Smart Electric Power Alliance

How to Design Multi-User Microgrid Tariffs

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In Partnership with

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How to Design Multi-User Microgrid Tariffs

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About SEPA

The Smart Electric Power Alliance (SEPA) is dedicated to helping electric power stakeholders address the most pressing issues they encounter as they pursue the transition to a clean and modern electric future and a carbon-free energy system by 2050. We are a trusted partner providing education, research, standards, and collaboration to help utilities, electric customers, and other industry players across four pathways: Transportation Electrification, Grid Integration, Regulatory Innovation and Utility Business Models. Through educational activities, working groups, peer-to-peer engagements and custom projects, SEPA convenes interested parties to facilitate information exchange and knowledge transfer to offer the highest value for our members and partner organizations. For more information, visit www.sepapower.org.

About Pacific Energy Institute

Pacific Energy Institute is addressing the need for independent, informed and balanced perspective on the complex issues related to a more distributed electric system. We seek to change the conversation by drawing upon leading insights from places like Australia, California and Hawaii. Our focus is on distilling this rich set of provincial, country and regional insights into actionable strategies that can facilitate policy, business strategy and regulation worldwide. Our tailored research is based on sound system engineering and economic principles that shape practical solutions to achieve economically and environmentally sustainable outcomes. This approach is why our experts' individual and collaborative work over the past decade continues to provide an important source of expert research, analysis and recommendations to inform policies and practices.

Disclaimer

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Introduction

States, communities and utilities can utilize microgrids as a tool to enhance the resilience of customers and communities against natural disaster, cybersecurity and other threats. Increasingly, state and local governments, such as California, District of Columbia, Hawaii, Illinois, New York and Puerto Rico are seeking to enable the development of community scale microgrids to address identified resilience needs. In addition, many states, communities and utilities are developing strategies to achieve carbon and emission reduction targets, and are beginning to recognize the value of microgrids for integrating additional clean energy resources onto the grid.

A multi-user (or community) microgrid is a microgrid that links distributed energy producing resources with multiple customers across a segment of a utility's distribution system in an islanded mode. This differs from customer microgrids that are entirely behind the meter, using only customer or third-party resources and electrical infrastructure. The purpose of this paper is to provide a framework for regulators, utilities and stakeholders to guide the development of a multi-user microgrid tariff that can serve the resilience needs of a community or smaller group of customers.

SEPA Framework

As a starting point, it is essential to clearly identify the objectives and scope of the tariff. This is often informed by legislation and/or other policy factors that will drive tariff development. These objectives will also need further refinement to determine requirements within a tariff and/or interconnection rule (e.g. performance and clean energy requirements).

As microgrids are fairly new to the industry, terminology and operational understanding varies. Appropriately scoping the many complex issues related to multi-user microgrids requires identifying and defining common microgrid terminology, including key operational and participation roles, as well as technical elements. Understanding microgrid archetypes and determining the focus of the tariff is essential. Failure to address this need for common terminology and understanding will lead to confusion and misunderstanding among stakeholders.

Multi-user microgrids may have various islanded operational structures that a tariff needs to address.

A key aspect is blue-sky energy and grid services—services delivered under normal conditions—as well as island resilience services that the microgrid and its resources may provide for compensation from wholesale markets, utility and/or customers within the microgrid boundary during island mode. Beyond the microgrid boundary, the utility will provide necessary distribution services to the multi-user microgrid.

These elements inform the scope and development of a multi-user microgrid tariff structure and the detailed elements that form the tariff. Additionally, utilities need to assess microgrid interconnection and islanding capabilities. This typically involves evaluating existing interconnection standards and processes to determine necessary modifications within the tariff around interconnection and coordination.

SEPA has developed a conceptual framework to guide development of a multi-user microgrid tariff, which involves the initial strategy and ultimate development.

Structure of Paper

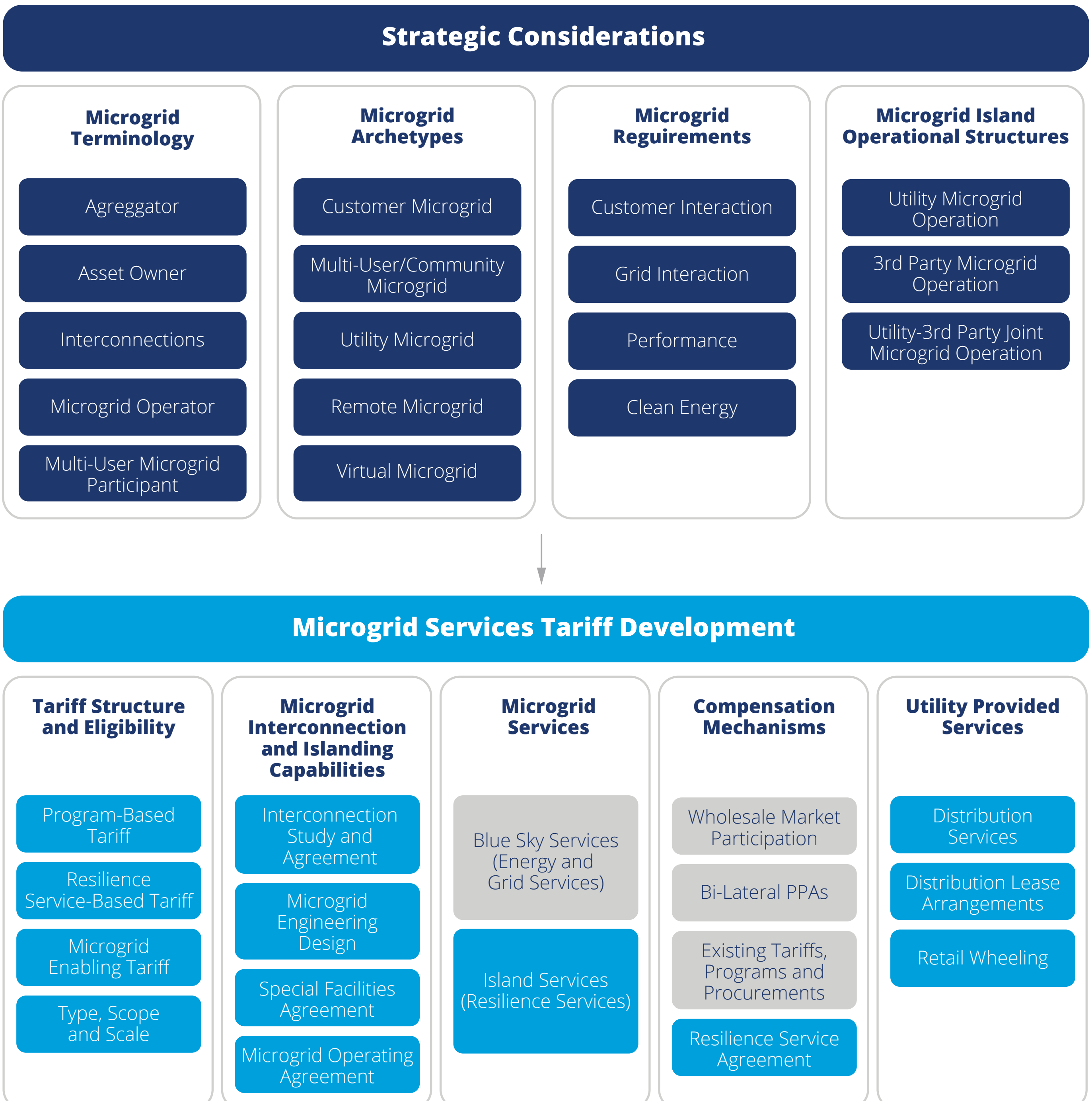
This paper will explore the two phases of microgrid tariff design and additional important considerations to enable community based multi-user microgrids:

