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feedback on the CEC microgrid roadmap

I have attached my feedback on the CEC roadmap. In general, it is an excellent document and covers much of the issues relating to the deployment of microgrids. I would offer one point and that would be to include something that identifies the difference between a commercial/Industrial and residential microgrids. There are a number of players in the residential side looking to develop the opportunity.

I would also suggest including a discussion on the impact of IoT/demand response on the grid and its potential impact. The more demand response is implemented the greater impact on the Duck-Curve.

See the end of the documents for additional comments

Additional submitted attachment is included below.

ROADMAP FOR COMMERCIALIZING MICROGRIDS IN CALIFORNIA

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EXECUTIVE SUMMARY

Microgrids have been operating in California for several decades in one form or another, and have the potential to be an excellent tool to assist the utilities in California and the California Independent System Operator (ISO) to address some of the grid management challenges of the future. Microgrids can control their internal load and generation sources and respond to the grid as a single point of interconnection. This is helpful when the grid is experiencing challenges from variable generation such as wind or solar or weather conditions which create rapid changes in the load as distribution level generation, primarily solar rooftop PV, fluctuates in the energy being provided to the grid.

California has some of the most aggressive clean energy policies in the nation. From the transition of large primarily natural gas fired central power plants to a future grid that will obtain more than 50 percent of its electricity from renewable resources, the electric grid is under a significant shift from the classic configuration of a high concentration of larger central power plants. This new mixture of renewable energy generation resources includes a high amount of distributed energy resources (DER).

California Legislature, Senate Bill 350, commits California to reduce 2030 greenhouse gases by 40% below 1990 levels; increases renewables to 50% of the share of energy production; doubles efficiency targets; and encourages widespread transportation electrification. Assembly Bill 327 requires reform of utility distribution planning, investment, and operations to "minimize overall system cost and maximize ratepayer benefits from investments in preferred resources".

In support of the state policy goals, staff from the California Energy Commission (Energy Commission), California Public Utilities Commission (CPUC) and California ISO formed a team to develop this *Roadmap for the Commercialization of Microgrids in California*. Where California has very aggressive energy goals and has set specific targets for renewables, energy efficiency, demand response, energy storage, and others, there is no specific policy or energy target established for microgrids. This roadmap is being developed because microgrids as a potential end customer energy solution provides those customers and the grid operators unique services and has the potential to be a useful method to help California reach its future energy goals.

For this roadmap, a microgrid is defined as:

> *A single or group of interconnected loads and distributed energy resources (DER) within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. Additionally, a microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode. Finally, microgrids can also manage customer critical resources and provide the customers, utilities and grid system operators different levels of critical services and support as needed.*[1]

[1] Energy Commission GFO 17-302

After providing a brief Introduction chapter, the roadmap is divided into two sections, the Key Issues Facing Commercializing Microgrids in California and the specific roadmap actions needed to assist in the commercialization of microgrids in California. The roadmap singles out California instead of the nation because in meeting California's aggressive energy goals, California is moving away from fossil fuel systems that use diesel backup generators and natural gas power generation. Those systems are popular elements of microgrids outside of California; however, those fossil fuel powered generation systems are not preferred as sources of generation for microgrids in California.

In Chapter 2: Key Issues Facing Commercializing Microgrids in California, this roadmap identifies six areas where future work needs to be addressed. They are:

- How Microgrids Operate and their Value
- Improving the Electric Grid with Microgrids
- How Microgrids Can Play a Role in Implementing the Policy Goals
- How Microgrids Can Support California's Policies to Permit High Concentration of DERs on the Grid
- How Do Microgrids Operate in the Current California Regulatory Framework and
- Microgrid Technical Challenges.

The chapter reviews the unique capabilities a microgrid offers in these areas and specific future actions that can help transition microgrids from a current state of being a promising emerging technology solution to a successful commercial product that helps California meet its future energy goals and provides end customers new ways to manage their individual energy needs. In Chapter 3: Roadmap Actions, the roadmap identifies 27 action items that address the issues raised in Chapter 2. The staff from the three state agencies, with help from the participants from the public workshops, will develop a strategy on how to address these actions and will hold routine reviews (typically annually) to report on the status of addressing the completion of the activities necessary to address the commercialization of microgrids in California.

Note: If needed, insert a blank page so that Chapter 1 begins on the right.

CHAPTER 1: Why Microgrids Are Important to California

California has some of the most aggressive clean energy policies in the nation. From transition of large primarily natural gas fired central power plants to a future grid that will obtain more than 50 percent of its electricity from renewable resources, the electric grid is under a significant shift from the classic configuration of a high concentration of larger central power plants. This new mixture of renewable energy generation resources includes a high amount of Distributed Energy Resources (DER).

California Legislature, Senate Bill 350, commits California to reduce 2030 greenhouse gases by 40% below 1990 levels; increases renewables to 50% of the share of energy production; doubles efficiency targets; and encourages widespread transportation electrification. Assembly Bill 327 requires reform of utility distribution planning, investment, and operations to “minimize overall system cost and maximize ratepayer benefits from investments in preferred resources.” In 2016, the California Public Utilities Commission (CPUC) initiated the California’s Distributed Energy Resources Action Plan and developed working groups to help implement the transition to this new grid system. The Energy Commission is assisting the CPUC in their working group activities through research efforts under the Electric Program Investment Charge (EPIC) Research and Development Program and by leading a three agency working group (Energy Commission, CPUC, and the California Independent System Operator (California ISO)) to develop a Roadmap to Commercialize Microgrids in California. Microgrids are considered one of the most effective methods to help integrate DERs on the grid and at the same time provide grid operators more control of DER resources.

The CPUC has also initiated public rulemaking processes for energy storage, demand response, smart inverters, electric vehicle integration, and time-of-use rate development. Interagency roadmaps have also been developed for demand response, energy storage and vehicle-grid integration. This microgrid roadmap will provide information to illustrate how microgrids can play a key role in helping California meet the aggressive policy goals.

What Is A Microgrid?

Microgrids have been operating in California for several decades in one form or another, and have the potential to be an excellent tool to assist the utilities in California and the California ISO to address some of the grid management challenges of the future. Microgrids can control their internal load and generation sources and respond to the grid as a single point of interconnection. This is helpful when the grid is experiencing challenges from variable generation such as wind or solar or weather conditions which create rapid changes in the load as distribution level generation, primarily solar rooftop PV, fluctuates in the energy being provided to the grid.

For this roadmap, a microgrid is defined as:

> *A group of interconnected loads and distributed energy resources (DER) within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. Additionally, a microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode. Finally, microgrids can also manage customer critical resources and provide the customers, utilities and grid system operators different levels of critical services and support as needed.*[2]

Microgrids are more than just a smaller version of the primary electric grid. Figure 1 provides an example of a microgrid designed to support a small community. The system has several sources of electricity, such as wind power systems, solar energy and a traditional grid substation. This microgrid also includes several energy storage systems that provide the microgrid energy to operate when the primary source of energy is not operating at full capability. The system has a microgrid controller that manages all the assets in the microgrid and determines which systems will operate and how long they are needed to operate to ensure the end customers have the electricity they need to perform their daily activities. This diagram shows how a large and diverse source of energy generation can be managed to support customer loads that vary with time and condition. Additionally, the microgrid controller can determine if the system has excess energy capacity that can be provided to the utility grid to support the needs of that grid at the same time. When properly designed and managed, microgrids can provide superior services to their end customers, and when the conditions are right, provide added services to the utility that services them. This illustrates the key value that a microgrid offer to the overall utility system—the ability to manage their own customer load and at the same time, be able to respond to time critical needs of the utility grid they rely upon.

