ☐ Microgrid controller enabling optimal economic operation while operating in parallel of the macrogrid
- ☐ Wholesale energy market participation
- ☐ Wholesale ancillary services market participation
- ☐ Other (please specify)

9. What are the technologies deployed at the microgrid(s)? (Check all that applies)

- ☐ What are the technologies deployed at the microgrid(s)? (Check all that applies) Integrated solar photovoltaic
- ☐ Integrated wind turbine generator
- ☐ Fossil-fuled based turbine generator
- ☐ Fuel cell
- ☐ Electric energy storage
- ☐ Thermal energy storage
- ☐ Electric vehicles (for demonstration only)
- ☐ Electric vechiles (Active multiple chargers)
- ☐ Microgrid controller
- ☐ Building energy management system
- ☐ Other (please specify)

You can go back to previous pages and update existing responses until the survey is finished or until you exit the survey. After submitting the survey, you will not be able to update existing responses.

Prev Next

3. Barriers

75%

This section is designed to allow us to understand the specific issues preventing microgrids from being deployed or hindering potential benefits from being captured. A straw-man list of barriers are provided below; however, if there is a barrier that is not on the list, feel free to utilize the comment sections below to describe a specific issue.

10. Technology barriers - Rate each barrier from 0 = not a barrier at all to 5 = Preventing deployment

	0	1 (low barrier)	2	3	4	5 (high barrier)
Maturity of plug-and-play **building system controls** technology for microgrid	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Maturity of plug-and-play **demand response controls** technology for microgrid	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Maturity of plug-and-play **microgrid system controls** to maintain stability of multiple generation assets	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						

	0	1 (low barrier)	2	3	4	5 (high barrier)
Maturity of plug-and-play **utility-level system controls** to minimize effort to island or rejoin the grid	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Other technology barriers	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						

11. Technical Knowledge barriers - Rate each barrier from 0 = not a barrier at all to 5 = Preventing deployment

	0	1 (low barrier)	2	3	4	5 (high barrier)
Lack of **standardized configuration** for different types of microgrid designs	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Lack of understanding in **how technologies (generation, storage, and building management systems) work together while operating in parallel** with the macrogrid	☐	☐	☐	☐	☐	☐

	0	1 (low barrier)	2	3	4	5 (high barrier)
Please describe the barrier and provide any recommendations to address the barrier:						
Lack of understanding in the **operation of different modes of microgrids** (eg. How to maintain stability within an isolated microgrid with limited generation? How to operate transitions between microgrid and macrogrid?)	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Lack of understanding in **end user behaviors for load reductions** to maintain microgrid stability	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Lack of understanding in **load forecasting** to optimize the economics of microgrid	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Lack of understanding in **weather forecasting** for generation requirements to optimize the economics of microgrid	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						

	0	1 (low barrier)	2	3	4	5 (high barrier)
Other technical knowledge barrriers	☐	☐	☐	☐	☐	☐

Please describe the barrier and provide any recommendations to address the barrier:

12. Training and Education barriers - Rate each barrier from 0 = not a barrier at all to 5 = Preventing deployment

	0	1 (low barrier)	2	3	4	5 (high barrier)
Lack of **experienced designers** of microgrids	☐	☐	☐	☐	☐	☐

Please describe the barrier and provide any recommendations to address the barrier:

Lack of **experienced operators** of microgrids	☐	☐	☐	☐	☐	☐

Please describe the barrier and provide any recommendations to address the barrier:

Lack of awareness and knowledge from **utilities**	☐	☐	☐	☐	☐	☐

Please describe the barrier and provide any recommendations to address the barrier:

	0	1 (low barrier)	2	3	4	5 (high barrier)
Lack of awareness and knowledge from **end users**	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Lack of awareness and knowledge from **regulators and policy makers**	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Other training and education barriers	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						

13. Codes and Standards barriers - Rate each barrier from 0 = not a barrier at all to 5 = Preventing deployment

	0	1 (low barrier)	2	3	4	5 (high barrier)
Lack of **common standards in areas such as safety and reliability**	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						

	0	1 (low barrier)	2	3	4	5 (high barrier)
Lack of **local codes and standards for permitting**	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Other codes and standards barriers	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						

14. Economics and Financing barriers - Rate each barrier from 0 = not a barrier at all to 5 = Preventing deployment

	0	1 (low barrier)	2	3	4	5 (high barrier)
High **cost microgrid isolation and stability controls** (eg. main transfer switch for islanding, master microgrid stability controller, and generation switchgear and controls)	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
High **cost of distribution automation technologies** (eg. Sectionalizing switchgear, remote switchgear control, automatic fault protection, and smart meters with data	☐	☐	☐	☐	☐	☐