- **Strategic Considerations** provides guidance to determine what is in and out of scope for a multi-user microgrid tariff. This section includes a framework for identification of microgrid objectives/requirements, applicable microgrid archetypes, appropriate operational structures, and microgrid services to address in a tariff. This section also includes examples of legislative and regulatory action that address issues and barriers to strategic implementation of microgrids.

After the scope of the tariff has been determined, more tactical considerations can be considered.

- **Microgrid Services Tariff Development** provides an overview and key considerations of the elements to include in a microgrid services tariff and how to structure the tariff. This section includes information on potential microgrid tariff structures, interconnection

Figure 1: Multi-User Microgrid Tariff Framework



Source: Smart Electric Power Alliance, 2020.

processes and service agreements. The section also highlights examples of legislative and regulatory action that address issues and barriers to structuring microgrid service tariffs, as well as real world examples of how utilities are approaching microgrid tariff design.

- **Additional Considerations** provides an overview of several prominent issues surrounding tariff development that should be considered when seeking to enable community based multi-user microgrid development.

- **Key Takeaways** highlight key recommendations for utilities and local and state governments to consider for microgrid resilience strategies and mitigating risk against threats of natural disasters in their service territories or jurisdictions.
- **Appendix A: Microgrid Definitions and Archetypes** provides a detailed list and description of microgrid definitions and microgrid archetypes to reference to the strategic consideration and microgrid services tariff development discussions.

Strategic Considerations

Tariffs are designed to embrace the strategic goal of the system. Tariff designers must clearly understand the drivers for microgrid deployments, and what purpose the tariff will serve. These answers will stimulate the discussions required to identify the rules and requirements around the interactions between the microgrid and microgrid participants, and the microgrid and the macro-grid[1]. The first step in this process is agreeing on a common definition of microgrids and multi-user/community microgrids. To date, states have adopted or adapted DOE's definition of microgrids as a starting point.[2]

Figure 2: Multi-User Microgrid Tariff Framework—Strategic Considerations

Microgrid Terminology	Microgrid Archetypes	Microgrid Reguirements	Microgrid Island Operational Structures
Agreggator	Customer Microgrid	Customer Interaction	Utility Microgrid Operation
Asset Owner	Multi-User/Community Microgrid	Grid Interaction	3rd Party Microgrid Operation
Interconnections	Utility Microgrid	Performance	Utility-3rd Party Joint Microgrid Operation
Microgrid Operator	Remote Microgrid	Clean Energy	
Multi-User Microgrid Participant	Virtual Microgrid		

Source: Smart Electric Power Alliance, 2020.

What Should a Tariff Include?

Several states through legislation and/or regulation have recognized that the use of microgrids can build energy resiliency into communities, thereby increasing public safety and security.[3] This legislation is spurred by utility customers seeing potential benefits from investing in distributed energy to ensure their own level of reliability and to better manage their own usage. Recent legislation also empowers customers to participate through an aggregated single entity to the distribution system operator to provide potential community benefits (e.g. avoiding power interruptions and assuring access to critical services).[4]

1 Macro-grid requirements are not typically covered under microgrid tariffs but must be considered.
2 D. Ton and M. Smith, The U.S. Department of Energy's Microgrid Initiative. The Electricity Journal, Vol. 25, Issue 8. October 2012.
3 Hawaii Act 200. 2018.
4 California Senate Bill 1339. Available at: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1339

Definition

A **microgrid** is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode.

States have recognized several barriers to development, including interconnection challenges and a lack of standardized terms regarding the value of services exchanged between the microgrid operator and the utility.[5] To address these issues, several state regulatory commissions are leading the development of a microgrid services tariff that is:

- Designed to provide fair compensation for electricity, electric grid services, and other benefits provided to, or by, the electric utility, the person or entity operating the microgrid, and other ratepayers; and
- To the extent possible, standardizes and streamlines the related interconnection processes for microgrid projects.[6]

This type of policy sets the strategic direction for a multi-user microgrid tariff. At a more tactical level, state regulatory decisions have refined the scope of multi-user tariffs. In Hawaii, the commission ordered that a microgrid services tariff focused on multi-user microgrids should minimally address the following:[7]

- A tariff that, as an initial step of development, supports resiliency of energy services during emergency events and grid outages;
- A tariff should include how the participating customers would opt-in to a microgrid, island from the grid, operate as a single controllable entity during islanded condition, and reconnect with the grid;
- Recommendations for determining compensation, if any, to the electric utility for use of the utility's distribution system during an outage, if necessary;
- Recommendations for new and modifications to existing programs to support microgrid development, where appropriate;
- Recommendations to standardize interconnection and microgrid terminology, and specific interconnection process improvements.
- Recommendations on appropriate compensation for clearly identified grid services, consistent with guidance above (i.e., microgrids that offer broad-based benefits for non-participants).

These requirements provide the strategic direction for the development of a multi-user microgrid tariff and will help shape productive stakeholder discussions. Without this level of clarity around "why and what", microgrid working groups can wander in many unproductive directions given the wide range of potential microgrid types and respective issues.

Key Questions to Consider:

- Why are you developing a microgrid tariff?
- What are you trying to solve and what role are you looking for the tariff to address?
- How do you want to define this microgrid tariff, and what does it apply to explicitly?
- What is the scope of the microgrid tariff—what is included and what is excluded?
- What regulatory and/or legislative issues regarding the purview of Commission and definitions of microgrids and utilities must be considered?