Microgrids operate as subsets of the larger regional electric power grid. They include at least some power distribution connections between the utility interconnection point and the buildings or other loads being served. Microgrids also include some form of controllable power generation on the customer side of the utility's meter. When the utility grid is in service, a microgrid can operate its generator synchronized to the utility grid.

When the utility grid fails, the same microgrid can operate autonomously. Microgrids typically have a single interconnection point with the utility grid and a contract governing such things as technical requirements for safe interconnection, capacity limits for exporting and importing power, maintenance responsibilities, communication protocols, applicable tariffs and billing terms.

As explained in the CPUC White Paper, *Microgrids: A Regulatory Perspective*, a microgrid can be as simple as a single generator providing power during an outage, or as robust as an entire neighborhood outfitted with solar and other technologies producing enough electricity to serve their local needs for hours, whether or not there is a grid emergency or blackout. In these instances, customers are seeking two primary services: reliability and resiliency.

Additionally, many customers are seeing the potential benefits of investing in their own

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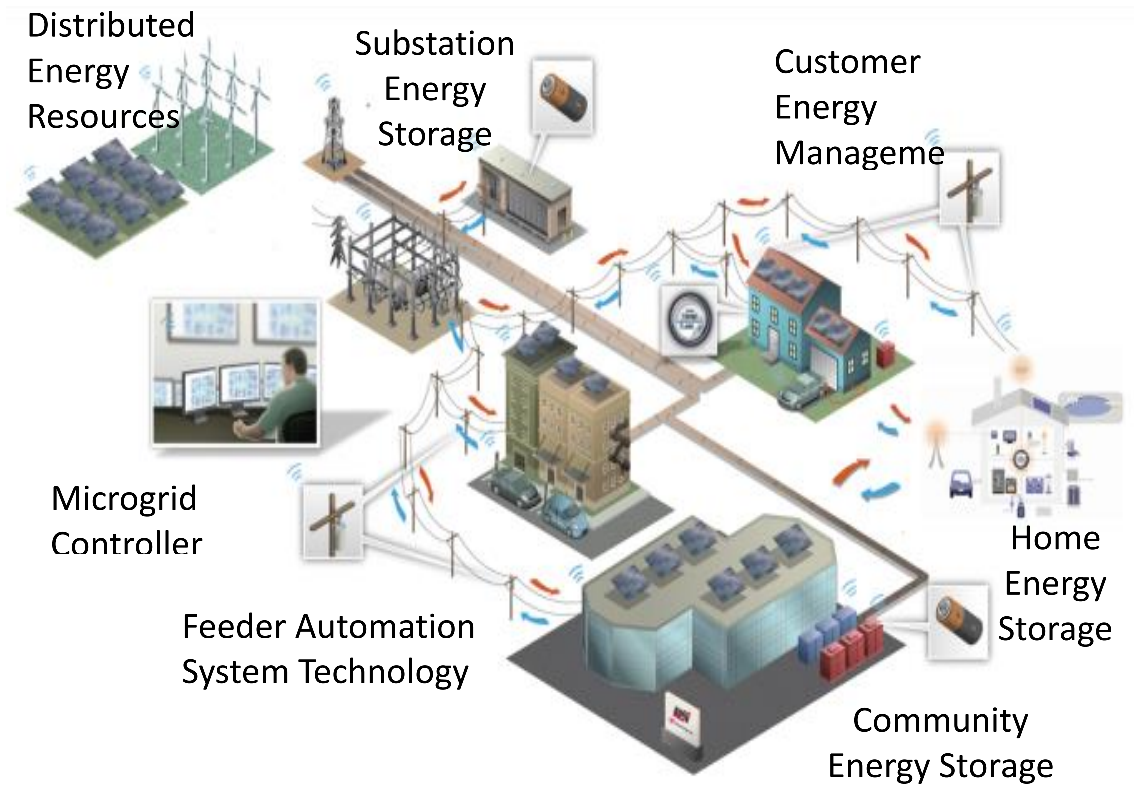
[2] Energy Commission GFO 17-302

technologies to both ensure their own level of reliability, but also to better manage their own usage. The interaction between the customer side efforts and the electric grid is still in its infancy, but managing the grid remains the responsibility of the utility.

Figure 1: Borrego Springs Microgrid



Source: SDG&E

Utilities, and their regulators, are entrusted with the duty to provide electricity that is reliable and safe to their customers, but the historical method by which that was achieved is beginning to change. It is imperative for utilities to provide safe and reliable electricity and ensure the system is more resilient and secure to deliver electricity.

The reliability and resilience demands are determined by the individual customer sites such as hospitals, police/fire, water/wastewater systems, and emergency facilities. By allowing the customer or microgrid operator to manage itself according to its needs, and then acting as an aggregated single entity to the distribution system operator, allows for a number of innovations and custom operations; the interconnect point must only know whether power requirements are to be sent into the microgrid or whether power is flowing out.

Microgrids can overcome the challenges of grid-scale integration by using distributed energy resources, as a "local portfolio" that can be managed at a distribution level and based on local conditions. Operating the distribution system at the local level (customer or load level) is simplified and improved by integrating microgrids into the electricity grid.[3]

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[3] California Public Utilities Commission, White Paper on *Microgrids: A Regulatory Perspective*, April 14, 2014.

CHAPTER 2: Key Issues Facing Commercializing Microgrids in California

How Microgrids Operate and their Value

Now, more than ever, energy consumers have the ability to manage their energy consumption along with their potential to generate and store energy. Solar PV costs continue to decline and more recently, electricity storage in the form of batteries is following the same path of downward costs. These cost reductions, combined with advances in inverters and power control capabilities, have given consumers new opportunities to best meet their individual energy needs while adding increased energy reliability and resiliency in case of grid disturbances. More and more, major installations, university campuses, military installations and others are transitioning to the use of microgrids to meet their energy needs while having more control on their direct operations than when under the control of only the utility. These examples demonstrate early-on the value of microgrids in a real-world environment.

Microgrids by definition are a separable group of consumer level loads and generation that meet the cohesive need of a single owner, managed and organized in such a manner that these systems can be integrated into a single electrical system that works in unison like an orchestra or finely tuned machine. Microgrids operate by having some form of open communication between the systems connected onto the microgrid so that the system operator has the ability to make overall management decisions on the performance of each system within the microgrid. During normal operations, the microgrid can be operated in a manner that maximizes value to the end user and ensures efficient overall operation of the systems connected to the microgrid. In times of grid disturbances, the microgrid can ensure the components of the microgrid are receiving the energy services they need to operate and when necessary, the microgrid can separate from the utility grid and operate in an islanded mode for a short time or extended periods of time depending on the capabilities inherent to a specific microgrid. Some microgrids can operate in the island mode for hours and others for days based on the needs of the microgrid customer. When conditions on the utility grid return to normal, the microgrid can reconnect to the utility grid and return to normal operations.