	0	1 (low barrier)	2	3	4	5 (high barrier)
warehousing) Please describe the barrier and provide any recommendations to address the barrier:						
High **cost of communication infrastructure** (Costs from smart-grid enabled substation communication infrastructure up to the point of common coupling, i.e. the utility transformer.) Please describe the barrier and provide any recommendations to address the barrier:	☐	☐	☐	☐	☐	☐
High **cost for interconnection** Please describe the barrier and provide any recommendations to address the barrier:	☐	☐	☐	☐	☐	☐
Utility rates for standby services, wheeling, capacity charge and/or departing load charges Please describe the barrier and provide any recommendations to address the barrier:	☐	☐	☐	☐	☐	☐
Lack of **standardized method to establish the value and costs of microgrids** for evaluation for various stakeholders Please describe the barrier and provide any recommendations to address the barrier:	☐	☐	☐	☐	☐	☐

	0	1 (low barrier)	2	3	4	5 (high barrier)
Lack of **standardized method to evaluate the risks** of microgrid Please describe the barrier and provide any recommendations to address the barrier:	☐	☐	☐	☐	☐	☐
Lack of **standardized contracts** for microgrid make financing projects difficult Please describe the barrier and provide any recommendations to address the barrier:	☐	☐	☐	☐	☐	☐
The **existing retail electricity tariffs** do not allow all microgrid benefits to be moneteized Please describe the barrier and provide any recommendations to address the barrier:	☐	☐	☐	☐	☐	☐
Lack of **wholesale market access mechanism** to allow all microgrid benefits to be monetized Please describe the barrier and provide any recommendations to address the barrier:	☐	☐	☐	☐	☐	☐

	0	1 (low barrier)	2	3	4	5 (high barrier)
Lack of **government assistance**, such as Green Banks, to reduce first mover risk for the initial contract years	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Other economics and financing barriers	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						

15. Interconnection barriers - Rate each barrier from 0 = not a barrier at all to 5 = Preventing deployment

	0	1 (low barrier)	2	3	4	5 (high barrier)
Current interconnection rule impose limitations on microgrids	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
High cost to meeting interconnection requirements	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						

	0	1 (low barrier)	2	3	4	5 (high barrier)
The **adequacy of IEEE 1547.4** to address the integration of microgrids	☐	☐	☐	☐	☐	☐

Please describe the barrier and provide any recommendations to address the barrier:

Other interconnection barriers	☐	☐	☐	☐	☐	☐

Please describe the barrier and provide any recommendations to address the barrier:

16. Market Rules and Regulatory barriers - Rate each barrier from 0 = not a barrier at all to 5 = Preventing deployment

	0	1 (low barrier)	2	3	4	5 (high barrier)
Lack of **regulatory definition of an allowable non-utility microgrid owner**	☐	☐	☐	☐	☐	☐

Please describe the barrier and provide any recommendations to address the barrier:

Lack of **service and billing rules for non-utility microgrid**	☐	☐	☐	☐	☐	☐

Please describe the barrier and provide any recommendations to address the barrier:

	0	1 (low barrier)	2	3	4	5 (high barrier)
Lack of **clearly defined roles and responsibilities between the microgrid operator and utilities**	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						
Other market rules and regulatory barriers	☐	☐	☐	☐	☐	☐
Please describe the barrier and provide any recommendations to address the barrier:						

17. Please comment on any additional barriers that are preventing you from deploying microgrids. For example, you may describe how a technology, rule, standard, and/or process affect your project specifically.

Please comment on any additional barriers that are preventing you from deploying microgrids. For example, you may describe how a technology, rule, standard, and/or process affect your project specifically.

You can go back to previous pages and update existing responses until the survey is finished or until you exit the survey. After submitting the survey, you will not be able to update existing responses.

Prev Next

4. Additional Comments

100%

This section is designed to allow for additional comments regarding the barriers and recommendations you identified. Please keep in mind that the purpose of this effort is to gain a deeper understanding of the specific barriers hindering the deployment of microgrids and how statewide RD&D investments may enable more microgrids to proliferate in California.

18. What type of technologies or technical knowledge investments are needed to make it easier to plan, develop, fund, install and operate a microgrid?

What type of technologies or technical knowledge investments are needed to make it easier to plan, develop, fund, install and operate a microgrid?

19. What technology or process change will reduce the cost of microgrids?

What technology or process change will reduce the cost of microgrids?

20. What rules and regulations will assist in more rapid deployment of microgrids?

What rules and regulations will assist in more rapid deployment of microgrids?

21. Additional Comments:

Additional Comments:

You can go back to previous pages and update existing responses until the survey is finished or until you exit the survey. After submitting the survey, you will not be able to update existing responses.

Prev Done

Thank you for completing our survey! Please be informed that the California Energy Commission is planning to host a public workshop about Microgrid Assessment and Recommended Future RD&D Investments (MARFI) on January 27, 2015. The purpose of the workshop is to present the preliminary results of this survey on microgrid deployment barriers, and to solicit additional input to help identify RD&D gaps to guide future investments by the California Energy Commission.