Microgrid Archetypes

A fundamental step to developing a microgrid services tariff is determining which microgrid archetypes to include. Numerous types of unique microgrid configurations exist in relation to electrical boundaries, stakeholders, ownership, operational models and compensation models. The lack of a common understanding of terminology used in the industry regarding the labels and descriptions of the various types of microgrids has hampered microgrid tariff related discussion to-date. Table 1 offers a brief description of the larger set of microgrid archetypes, including customer, multi-user and others defined in greater detail in Appendix B. This microgrid taxonomy is

5 Hawaii Act 200. 2018.

6 California Senate Bill 1339. 2018.

7 Hawaii Public Utility Commission, Decision and Order No. 36481, Docket No. 2018-0163. Available at: https://www.hawaiianelectric.com/documents/about_us/our_vision_and_commitment/resilience/microgrid_services_tariff/dkt_2018_0163_20190820_PUC_order_36481.pdf

Table 1: Microgrid Archetypes Overview

Archetype	Description
Customer Microgrid	An independently developed microgrid with distributed energy producing resources and loads wholly wihin a single customer's site (single facility or campus, including any tenants).
Multi-user/ Community Microgrid	An independently developed microgrid using a utility distribution grid to link distributed energy producing resources with multiple specific customer loads or a community.
Utility Microgrid	Utility microgrids have focused on mulit-user/community scale projects. These are distinguished by the utility taking lead to independently developing or working in partnership with resource providers.
Remote Microgrid	A resilient power system for a facility/campus that is not grid connected (off-grid). This is an effective solution for specific applications but is not within the scope of grid connected microgrids sought by state policies for community resilience.
Virtual Microgrid	Also known as a virtual power plant (VPP). A VPP is not able to island and therefore not within the scope for microgrids based on jurisidictions to date. VPPs are providing blue-sky services.

Source: Smart Electric Power Alliance and Pacific Energy Institute, 2020.

designed to help stakeholders understand relationships and interactions that are critical to establish prior to developing a multi-user microgrid tariff.

Each type of microgrid has unique characteristics that shape the discussion of function, roles, responsibilities, operational requirements among other considerations. This paper focuses on multi-user microgrid archetypes, which are more fully described below.

Multi-user/Community Microgrids

Multi-user or Community Microgrids are microgrids that are designed to serve a group of customers or community using the utility distribution to link the microgrid resources and customers. Multi-user microgrids can be either a) independently developed, b) utility developed or c) joint utility-private developed. For the purpose of a tariff, these are non-utility-led developments by customers or independently developed community microgrids.

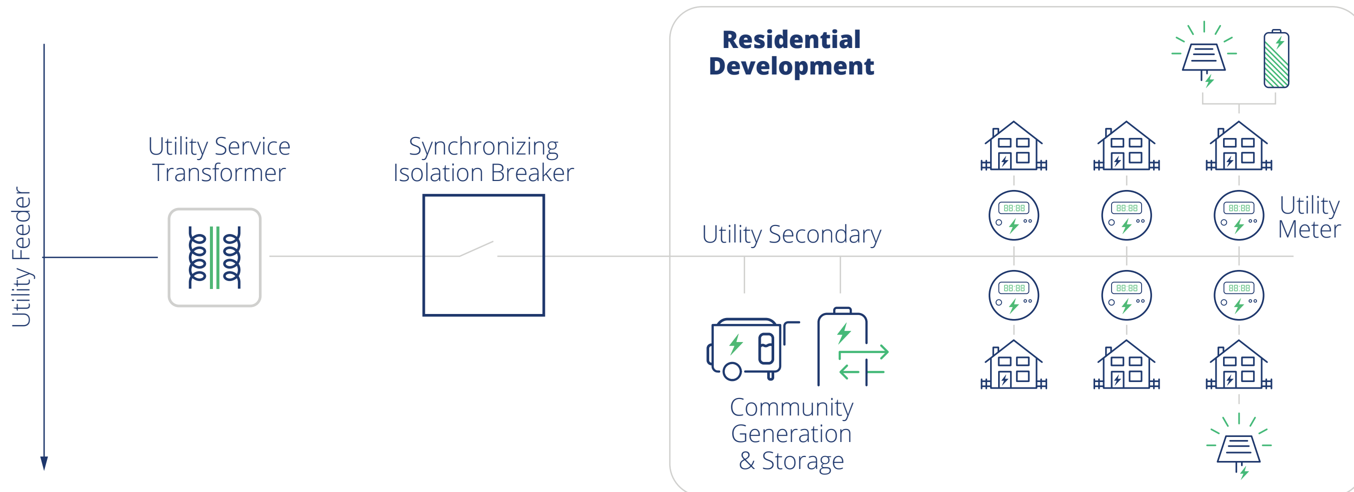
Multi-user microgrids produce the most confusion in industry literature and stakeholder discussions since they are relatively new—as opposed to customer microgrids, which have been widely developed over several decades and don't involve as many parties. Further, multi-user microgrids require the use of a segment of the utility distribution system to function in island mode. This creates a number of challenges for tariff development. The scale of multi-user microgrids can be as small as two adjacent customers or an entire community encompassing many thousands of customers. Thus, the scale of a multi-user microgrid adds complexity and considerations for tariff design. Two basic multi-user archetypes can help facilitate discussion of the scope of a tariff and the related issues to address:

> **Definition**
>
> **Multi-user microgrids** act as a single controllable entity with respect to the utility's electrical grid normally operated in grid-connected mode and operate in an island mode for resiliency within clearly defined electrical boundaries linking associated resources and loads within their micro-control area using utility distribution wires or other utility infrastructure.

- **Simple Multi-user Microgrid** involves a set of contiguous loads and resources using a small section of a utility distribution grid to form a microgrid that involves a single, relatively simple, point of common coupling and related operational coordination to ensure safety and operational effectiveness. This type of microgrid will have a single entity representing all customers involved with the microgrid, such as a homeowners association, property manager/owner, or independent microgrid operator as illustrated in Figure 3.