The operation of the microgrid is normally determined by the needs of the primary customer or end-user. There is clearly an added cost to design, install and operate a microgrid. The end-user who makes this investment normally has a history of energy issues or specific energy needs that justifies the cost and effort to install and operate a microgrid. The economic decisions to make the transition to a microgrid are explained later in this document. Not only do microgrids provide value to the microgrid owner, but they can also play a role in helping California meet existing and future energy demands and policy goals in these areas:

- Increased use of renewable power generation (solar/wind);

- Greenhouse gas (GHG) reduction;
- Supporting the goals of distributed energy resources (DER);
- Promoting energy efficiency (EE) goals;
- Supporting storage deployment goals; and,
- Supporting transportation electrification goals.

Normally, a microgrid is not developed and operated to provide distribution or transmission level grid services, once a microgrid is operating, the owner/operator has the flexibility to provide some or all of the utility grid services mentioned above. Currently, there is no indication that a microgrid in California has been designed, built and operated for the sole purpose of supporting the utility grid. In many cases, existing microgrid owners/operators have explained that the more of these added services a microgrid can support, the better the commercial business case is for that microgrid.

The true value of the microgrid is defined by the individual, organization or team that went through the effort to design, construct and operate a microgrid. Several studies have been completed, and research efforts have been sponsored by the California Energy Commission that highlight three top values that early adopters to microgrids in California identify as for the reason they made the effort to build and operate a microgrid. They are:

1. **Reliability**. The owner or end user either experienced a serious reliability issue in the past that they did not want to repeat, or based on information from similar industry members, they did not want to have such a reliability issue in the future.
2. **Reduce Energy Costs**. These owners, end users indicate the next priority is to get control of their energy costs. The microgrid provides opportunities to address load leveling, energy conservation, and participate in energy programs like demand response, ancillary services and other utility grid support services.
3. **Expansion of Renewable Energy**. In California there are incentives and grant programs to help reduce or defer the cost of installing these systems in order to meet ambitious state goals.

One of the significant challenges to the future commercial growth of microgrids is lack of detailed information on the above three and other value streams generated by microgrids. During the public workshops conducted in the development of this roadmap, the need was identified for a clear definition of these value streams, how the value streams can be monetized and have the state of California provide assistance in helping interested parties pursue microgrids by providing example business cases, guidebooks and lessons learned and other documents to help individuals and organizations determine when microgrids are right for them.

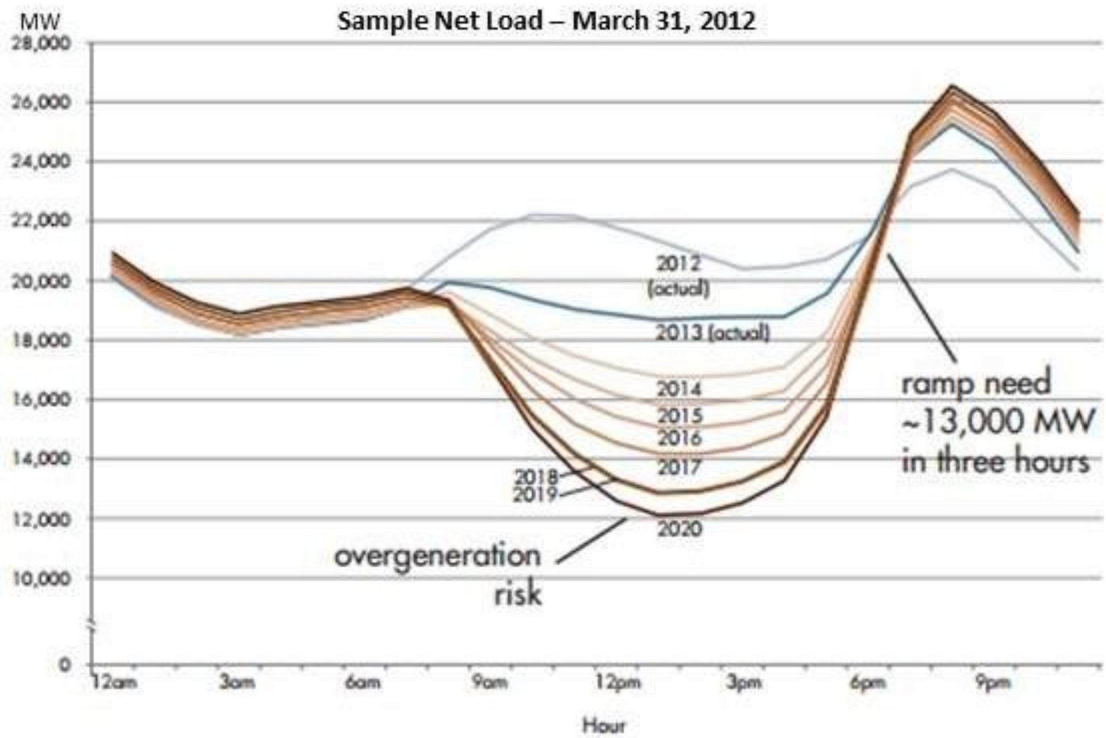
Improving the Electric Grid with Microgrids

California policy makers are making California one of the most aggressive states in the country when it comes to the transition to clean energy. Aggressive goals require the California Electric Grid to obtain 33 percent of its energy by renewable sources by 2020 and 50 percent by 2030. At this same time, the state is looking to provide very aggressive energy efficiency improvements, expand the system wide demand response capabilities, integrate a large number of zero emission vehicles and maintain a grid that supports all the customers in California with high reliability and resiliency. Currently, the most dynamic element of these changes is the transition to high concentrations of renewable energy. Where there are aggressive goals, the progress the California utilities have made over the last decade has been impressive.

> *"In California, it's already a reality," said Steve Berberich, president and CEO of California Independent System Operator Corporation. On a typical day, CAISO will pull about 30,000 megawatts of energy production, with around 6,500 megawatts from solar, 5,000 megawatts from wind and another 5,000 from geothermal and other services on the system. In addition, California's grid system has roughly 4,000 megawatts of behind-the-meter solar, which is growing at a rate of about 70 megawatts per month.*
>
> *"On any given day, California gets more than 30 percent of its electricity from renewable energy. On many days that amount climbs to 40 percent, and on some days renewables reach 50 percent," said Berberich.*
>
> *"Now we have to think about the system as a renewable-energy-based system complemented by other things," he said, speaking at the Edison Electric Institute's annual convention this week in Chicago.* (GTM Article June 16, 2016)

As California continues to transition to a renewable energy future, there are substantial challenges in managing the electric grid to support this high concentration of renewable generation. For years, the California ISO has expressed the challenge facing California by the use of the "Duck Curve". The energy net load chart shows clearly how the future grid will have energy ramping down challenges in the morning hours as solar generation materializes, over supply generation conditions during the midday, and ramping up challenges in the evening as the sun sets and consumers go home and increase their electrical load and set the day's peak demand. While this graphic was created to show potential future operational challenges brought on by integrating high percentages of renewable generation into the grid, it can be noted that during certain times of the year, the ISO has begun to experience conditions ahead of this forecast. For example, on May 15, 2016, the ISO experienced a net load of 11,663 MW and on December 18, 2016, the ISO experienced an afternoon 3 hour ramp of 12,960 MW. While these conditions are not consistent throughout the year, it is clear that these conditions are beginning to materialize faster than anticipated, particularly in the spring months when consumer loads are lower and renewable generation output is high.