  Two examples of this type of microgrid in development include Hudson Yards in New York and Humboldt

Figure 3: Simple Multi-user Microgrid

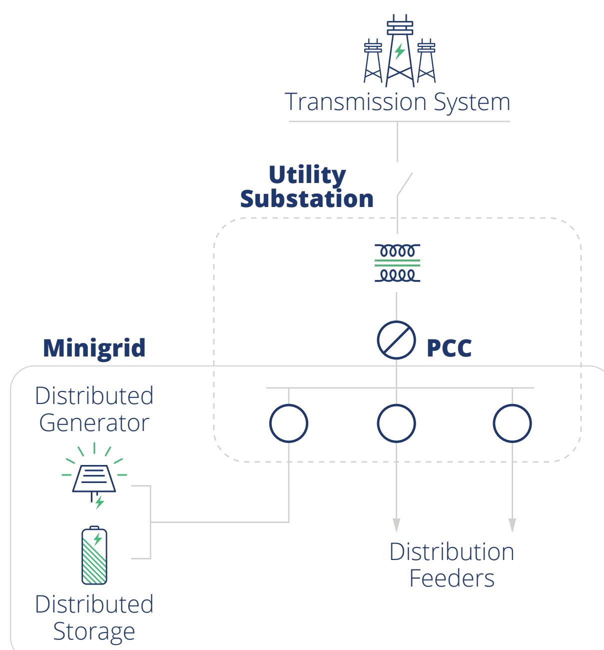


Source: P. De Martini, 2020.

County Airport in California.[8] Reynolds Landing in Alabama is a utility-led functional multi-user microgrid developed by Alabama Power and homebuilder Signature Homes.[9]

- **Minigrid** is a type of community microgrid configuration that involves creating a boundary that encompasses a large geographic area to provide resilience for all the customers served by a distribution substation or radial transmission line and related distribution substations. This may involve an independent microgrid operator operating the multi-user microgrid on behalf of the participating users during island mode and in normal grid connected mode to meet operational, environmental, reliability, resiliency and redundancy goals of the users, as well as managing both purchases from and sales of services to the grid. This type of microgrid is not operated by the utility, but does make extensive use of a utility's distribution grid. As such, 3rd party operated minigrids are a relatively complex engineering solution involving significant operational coordination, customer issues, and other considerations to operate safely and effectively. No independently developed examples of this type of minigrid in the US currently exist. There are, however, utility-led developments that incorporate independent and customer resources. For example,

Figure 4: Minigrid Archetype

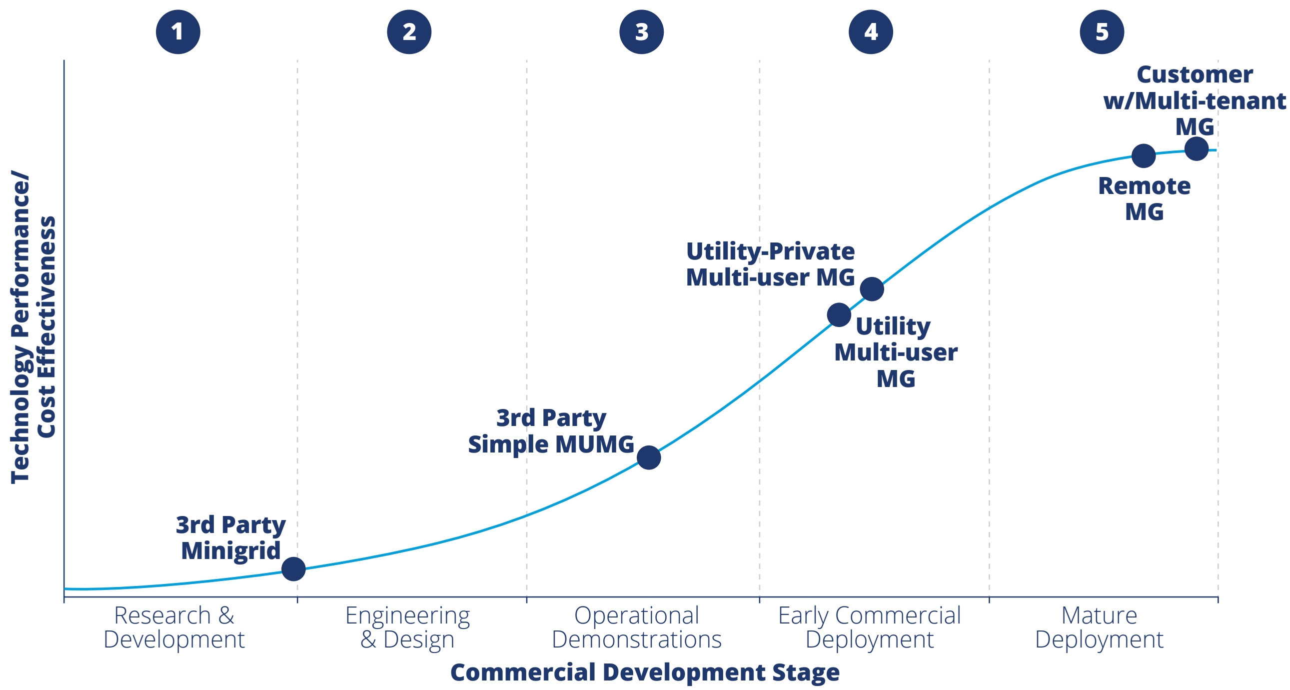


Source: P. De Martini, 2020.

8 The Humboldt County Airport microgrid will include a 2.25 MW solar array and 2 MW battery storage system. The system is expected to be fully operational in December of 2020. https://redwoodenergy.org/community-choice-energy/about-community-choice/power-sources/airport-solar-microgrid/

9 The Reynolds Landing neighborhood microgrid supports 62 single-family homes with a 1 MW microgrid maintained by Alabama Power. https://www.greentechmedia.com/articles/read/alabama-reynolds-landing-microgrid-grid-edge

Figure 5. Microgrid Commercial Development Maturity Curve



Source: B. Blair and P. De Martini, 2020.

PG&E's recently approved make ready program[10] would enable this type of community multi-user microgrid. In the graphic below, the electrical boundary (point of common coupling—PCC) is the low side transformer breaker at the substation. All loads on the two feeders illustrated are within the minigrid.

These two types of multi-user microgrids discussed above are currently in different stages of commercial deployment and operation. The figure below shows the relative maturity of each type of multi-user microgrid with and without utility involvement in the operation. Currently, both private single location and community microgrids are in an engineering and design proposal stage as evidenced in the NY Prize effort, the largest in the US. Only Hudson Yards, a single location multi-user microgrid, is in early operational stage. The Humboldt Airport multi-user microgrid is slated for operation in early 2021.

While independently developed microgrids are new, several utility-private or utility multi-user microgrids and single location microgrids have been developed and in operation. Customer microgrids with multiple tenants are quite common, but do not require the utility distribution grid to form the microgrid, substantially reducing the complexity. Remote microgrids are widely used worldwide and increasingly in countries such as the US to serve small communities or remote facilities. Multi-user microgrids in this context are largely addressing very early stage development efforts and will likely need to evolve over time based on lessons learned as these initial efforts mature into commercial operation.

Key Questions to Consider:

- What entity is sponsoring the microgrid and for what purpose?
- What type of microgrid are you trying to enable through a microgrid tariff?
- What definitions of microgrid archetypes are arising and being addressed through existing/new legislative/regulatory action?
- Are there types of microgrids that can already be enabled under existing tariffs, programs, and interconnection and service rules?

10 PG&E Distributed Generation-Enabled Microgrid Services (DGEMS) program. https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442463844

Microgrid Islanded Operational Structures

Generally, a community microgrid tariff will enable customer or 3rd party development and operation of a multi-user microgrid. Customers and/or 3rd parties will minimally own the energy producing assets and controls to balance energy output with customer loads to maintain frequency and voltage necessary for islanded operation of the multi-user microgrid. Since multi-user microgrids use the utility distribution grid to connect these resources with customers, it is critical to establish operational roles and responsibilities, as well as coordination protocols and procedures, between the several entities that may be involved. The structure of the operational roles is a strategic consideration to incorporate into tariff and related pro forma interconnection and operating agreements. While stakeholder discussions tend to focus on asset ownership, the larger and more complex issues involve the operation of the multi-user microgrid in island mode and transitions to-and-from blue-sky mode.

Initial discussions in several jurisdictions have identified three basic models involving both the control of the resources as well as operational responsibility for the segment of utility distribution grid needed to form the multi-user microgrid. Again, this is distinctly different than issues considered for customer microgrids that often are already addressed in existing interconnection rules. The basic models for islanded operation are:

- Utility dispatch of customer/third party microgrid resources and operation of the island distribution infrastructure
- Third-party microgrid operator control of resources and islanded distribution grid
- Third-party microgrid operator control of resources and utility operation of the island distribution infrastructure

Utility Microgrid Operation

The utility microgrid operational model involves the utility retaining operational responsibility and controls for the distribution system as well as the microgrid controller (i.e., control software and computing hardware) used to balance loads and resources when in islanded mode. The utility in this model is the microgrid operator. The utility issues dispatch signals from the microgrid controller to a customer or third-party (resource operator) that has operational control of the energy producing resources as well as any load modifying resources. The resource operator in this model is only responsible for following dispatch instructions and coordinating resource operations and maintenance with the utility distribution operator. The resource operator may have separate resilience and islanded energy service contracts with the microgrid customers, as permitted in the jurisdiction. This approach is similar to utility-private partnership microgrids such as Commonwealth Edison's Bronzeville microgrid.[11] This model is simpler in relative terms regarding protection and controls as well as operational coordination.

3rd Party Microgrid Operation

Third-party multi-user microgrid operation involves a third-party microgrid operator that assumes the utility's operational responsibility. The operator controls for the segment of the distribution system used in the microgrid, as well as the microgrid controller used to balance loads and resources when in islanded mode. This microgrid operator also has operational control of the energy producing resources as well as any load modifying resources. The third-party microgrid operator in this model is responsible for safe operation of the distribution segment and coordinating microgrid operations and maintenance with the utility distribution operator. The microgrid operator may have separate resilience and islanded energy service contracts with the microgrid customers, as permitted in the jurisdiction. This model is more complex in relative terms regarding protection systems, operational coordination and transfer of operational responsibility from blue-sky to island mode and back.

Multi-user microgrid owners have advanced the concept of leasing the segment of the distribution grid from the utility to form the microgrid. This lease would require the utility to operate and maintain the distribution segment in blue-sky mode and maintain during island mode. This arrangement is very complex in practice to ensure safe operation. Only one microgrid in the US uses this model, the Hudson Yards[12] in New York City microgrid, which uniquely involves coordinated use of ConEdison's low voltage secondary distribution network that is effectively a customer microgrid with multiple tenants.

11 https://bronzevillecommunityofthefuture.com/project-microgrid/

12 https://www.districtenergy.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=f5ab2fea-d7ce-6298-be2c-85c504139124&forceDialog=1

Utility-3rd Party Joint Microgrid Operation

The utility-3rd party microgrid operational model involves the utility and third party having joint microgrid operational responsibility. The utility retains operational responsibility and controls for the distribution system employing a grid-side controller. A customer or third-party (microgrid aggregator) has operational control of the energy producing resources, as well as a resource controller to control energy producing resources and demand resources when in islanded mode. The microgrid aggregator is required to maintain frequency and voltage in response to control parameters/signals from the utility grid controller. The resource operator in this model is responsible for energy supply and maintaining frequency and voltage in compliance with utility parameters and coordinating resource operations and maintenance with the utility distribution operator. The microgrid aggregator may have separate resilience and islanded energy service contracts with the microgrid customers, as permitted in the jurisdiction.

This approach is employed by the Redwood Coast Airport Microgrid (RCAM)[13] in Northern California jointly operated by Redwood Coast Energy Authority, the local community choice aggregator, and PG&E, the distribution utility. This model is moderately complex in relative terms regarding protection and controls as well as operational coordination. It is similar to the grid operator-aggregator roles and responsibilities widely used for energy and grid services in blue-sky conditions. In the RCAM project, as with many multi-user microgrids, the energy producing resources are in front of the meter and participate in the CAISO market during normal conditions.

The operational model for multi-user microgrids must be predetermined by all parties to limit the performance risk, ensure safety and reliability of the microgrid system and to assign operational and maintenance responsibilities between the utility, the microgrid operator and the multi-user microgrid participants. This includes approvals for planned and unplanned islanding and return to normal grid connected mode as well as addressing liability related to service quality and safety. Operation and coordination roles and responsibilities along with protocols and procedures are necessary to establish through a tariff and related operational provisions in a modified interconnection agreement or separate microgrid operating agreement.

Legislative and Regulatory Insights

Maine: L.D. 13 in Maine requires a contractual relationship between the microgrid operator and consumers within the area to be served by the proposed microgrid. It also states that any microgrid operator proposing a microgrid needs to have the financial and technical capacity to build and operate one, and must demonstrate that the microgrid will not impede grid operations.

Key Questions to Consider:

- What are the roles and responsibilities between utility and third-party involving the control of the resources and operations of segment of utility distribution?
- What are the different island operating models covered within this tariff?
- Is there a need to develop a proforma microgrid operating agreement distinct from an interconnection agreement to address the operational coordination protocols and procedures?