Figure 2: The Duck Curve



The duck curve shows steep ramping needs and overgeneration risk.

Source: California Independent System Operator

Microgrids have the potential to provide a unique way to assist the grid during these times of challenges. In addition to the larger concentration of renewables on the California Electric Grid, the grid generation sources are transitioning from classical large central natural gas power plants to more and more distributed energy resources (DER). This further complicates the California ISO energy management challenges unless the ISO can gain better visibility into the operational impact of DER as it offsets distribution loads. This transition is already happening in southern California with the closing of the San Onofre Nuclear Generating Station (SONGS) and the large scale natural gas leak from the Aliso Canyon Natural Gas Storage Facility. Both if these unexpected events resulted in large amounts of DER being brought on line to replace the capabilities lost as a result of these incidents. Additionally, PG&E has announced a plan to close down the Diablo Canyon Nuclear Power Plant and replace its capability partially with new DER systems on the grid. All these challenges offer new opportunities for microgrids to provide services to support the California Electric Grid. A challenge that microgrids face is that they are still considered experimental or developmental in many key decision maker minds. Clear and easy- to-use business cases do not exist for end users to make informed decisions on if a microgrid is the right choice for them. The long-term performance of microgrids, including all of their technical and operational components have not been demonstrated for decades like the other generation alternatives that are operating today in California.

In addition to electric grid reliability, resilience (the ability of a system to recover and, in some cases, transform from adversity) is a growing concern expressed by many in the utility industry.

The National Infrastructure Advisory Council (2009, 8) defines critical infrastructure resilience as:

> *"…The ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event.* [4]

One of the primary characteristics of a microgrid is the ability to "island" or disconnect from the area electric power system (EPS), and continue to provide power to its customers during events when either the EPS is down, or there is a fault condition on the local distribution feeder. Building a microgrid around a combined heat and power system (CHP) that is providing power to a campus, for example, can result in resilient facilities that can ride out even extremely disruptive events. The ability to island can also be effective if distribution feeders are partitioned in order to isolate faults. Sections of a distribution feeder can safely be kept energized by islanding feeder sections using power electronics technology, while isolating the section where the fault occurs. This allows crews to work safely to restore the fault condition, while maximizing the number of customers that continue to receive power. [5]

For microgrids to be able to provide these services and assist the California Electric Grid in the future, there are several key actions that need to happen:

- Microgrids must be considered a commercial solution that can be accurately planned, constructed, and operated.
- More field experience is required from a wider variety of microgrids to demonstrate capability, value, and effectiveness.
- Easy to evaluate business cases must be made available to individuals and organizations who want to consider microgrids in the future.

How Microgrids Can Play a Role in Implementing the State's Policy Goals

To address how microgrids can help California meet future policy goals, we need to look at the different capabilities and features microgrids offer. Microgrids are able to increase the concentration of renewables, DER, electric vehicles, energy efficiency, and demand response. Microgrids can help grid operators manage their systems by being able to rapidly reduce their load or by being able to accept over generation from the utility grid. Some of these unique microgrid values are explained below.

Microgrids Can Increase the Penetration of Renewables on the California Electric Grid

[4] Aaron Clark-Ginsberg, Stanford University, *What's the Difference between Reliability and Resilience?*

[5] California Public Utilities Commission, White Paper *Microgrids: A Regulatory Perspective*, April 14, 2014.

DNV GL completed a research assessment on microgrids under contract to the California Energy Commission. In that effort, they identified an important societal benefit of microgrids 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.[6]

As explained in the CPUC staff Microgrid White Paper, microgrids fundamentally rely on integrated control systems to coordinate distributed generation including intermittent renewables, with storage units and/or demand response operations.

Microgrids are able to overcome the problems of grid scale integration by using distributed energy resources as a "local portfolio" that can be managed at a distribution level, based on local conditions. Further, operating the distribution system at the local level (customer or load level) is simplified and improved by the integration of microgrids into the electricity grid.

From a management standpoint, customer side resources today are not usually visible to either the ISO or to the DSO. Microgrids change that equation to the degree that they participate in wholesale markets as described above, or provide EPS services (such as volt/VAR control) to the DSO. Individual distributed energy resources that comprise the microgrid, along with controllable load, can be dispatched to serve the local load and generator output conditions, while appearing as an aggregate resource to the ISO or DSO. This will allow the ISO or DSO to use the microgrid as a resource for the macrogrid, without being concerned with the details of operation or having visibility into the internal operation of the microgrid. Similarly, the microgrid management system can help provide distribution level services as part of a distributed control system. Individual resources, such as smart inverters that can supply reactive power or voltage support, can be controlled at a more local level. This functionality saves the engineering cost and need for monitoring that more centralized distribution system management implementation requires. [7]

Microgrids Can Support California's Policies to Permit High Concentration of DERs on the Grid

Microgrids fundamentally rely on integrated control systems to coordinate distributed generation including intermittent renewables, with storage units and/or demand response operations. These resources are known collectively as distributed energy resources (DER). Management of these resources as a microgrid allows for a single connection point with the distribution system. Reliability and resilience are dealt with locally, so that needs are determined by the individual customer sites. By allowing the customer or microgrid operator to manage itself according to its needs, and then acting as an aggregated single entity to the distribution system operator, a number of innovations and custom operations are possible. The interconnect point only needs to know whether power should be sent into the microgrid or whether power is flowing out. Microgrids are able to overcome the problems of grid-scale

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[6] DNV GL, *Microgrid Assessment and Recommendation(s) to Guide Future Investments*, July 2015.

[7] California Public Utilities Commission, White Paper *Microgrids: A Regulatory Perspective*, April 14, 2014.

integration by using DER as a "local portfolio" that can be managed at a distribution level, based on local conditions. Further, operation of the distribution system at the local level (customer or load level) is simplified and improved by the integration of microgrids into the electricity grid.[8]

How Do Microgrids Operate in the Current California Regulatory Framework?

As previously mentioned, there are no specific California regulatory directives requiring microgrids to be used by the California utilities or the California ISO. Additionally, there are no California laws or Governor's Executive Orders directing specific actions for microgrid use. This roadmap is being developed to address the commercializing microgrids because microgrids provide the industry a solution that, when appropriate, can be more effective, lower cost, or better overall solution than other current alternative solutions. While there are no regulatory actions and proceedings addressing microgrids, there are numerous regulatory actions addressing elements of microgrids or actions that will impact microgrids in the future, including these actions:

CPUC Interconnection Proceeding (R.17-07-007 (active) and R.11-09-011 (inactive))

- The application, technical review, and interconnection processes for each interconnection within a microgrid are the same as those for typical distributed generation interconnections under Rule 21.
- Currently, CPUC's interconnection rules (Rule 21) do not include a standard for DC metering. The Commission may consider whether to adopt such a standard in R.17-07-007. If adopted, a DC metering standard may streamline the interconnection process and lower interconnection costs for DC microgrid applications.

CPUC Energy Storage Proceeding (R.15-03-011)

- Up to 1,325 MW of storage by 2020, plus up to 500 MWs per AB 2868 (2016)
- Policy Objectives: Integrate of renewable energy sources
- Benefits: Smooth transition to islanded operation and provides energy supply for the microgrid

Distributed Resources Plans Proceeding (R.14-08-013)

- The goal of the Distribution Resource Plans (DRP) proceeding is to move the state towards a high- penetration distributed energy resource (DER) future that accomplishes the goals of making the grid greener and producing ratepayer benefits.

Formal proceeding documents are found using the Rulemaking numbers listed above.

The Distribution Resource Plan Proceeding has authorized two microgrid projects. The goal is to develop a demonstration project where the utility would serve as a distribution system operator of a microgrid where DERs serve a significant portion of customer load and reliability

[8] California Public Utilities Commission, White Paper *Microgrids: A Regulatory Perspective*, April 14, 2014

services. These are the Borrego Springs microgrid in the SDG&E territory and a microgrid in the norther area of Mono County in SCE's territory.[9]

AB 2514 (2010), which was the precursor to the 1,325 GW procurement target specified the following policy objectives: integrate renewable energy sources, reduce GHG emissions, reduce the need for new fossil-fuel powered peaking generation, eliminate or reduce transmission and distribution losses, reduce the demand for electricity during peak periods, avoid or delay investments in transmission and distribution system upgrades, and provide ancillary services. AB 2868 (2016) dictates the following policy objectives: achieve ratepayer benefits, reduce dependence on petroleum, meet air quality standards, reduce emissions of greenhouse gases, and prioritize low income and public facilities.

Citing the benefits of energy storage for reducing greenhouse gas emissions, providing grid support and promoting market transformation, California regulators have doubled incentives for the Self-Generation Incentive Program (SGIP), giving the lion's share to energy storage funding.

The Self-Generation Incentive Program (SGIP) provides financial incentives for the installation of new qualifying technologies that are installed to meet all or a portion of the electric energy needs of a facility. The SGIP contributes to greenhouse gas (GHG) emission reductions, demand reductions, and reduced customer electricity purchases, resulting in the electric system reliability through improved transmission and distribution system use; and market transformation for distributed energy resource (DER) technologies.[10]

The CPUC developed the DER Action Plan as a roadmap in 2016 to integrate DERs into the state's electrical power system to reduce GHG emissions and to maximize DER grid value. Microgrid services that support the Action Plan include:

- Increasing the amount of renewable power that reduces GHG;
- Providing resilient and reliable sources of power during outages; and
- Reducing power generation when necessary.

The CPUC White Paper *Microgrids: A Regulatory Perspective* discusses the distribution interconnection rules that have been established by the Commission. The White Paper recognizes three types of generation interconnection: net metering, self-generation (non-export), and wholesale distribution access tariff (WDAT). It is important to note that none of these interconnection techniques support a general advanced microgrid, yet all require the approval of the utility. A net metered microgrid could not support energy sharing, although virtual net metering supports multiple users behind a single point of common connection.

Furthermore, existing laws and rules limit the ability of a customer to purchase electricity from any provider other than the incumbent utility. Also, with electricity produced by net-metered resources, a microgrid could not be islanded under current rules because net-metered systems have to power down in the event of an outage or grid failure.

[9] California Microgrid Scoping workshop, July 26, 2017

[10] SGIP Handbook, Center for Sustainable Energy, 2017

In most of the United States, the existing distribution system is owned and operated by a monopoly DSO, usually under a local franchise agreement. This was considered to be essential in the early days of electrification because communities wanted to reduce the amount of redundant infrastructure. The monopoly ownership and control of the existing distribution infrastructure creates a problem for independent microgrid development because the DSO is the gatekeeper for modifications to that infrastructure. This is the case both practically and in regulation. The DSO is responsible for safety, cost and operational stability.

However, utility control of the distribution system can be addressed by regulators in a variety of ways. If a comprehensive site survey is done to determine optimal sites for microgrids, the distribution grid characteristics in the optimal sites can be modeled using automated grid simulation and power flow modeling tools. This approach streamlines the engineering effort required to address the impact of modifications that may be required for microgrid development. A comprehensive model of the distribution grid that enables simulation and modeling will be required in any case to streamline any distributed generation implementation. Expanding the simulation capability to include microgrid modeling would give greater flexibility from a policy standpoint.

A second option for regulators would transform the role of the utility into a DSO responsible for ensuring the available capacity for distribution of electricity generated either behind the meter, connected on the utility side, or flowing from the transmission grid. The DSO would be able to determine appropriate costs for both interconnection and delivery of electricity traveling over the distribution grid. This approach would allow the customer and other service providers to offer additional products and services in support of a microgrid. It would also ensure that the utility, as DSO, is able to schedule and dispatch the two way flow of electricity, as well as manage the stability of the distribution system. The DSO approach also addresses the potential loss of revenue as the utility would now be responsible for the maintenance and operation of the infrastructure and be allowed to earn a rate of return on those assets. This might ultimately lead to a fixed price calculation for access and use of the distribution grid. In this case, the cost to the microgrid operator for using the distribution grid infrastructure is based on the actual operation and maintenance costs, plus a rate of return for the distribution system operator. A fixed cost structure, or “rent,” to use the distribution infrastructure would simplify the project planning process for developers and potentially lower costs for customers.

Reducing cost and complexity of integration of distributed resources into the distribution system is a primary policy goal. Reducing barriers to owning and operating coordinated sets of resources that make up a microgrid should also be included as a policy goal, since microgrids may provide the benefits of greater reliability and resilience, as well as lowered cost of integration for intermittent, distributed renewable generation and storage. Regulators can work with utilities to make identified areas of the distribution grid available for development and fix the costs of development (interconnection and safety upgrades), based on the characteristics of those areas. Further, regulators can work with utilities to fix the costs of operation and maintenance of the identified areas, so that those costs can be built into the rates offered to customers in those areas. Ensuring that the utility costs are recovered and are not stranding assets, as well as making the utility indifferent to the presence of microgrids, should be major policy goals as well.

Emerging Role of State Regulation in Microgrid Development

State utility commissions must play a role in enabling the development of microgrids as part of the larger process of grid modernization. Grid architectures and the governing standards will define how the technical interfaces function. Regulatory requirements will follow in order to define the framework for financial transactions that occur among the various parties involved with the microgrid. However, microgrid architectures and technical standards must adhere to requirements for reliability, environmental protection, safety, security, and resilience as defined by state legislatures and public utility commissions. Ultimately, the interests of both society and the ratepayer must be served, in part, through the development of new transmission and potentially new distribution markets with a robust competitive framework.