Clean Energy Requirements for Microgrid Generation Resources

Microgrids typically include both clean and carbon-based local generation assets, however as grid-forming resources, several states have identified the importance of ensuring microgrids have a positive contribution towards state-level clean energy mandates, targets and/or policies. In many circumstances, microgrid participants and end-users demand a level of resiliency, back-up generation or on-site fuel sources that require carbon emitting generation resources. As of July 2020, the SEPA Utility Carbon Reduction Tracker[14] recorded 56 utilities in the U.S. which have publicly stated carbon or emission reduction goals, and 25 utilities with goals of 100% carbon free or

13 https://schatzcenter.org/acv/

14 https://sepapower.org/utility-transformation-challenge/utility-carbon-reduction-tracker/

Legislative and Regulatory Insights

- **Hawaii:** Act 200 in Hawaii requires that the increased use of renewable energy provides significant economic, health, environmental and workforce benefits to the state. Microgrids can facilitate the achievement of clean energy policies by integrating renewable energy resources within microgrid projects. HECO's proposed microgrid services tariff[16] on March 30, 2020 included requirements that third-party multi-user microgrids operating in island mode will not be included in the calculation of HECO's RPS. However, the tariff states that microgrids must meet the requirements of all Hawaii laws and regulations governing generating resources, such as emission requirements.
- **California:** S.B. 1339[17] in California includes a requirement for all electric generation or storage technology (as part of a microgrid) to comply with the emissions standards adopted by the State Air Resources Board. In September 2019, the CPUC then issued an Order Instituting Rulemaking[18] around microgrids which stated that all microgrid implementation must be coordinated with relevant clean energy state policy goals and existing Commission responsibilities.
- **Maine:** L.D. 13 set up criteria for microgrid operators that require microgrids to meet Maine's renewable portfolio standard requirements.
- **District of Columbia:** In May 2019, the District of Columbia's Public Service Commission (DCPSC) MEDSIS Working Groups established four categories of regulatory treatment for consideration by the Commission, one of which specifically calls out whether or not the microgrid operator must comply with the D.C. code for RPS and/or fuel mix and emissions requirements.

net zero emissions by 2050. According to the National Council for State Legislature[15], 14 states have Renewable Portfolio Standards (RPS) of 50% or greater—requiring investor owned utilities (IOUs) sales in these states to come from 50% or more renewable resources. These clean energy policies at the utility and state levels are driving clean energy requirements for microgrid development, and are influencing the stakeholder conversations around microgrid tariff design.

Key Questions to Consider:

- Is there a minimum requirement for renewable generation in microgrids?
- Are there local or jurisdictional emission standards or requirements that the microgrids must comply with?

Microgrid Services Tariff Development

Tariff Structure and Eligibility

Multi-user/community microgrid tariffs may be structured in a number of ways to address specific uses depending on what a jurisdiction is seeking to enable and whether a societal benefit has been established for development of community microgrids and/or any value from a resilience service. Three basic forms include:

- Program based-tariff designed to enable the specific elements of a microgrid enabling program that is intended to incentivize microgrid development.

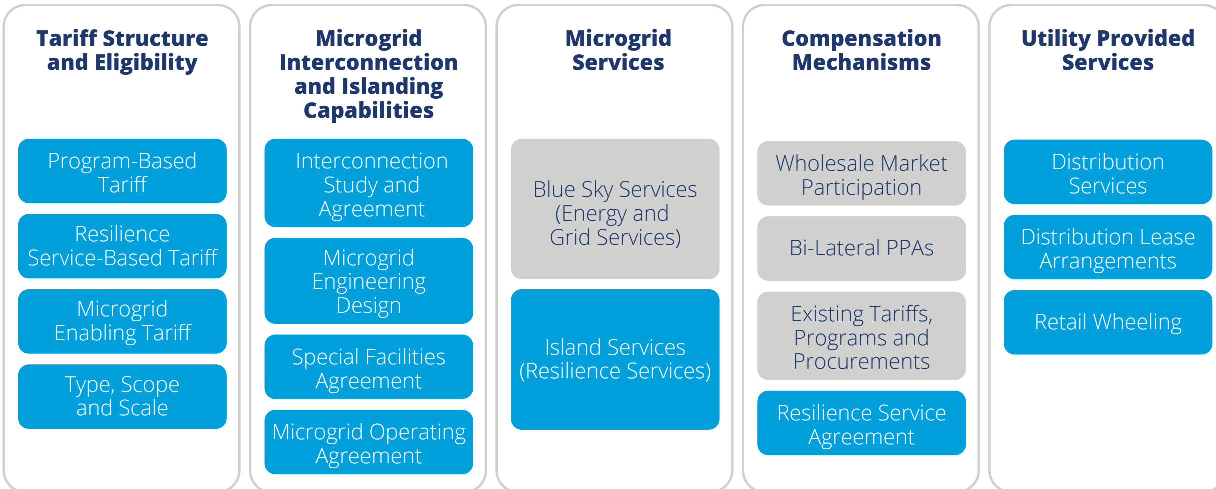
15 https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx

16 https://www.hawaiianelectric.com/documents/about_us/our_vision_and_commitment/resilience/microgrid_services_tariff/dkt_2018_0163_20200330_microgrid_services_tariff.pdf

17 https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1339

18 https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M314/K274/314274617.PDF

Figure 6: Multi-User Microgrid Tariff Framework—Development



Source: Smart Electric Power Alliance, 2020.

- Resilience service-based tariff designed to compensate a microgrid operator for providing microgrid forming service that provides frequency, voltage and other power quality services necessary to maintain electric service to customers.
- Microgrid enabling tariff designed to enable the development and operation of a multi-user microgrid, but does not include any microgrid service provision or compensation.

Program-Based Tariff

A program-based tariff may focus on specific geographic areas susceptible to outages and impact from major events. Additionally, such a program may focus on critical facilities and those customers with medical and other critical needs for highly resilient electric service. PG&E's Community Microgrid Enablement Program approved by the CPUC and related tariff is an example. This program includes incentives to offset the cost of distribution upgrades to enable a multi-user microgrid across a distribution line segment. A program enabling tariff would provide an umbrella structure covering the lifecycle of a microgrid project from application, engineering studies, development and testing and commercial operations. This program tariff may consist of interconnection processes and agreements, any special facilities agreements for distribution upgrades, and microgrid operating agreements.