Robust microgrid standards and an open architecture will allow for competition among system components vendors. To support interoperability of components, systems must support standard interfaces and communications. The microgrid standards should also enable developers to fashion value propositions that reduce cost and offer flexibility to the end user. Finally, the standards should allow the broadest flexibility possible to the existing utilities to incorporate microgrids into their operations while expanding the ability of the customer to access options and appropriate price points for the level and type of service received.

The role of standards cannot be understated. Standards can be used to ensure the microgrid has the technical ability to physically interconnect and operate with the utility distribution grid, as well as ensuring that all system components use the same set of interfaces. With regard to the physical interconnection of components to the microgrid, ensuring open standards and access for these products and services will enable them to be valued at an appropriate price. Standards such as these will enable service providers and customers to evaluate costs and services on an “apples to apples” basis.

The regulator can help with developing, adopting, and implementing the “rules of the road” for microgrids. These rules of the road can include the engineering specifications (*e.g.*, specific technical standards, such as IEEE 1547 or IEC 61850), the communication requirements (*i.e.*, what protocols will be used for communications between the microgrid and the distribution grid), information exchange (*i.e.*, what information needs to be exchanged between the microgrid and distribution grid), and additional monitoring, control, and telemetry requirements, which may include California ISO requirements. [11] A similar process is being carried out at the CPUC to implement Smart Inverters and define what capabilities they should have.

Technical Challenges Facing Microgrids

[11] California Public Utilities Commission, White Paper *Microgrids: A Regulatory Perspective*, April 14, 2014.

Microgrids provide end customer critical reliability, resilience, and operational services. They have the potential to offer lower cost energy and permit end users to participate in utility programs and California ISO wholesale energy markets. If designed to do so, microgrids can possess the operational characteristics to provide or support grid balancing services when requested or when available in an open market. Some of these are:

- Respond quickly and accurately to an energy need
- Change ramp directions quickly on demand
- Sustain upward or downward ramp for extended periods of time
- Start and stop multiple times a day when requested
- Respond for defined periods of time on request
- Start with short notice from a zero or low-electricity operating level
- Accurately forecast operating capability

For microgrids to reach the level of commercial status and reap the value of these capabilities there are many technical challenges to overcome. Some of these are to:

- Obtain recognized national and state standards and protocols for the key functions that are provided by a microgrid.
- Develop and provide clear and understandable business cases that will allow an end user or consultant to evaluate the cost and value of different microgrid configurations and make an educated decision on what system is right for them and/or which microgrid is not appropriate for them.
- Develop and publish clear training materials for workers on how to install, maintain, and operate microgrids.
- Encourage the development of new software models of microgrids that will provide the analyses and comparisons of different microgrid configurations.
- Address the challenges of cybersecurity and develop protocols and procedures to ensure microgrids of the future are protected to a required minimum level.
- Address the challenges and issues of third-party owned and operated microgrids in California face.

As microgrids transition closer and closer to commercialization, many issues will need to be resolved. For example, a microgrid can provide grid services that integrate energy storage, demand response, energy efficiency, and renewable technology through a single interconnection point to the grid. Currently, the CPUC and California ISO are completing regulatory hearings, proceedings or stakeholder initiatives to address many of these independent capabilities. However, it is very likely that microgrids will require new and different proceedings to address the unique differences in capabilities and services provided and how each is verified. For example, resources participating in the California ISO are measured for settlement on a 24x7 basis. This means that if a microgrid is providing services to the California ISO, any meter or telemetry deviations outside of ISO participation are captured and settled at the wholesale market level. Microgrid activity, outside of the ISO control or dispatch is 'uninstructed' and has financial consequences to the participant. There could also be performance and accuracy consequences if the microgrid is providing services outside the ISO market, which could lead to disqualification for market participation.

By their definition, most microgrids are likely to be interconnected within the distribution system. If these microgrids are seeking to provide services to the California ISO, they can only do so once the distribution utility approves and completes the interconnection process that allows the microgrid to participate and provide services through wholesale markets. Electricity customers are typically served by a Load Serving Entity (LSE). This entity could be in the form of a utility, energy service provider, or a Community Choice Aggregator (CCA). The load serving entities have a number of responsibilities and obligations that include forecasting customer load, serving customer loads, as well as, carrying energy reserves, and fulfilling resource adequacy requirements. When a microgrid begins to serve its own energy needs or participate in the grid by providing services, the relationship between the LSE and the microgrid must be defined. [12]

To properly address these issues, working groups will need to be formed that are willing to provide possible solutions to these and other issues and offer possible implementation plans the state agencies can act upon. The working groups can be managed by the industry most interested in the commercial success of microgrids or by working groups chaired or co-chaired by staff members from state agencies. Identifying and completing some of the key action items identified in this roadmap will be a significant movement in the right direction.

Understanding the Economics of Microgrids

The California Legislature recently enacted legislation to further California's deep commitment to reducing greenhouse gas emissions and deploying distributed energy resources. Senate Bill 350, approved by the Governor in 2015, commits California to reduce 2030 greenhouse gas emissions (GHG) by 40% below 1990 levels, increases to 50% the share of electricity to be produced by renewable generation, doubles targets for energy efficiency, and encourages widespread transportation electrification. Assembly Bill 327, approved by the Governor in 2013, requires reform of utility distribution planning, investment, and operations to "minimize overall system cost and maximize ratepayer benefits from investments in preferred resources," while advancing time- and location-variant pricing and incentives to support distributed energy resources. [13]

Microgrids offer California economic value in resiliency and enhanced efficiency. The economic impact that microgrids will have in California is unclear, as a monetary value cannot be assigned to the resiliency offered by microgrids.[14]

Additionally, regulation and planning processes leave unclear who carries the cost of implementing microgrids and what fees will be applicable to microgrids. Currently, microgrids

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[12] California ISO, Joint Agency Workshop Microgrid Roadmap, September 6, 2016.

[13] *California's Distributed Energy Resources Action Plan*, May 3, 2017.

[14] DNV GL, *Microgrid Assessment and Recommendation(s) to Guide Future Investments*, July 2015.

in California struggle to be cost-competitive because they are subject to standby charges and departing load charges. Current regulation also leaves unclear how microgrids may bundle their costs and who pays the cost of interconnection. [15]

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. [16]

As addressed in the CPUC White Paper *Microgrids: A Regulatory Perspective*, departing load charges apply to California utility customers who generate a significant amount or all of their own power. These charges cover such things as past under collections for forward power procured on behalf of these customers. However, if the generation is “clean” the customer may be exempt from these charges. These charges apply to any customer that no longer receives power from the incumbent utility, including customers who go “off grid.” In California, new Direct Access customers have to pay these charges, as well as customers who shift to a CCA. These charges are “vintaged” because the amount of forward power purchases that these customers are responsible for declines over time, and eventually goes to zero. Standby charges apply to self-generation customers who remain connected to the grid, whether or not they receive power from the incumbent utility. The customer pays these charges because the utility is required by law to deliver energy automatically if the customer’s generator is not working. Standby charges are assessed to cover the cost of providing this service. These costs are assessed based on the size of the customer’s generator. These charges are meant to reflect the share of the customer’s cost of operating and maintaining the infrastructure to provide them with reliable power.