Resilience Service-Based Tariff

A resilience service-based tariff will focus on specific locations and critical customers with identified needs as above, but the structure of the tariff is oriented toward the provision of a microgrid forming service, performance requirements, and related compensation. Compensation for this service will require finding a societal value for the proposed multi-user microgrid. That is, it is in all ratepayers' interest to compensate for a microgrid forming service or resilience service from the proposed microgrid. The Hawaii commission noted this requirement and placed the burden of showing societal value on microgrid developers for any proposed compensation.[19] As with a program-based tariff, this tariff will span a microgrid lifecycle and point to interconnection and special facilities agreements.

Microgrid Enabling Tariff

A microgrid enabling tariff is intended to clarify and streamline the process for the development and operation of any proposed multi-user microgrid. Specifically, this tariff addresses any prior barriers to multi-user microgrid development or operation, and implements legislative and regulatory requirements. This tariff does not include any service provision or microgrid compensation/incentive and would operate solely to provide incentives. As with program-based tariff, this tariff spans a microgrid lifecycle and points to interconnection, special facilities, and the microgrid operating agreement. The Hawaiian Electric draft

19 Hawaii Public Utility Commission, Decision and Order No. 36481

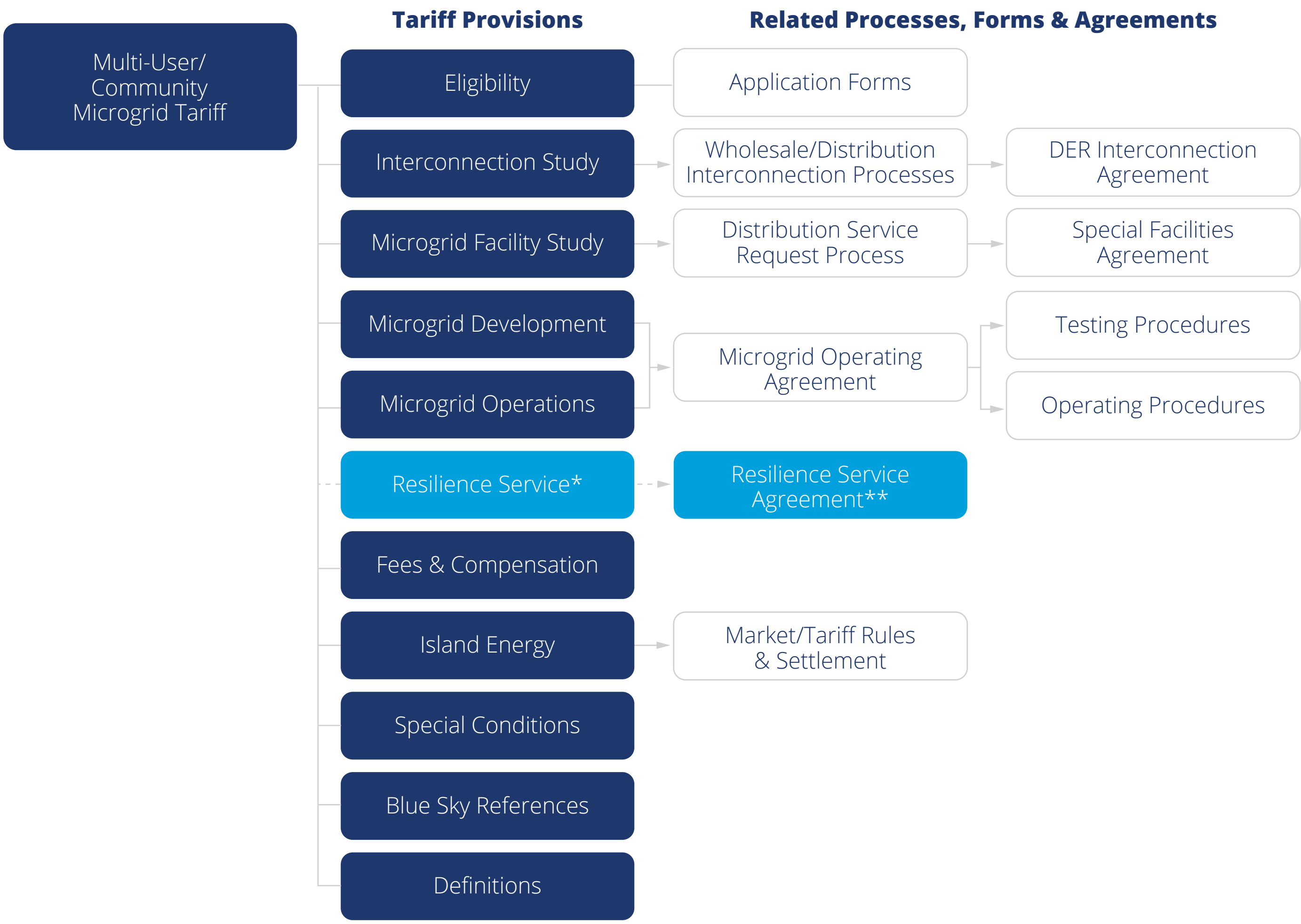
microgrid tariff[20] consistent with the Hawaii Commission's order is a form of microgrid enabling tariff that includes multi-user microgrids. PG&E has also recently filed a community microgrid enabling tariff.[21] These early tariffs do not preclude future resilience service provisions.

After establishing the purpose and form of a tariff, it is necessary to address specific details as illustrated in Figure 7 in a logical sequence in line with a microgrid development and operational lifecycle.

Each tariff element should be considered in relation to existing processes, blue-sky tariffs, and pro forma agreements that may be relevant.

The eligibility provision of a tariff defines the archetype, scope and scale of multi-user microgrids that are covered by the tariff. Significant differences exist between a tariff designed for customer microgrids versus multi-user microgrids that use the utility distribution grid to link resources and loads within the microgrid's boundary. In this context, a consideration as to the size of a microgrid on a distribution system is important. Larger multi-user microgrids, such as minigrids, involve considerable engineering, operational, and customer participation complexity that go beyond what may be addressed in a general tariff. These more complex, large multi-user

Figure 7: Multi-user/Community Microgrid Tariff Structure



*Resilience grid service only applicable if societal need established.

** Resilience service agreement will incorporate the operating agreement elements in addition to service requirements.

Source: P. De Martini, 2020.

20 Hawaiian Electric draft microgrid tariff: https://www.hawaiianelectric.com/documents/about_us/our_vision_and_commitment/resilience/microgrid_services_tariff/dkt_2018_0163_20200330_microgrid_services_tariff.pdf

21 PG&E filing from 8/17: https://www.pge.com/tariffs/assets/pdf/adviceletter/ELEC_5918-E.pdf

microgrids are better suited for bi-lateral agreements that can address the unique microgrid project and distribution system aspects. Additionally, eligibility will include aspects related to location and critical customer composition noted above, as well as criteria for a project's energy producing resources including any clean energy requirements.