If a microgrid is capable of supplying most or all of its own electricity needs and can island but remain connected to the grid, standby charges may also apply. The question for the regulator is who is responsible for these charges? Is it the microgrid owner/operator, or is it the individual customer? In either case, if the cost of standby service is included in the cost of service to the microgrid customer, it is a factor that will ultimately increase the cost of electricity and the competitiveness of the microgrid. For microgrid based electric supply to be cost competitive, the nature and amount of the standby charges need to be reevaluated by the regulator.

In contrast to the view of the microgrid as a consumer of macrogrid services, a major consideration that distinguishes microgrids from other types of customer generation is the ability to provide services to the grid. It is no longer the case with a microgrid that the grid connection exists solely for the benefit of the microgrid customers. The grid connection also benefits the system more broadly to the extent the microgrid provides operational services to

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[15] *Microgrids: A Regulatory Perspective*, CPUC Staff Paper, April 14, 2014.

[16] DNV GL, Microgrid Assessment and Recommendation(s) to Guide Future Investments, July 2015.

the grid, such as ancillary services or frequency regulation. With this consideration in mind, the following questions regarding standby charges are relevant:

1. Is interconnection with the Bulk Electric Services (BES) providing a benefit to the BES, or is it providing a benefit to the microgrid customer?
2. How should the cost of providing standby or grid connection-related services to the microgrid customer be balanced by services or other benefits the microgrid is providing to the BES?
3. How should this interconnection service be managed, i.e., through an interconnection tariff, a retail customer tariff, or should the utility "procure" the microgrid's services?

In California, the "bundled" customer (*i.e.*, where generation procurement, transmission, and distribution services are all provided by the incumbent utility to the customer) pays the generation charge as a "pass through," *i.e.*, the utility is required to charge for generation of power consumed by the customer at cost. The way the generation charge is set depends on the customer tariff, but ultimately the total retail cost of generation paid by all customers is the actual total cost of the electricity that is contracted for by the utility.

Transmission and distribution, on the other hand, are the revenue base on which the utility can collect a rate of return. The rate of return is guaranteed by the state. Rates for transmission and distribution are set based on operating costs and a return on equity. Normally, the transmission and distribution costs represent about 40% of the total cost a bundled customer pays for electricity.

For microgrids, the cost of electricity paid by the customer will depend on a number of factors:

- The cost (levelized cost of electricity or LCOE) of the electricity produced by the distributed energy resources supplying the microgrid compared to the retail rate;
- The cost of distribution services set by the distribution operator;
- Any additional costs associated with interconnection to the BES;
- Any additional revenues associated with services that the microgrid supplies to the macro-grid; and,
- Profit for the microgrid owner/operator.

Similarly, contractual arrangements between utilities and microgrid operators as part of resource procurement will need to be developed that are transparent to regulatory oversight, in terms of providing customer protection from abusive pricing and ensuring adequate incentives and cost recovery for both developers and utilities. The challenge associated with this is that utilities engage in a 10 year forward procurement mechanism, which may result in stranded costs if demand is lower than planned, whether it is from demand response, energy efficiency, or microgrids, and the utility ends up over-procuring resources, or procures resources not flexible enough to address the emerging grid conditions.

The regulatory agency also needs to address revenue, costs, and cost recovery. For example:

- How are the costs of microgrid development allocated and recovered?

- Is metering still relevant in a microgrid?17

As microgrids continue to evolve, owners and operators of microgrids are in a position to fulfill opportunities to provide grid services outside of the microgrid itself as a means to generate revenue. The opportunity to provide services beyond the microgrid may allow the microgrid to develop in ways that utilize a greater amount of wind and solar energy generation than would be required when serving only the microgrid. This extra generation capacity can then be offered as services into retail and wholesale markets for balancing supply and demand, ramping capacity, or for providing ancillary grid services such as frequency regulation or voltage control.

Microgrids can be viewed as a fundamental building block in creating the 21st century "smart" and modernized electric grid, serving as a multi-function grid resource. From the system operator standpoint, a microgrid can serve as:

- A reliable, dispatchable energy resource;
- An ancillary service resource;
- A load shed resource; and/or,
- A consumption resource to handle an oversupply of generation.

To the extent that a microgrid, or the business entity representing the microgrid, can participate in wholesale markets, revenue streams can be associated with these bulk electric system (BES) needs. A microgrid in a particular area can be designed and operated so as to address macrogrid conditions, at either the BES or local area power system, all the while generating revenue streams.

Independent system operator (ISO) managed grid operations today are conducted using economic dispatch principles. Energy is bid into the wholesale market and dispatched according to market price. The net load of the grid is affected by the deployment of customer side resources as a reduction in demand. Customer side resources are also treated as load reduction by the EPS or distribution system operator (DSO).

Similarly, the microgrid management system can help provide distribution level services as part of a distributed control system. Individual resources, such as smart inverters that can supply reactive power or voltage support, can be controlled at a more local level. This functionality saves the engineering cost and need for monitoring that more centralized distribution system management implementation requires. [18]

Microgrid developers have expressed the necessity to offset the costs of building and operating a microgrid through the provision of services to multiple service takers. Similar to electric storage, microgrids can be seen as having the potential to provide value to the wholesale market, the distribution grid, the transmission grid, and to local customers. Current market rules do not support the stacking of microgrid services and do not allow for the multiple

[17] California Public Utilities Commission, White Paper *Microgrids: A Regulatory Perspective*, April 14, 2014.

[18] California Public Utilities Commission, White Paper *Microgrids: A Regulatory Perspective*, April 14, 2014.)

benefits and services microgrids are capable of providing to the electricity system. For microgrids to realize their full value to the electricity system, these rules must be defined.

Microgrids can provide a number of benefits to the grid by the provision of additional services, beyond the simple production or storage of electricity. Microgrids can provide many different services to the grid including:

- Any necessary voltage support for distributed generation and solar;
- Consumption of excess generation by charging batteries, other storage devices, or customer products; and,
- Provision of additional wholesale ancillary services, such as regulation.

Determining how to appropriately value these services and provide a mechanism to collect and allocate revenues for these services will help drive microgrid development.

Chapter 3:
Roadmap Actions

For this roadmap to be successful in helping commercialize microgrids, it is important that clear actions be identified and plans defined on how to address these action items. This chapter identifies the specific action items that were identified during a series of five workshops and many follow-on planning meetings that occurred between these workshops. These action items were developed in public workshops and a priority was assigned to them based on their importance, the timeframe they needed to be worked, and ultimately their criticality in helping to move microgrids closer to a commercial presence in California. When defining priorities, the three agency staff members working on the roadmap reviewed the results from a survey that was completed by a government consultant where respondents were ask to rank each action item based its importance and criticality in moving microgrids closer to a clearly defined commercial product. As with the other three active state level roadmaps identifed in Attachment 1, it is anticipated that the three government agencies will hold routine review of the action items in this plan in a public forum on a routine basis.

Microgrid Operation and Value

The action items in this section address the need to develop information for the marketplace that defines what a microgrid is and how it operates. Furthermore, it is important to explain the overall value of a microgrid to the end user and the grid operator when compared to alternative choices.

Planning Action Items

1. Develop non-proprietary, publicly available educational and guidance materials for microgrids.
2. Develop, evaluate, and publish improved metrics to assess microgrid system performance.
3. Complete research that defines the building blocks necessary to implement microgrids from start to finish.

Improving the Electric Grid with Microgrids

Microgrids have the potential to provide unique services to the grid operator and the end user or customer who owns or operates a microgrid. It is important that these services be well defined and assessed for their value compared to alternative grid services that exist and operate today. Whether the microgrid is providing lower cost energy services to the owner or grid operator, it is important to understand how these services will be provided and how their cost compares to alternatives choices. Once this is known, then the microgrid operator can determine how their system can lower the burden on the overall grid when those services are needed to either reduce load on the grid provided by the microgrid or be available to provide specific energy services to the grid. The action items below address how these electric grid friendly services can be more easily defined, implemented and their overall benefits validated.

Planning Action Items

1. Develop methods to reduce cost barriers for microgrid participation in grid services requiring special metering and telemetry equipment.
2. Clarify the microgrid participation rules and requirements to provide multiple revenue streams. Where possible, leverage the rules and requirements being developed for the energy storage industry or other DER systems.
3. Develop and validate new benefit metrics for system resiliency that are provided by microgrids.

Microgrids Role to Implement State's Policy Goals

As mentioned in the primary portion of this roadmap, California has some of the most aggressive energy policies in the country that are increasing renewables on the grid, expanding the use of DER, improving the overall energy efficiency in all customer segments, integrating more and more electric vehicles onto the grid and expanding the use of low cost demand response services. Microgrids provide unique local level system control capabilities that allow large amounts of these desirable services to be integrated into the microgrid and then more easily integrated onto the larger utility grid. The action items below address some of the key barriers and challenges that the state faces in implementing the aggressive energy policies.

Planning Action Items

1. Develop different microgrid use cases that will support increased penetrations of renewables on the California electric grid.
2. Develop state level strategies to open wholesale and retail markets to microgrids that will support California's future energy policy goals.
3. Facilitate opportunities to work with California Tribal Communities and other special entities that want to include future microgrids in their utility operations.
4. Complete detailed research studies and analysis on the role microgrids play in California utilities to meet future policy goals.
5. Define the role of microgrids in future grid management with higher concentrations of DERs.

Microgrid Technical Challenges

Where there are microgrids operating throughout the nation and the world, there are still many technical challenges to the commercialization of microgrids in California. The development, testing, and ultimate approval of key standards and protocols need to be available to end users who want to assess the value of implementing a microgrid to support their needs. It is important to define how the management of the microgrid will address the ever increasing challenges from cybersecurity threats. Local agencies and government will need guidelines, and other documents to help them review and approve the necessary permits, CEQA documents and other similar items to approve the installation of these microgrids in a timely manner. And finally, different configurations and capabilities of microgrids need to be defined in a manner that is easy for potential future implementers to know their options and the value of the different options when comparing a variety of microgrid solutions to make a future procurement decision.

Planning Action Items

1. Develop and publish new processes and procedures where existing and future microgrids can provide publicly available lessons learned from fielded and operating microgrids.
2. Complete research to identify new opportunities for potential economic revenue streams for microgrids for services they can provide their owner/operator, the utilities, and the California ISO.
3. Develop a process to reduce the risks and problems of microgrid islanding.
4. Prepare guidelines to assist local government agencies and others in selecting and supporting future microgrid projects.
5. Evaluate how microgrids can provide new options to address the impacts of the aging California natural gas infrastructure.
6. Define minimum cybersecurity requirements for microgrids.
7. Analyze and compare the commercial viability of different microgrid configurations.
8. Fund technical research to address current regulatory issues facing microgrid deployments.

How Microgrids Operate in the Current California Regulatory Framework?

Understanding how microgrids are able to respond to and meet future California regulatory requirements is a key element in the eventual commercial success of microgrids. Minimizing the time to meet these regulations, responding to all the needed elements of the regulations and operating in an environment of change is critical to the overall commercial success of microgrids. The action items below address what is needed from microgrid developers to bring this product closer to a stable, commercial success.

Planning Action Items

1. Develop microgrid service standards necessary to meet state and local permitting requirements.

2. Develop methods to reduce cost barriers for microgrid interconnection requirements.
3. Develop guidelines that determine what impact studies are required for microgrids to connect to the utility grid.
4. Determine if separate utility rates and tariffs are necessary to support microgrids.
5. Form a working group to codify standards and protocols needed to meet California utility and California ISO microgrid requirements.

Economics of Microgrids

Microgrids must compete in an economic environment that is difficult and complex. In many cases, microgrids are integrating many items that are normally managed as independent silos. A clear capability to define the economic business case for microgrids as compared to alternative solutions must be developed. The economic value of a microgrid to the end user/owner must be clear and easy to understand. Services provided to the end customer and the grid operator needs to be defined and monetized. Many of the services microgrids provide today do not have an agreed upon economic value at this time, and society as a whole will need to determine if there is a real value for some of these services such as: the social value of emission reduction, the community value of high reliability or fast response to emergency situations, peace of mind during natural disasters, etc.

Planning Action Items

1. Develop and validate new benefit metrics for the system reliability provided by microgrids.
2. Enact the state approved rules under which microgrids can participate in wholesale and retail markets. This includes the emerging Block-Chain methods.
3. Define different revenue streams available to microgrids beyond the ones that currently exist, such as volt-amp reactive (VAR) services, flexible energy services, and emergency services.
4. Develop a plan similar to DOE’s “Sunshot Program” that would find ways to reduce soft costs in design and construction.

Andy’s Comments:

Other areas of consideration: EOL – End of Line projects. A microgrid could be considered for a housing development that might be planned around the end of a distribution line. Rather than going through the hassle of upgrading the line which can be expensive and time-consuming, why not build a microgrid that does both grid voltage support and supplementary demand? Perhaps a recommendation would be that any new development where it was determined a utility power line upgrade would be necessary, a study be done on comparing the economics of the two options.

GLOSSARY

Term	Definition
EPIC	Electric Program Investment Charge
Smart Grid	Smart Grid is the thoughtful integration of intelligent technologies and innovative services that produce a more efficient, sustainable, economic, and secure electrical supply for California communities.

REFERENCES

To Be Added

ATTACHMENT 1:

EXISTING CALIFORNIA LEVEL DER ROADMAPS

Below are the web links to the three existing Distributed Energy Resource Roadmaps that were developed by the California ISO, the CPUC and the California Energy Commission. The roadmap for the Commercialization of Microgrids in California was a follow-on effort to these three documents.

Advancing and Maximizing the Value of Energy Storage Technology--A California Roadmap (December 2014):

https://www.caiso.com/Documents/Advancing-MaximizingValueofEnergyStorageTechnology_CaliforniaRoadmap.pdf

California ISO Demand Response and Energy Efficiency Roadmap: Maximizing Preferred Resources (December 2013)

https://www.caiso.com/Documents/DR-EERoadmap.pdf

California Vehicle-Grid Integration (VGI) Roadmap: Enabling vehicle-based grid services (February 2014):

http://www.caiso.com/informed/Pages/CleanGrid/Vehicle-GridIntegrationRoadmap.aspx