Key Questions to Consider:

- What is the appropriate form of multi-user microgrid tariff for the intended purpose?
- What are the elements of the tariff?
- Based on strategic considerations, who and what type of multi-user microgrid is eligible for the tariff?

Microgrid Interconnection and Islanding Capabilities

Multi-user microgrids require energy producing resources that are capable of providing energy to participating customers' load across a distribution line segment during island mode. This requires the ability of the energy producing resources to follow customers' load and maintain frequency and voltage within service quality standards. Additionally, multi-user microgrids must be able to seamlessly transition at a point of common coupling between normal grid connections and island mode, and resynchronize back to normal grid connected mode.

Depending on state regulation, multi-user microgrids will require energy producing resources in front of the meter directly connected to the distribution circuit and/or behind the meter resources that are capable and allowed to export onto a distribution circuit. Special considerations should be given whether resources behind a microgrid may need to have their allowable operation models and the ability to export expanded during microgrid operation. These microgrid project resources will need to undergo an interconnection study that addresses both the normal, blue-sky conditions and conditions requiring proposed island mode. This study will assess system impact of the additional exporting resources as well as the necessary distribution upgrades for interconnection and microgrid formation (e.g., recloser to create the point of common coupling, and protection and controls), and the interconnection and operational requirements for the proposed microgrid. These studies will be performed under existing interconnection rules (and wholesale access tariffs as applicable) and distribution service request rules. In some cases, modifications to existing interconnection and service request rules will be necessary to clarify applicability to multi-user microgrids or remove any barriers to multi-user microgrids.

Key Questions to Consider:

- Do existing interconnection and distribution service request rules need to be modified to enable multi-user microgrids?
- How should microgrid related IEEE standards be addressed?

Microgrid Services and Compensation Mechanisms

Multi-user microgrids are typically designed to provide both blue-sky services and island services that can serve individual microgrid customers or the grid.

Blue Sky Services

Blue sky services often involve wholesale market participation and/or bi-lateral power purchase contracts with load serving entities, or retail customers depending on the situation and applicable regulation. As illustrated in Table 2, blue sky services for multi-user microgrids can provide both service to the customer and to the grid. As the resources are typically in front of the meter, the blue sky service for the customer can take the form as community solar energy. Additionally, the microgrid resources may provide grid services, such as wholesale energy market participation and ancillary services, as well as distribution NWA services. These blue-sky revenue streams are often the primary driver for multi-user microgrid project economics. As such, it is important that a multi-user microgrid tariff acknowledges that the microgrid project resources may participate in eligible wholesale market opportunities as well as utility programs, tariffs and procurements, as long as these do not impede the ability of the microgrid to function in island mode. Beyond this clarification, a microgrid services tariff scope should not cover blue sky service provision and focus instead on island mode. This focus on island mode

Table 2: Types of Multi-User Microgrid Blue-Sky and Island Services		
	Customer Service	**Grid Service**
Blue-Sky Service	▪ Community Solar Programs ▪ Decarbonization	▪ Wholesale Energy Market Participation / PURPA PPA ▪ Wholesale Ancillary Services ▪ Distribution NWA
Island Service	▪ Resilience Services ▪ Islanded Energy Services	▪ System Resilience Services ▪ Microgrid Forming Services

Source: Smart Electric Power Alliance and Pacific Energy Institute, 2020.

will reduce potential conflicts with existing and future blue-sky revenue opportunities. It may be necessary to make changes to existing tariffs, programs and procurements to explicitly enable microgrid resources to participate in other market opportunities, as was done in Hawaii.

Islanded Services

Islanding capabilities also provide services to both the customers within the multi-user microgrid boundary, and potentially societal value beyond the microgrid participating customers.

Customer resilience service will typically involve a separate bi-lateral service arrangement between the microgrid developer/operator and participating customer with the terms and prices outside regulatory jurisdiction. As such, these customer resilience services are considered outside the scope of a multi-user microgrid.

Grid resilience services include the provision of microgrid forming services - and in certain cases, societal value - by the microgrid operator to the distribution utility and community. This service may be defined as maintaining frequency and voltage within existing service quality standards during island mode. Compensation for this service may involve one of three methods:

- **Avoided Cost**—similar to distribution deferral methods used in non-wires alternatives. The avoided cost of the distribution alternative (e.g., utility developed microgrid, undergrounding, etc.) is used as the basis for the value of the service. California and New York both include this potential grid service in their respective distribution deferral frameworks.
- **Cost of Service**—this method uses the incremental costs for the microgrid developer/operator to determine compensation for providing the service. This requires a cost accounting of the discrete incremental costs incurred to establish the microgrid project's microgrid forming capability. Cost of service is used by CAISO and others to determine compensation for black start service and certain other wholesale reliability services.
- **Avoided Loss Value**—this method uses the value of lost load/value of service approach to determine the societal value of the avoided loss of electric service to the participating customers. This method requires participating critical customers that have demonstrably material societal value and an economic valuation method that produces reasonable values. This is important as the compensation will be paid by all ratepayers.

Key Questions to Consider:

- What are the different value streams that microgrids can operate in (e.g. blue sky and island operating modes)?
- Do existing blue sky tariffs, programs, procurements and wholesale market opportunities allow distributed resources within a multi-user microgrid to participate? Are there any restrictions?
- How should other existing DER tariffs and programs be addressed in the tariff?
- What microgrid island resilience services or functions should be considered in developing a microgrid tariff? What are the performance requirements and methods for payment and compensation?
- Are microgrid resilience services to participating customers within the purview of the regulator?
- Is a microgrid operator treated as a DER aggregator or energy services provider under the state's regulations? Are there corresponding requirements?

The performance requirements for grid resilience services may be more stringent than standard service quality requirements. For instance, non-performance recourse provisions will often be included in a microgrid services agreement similar to a non-wires alternative (NWA) service agreement.

Utility Provided Services

A multi-user microgrid involves using a segment of a utility's distribution circuit to link project resources with participating customers. The utility will need to continue to provide distribution service to transport the energy produced by the resources within the microgrid. In restructured states, existing retail wheeling rules or tariffs should apply to island mode as well as normal conditions. PG&E's community microgrid tariff reflects the continuity of their role as distribution service provider during island mode. In California, retail energy may be provided by the utility, a community choice aggregator, or a competitive retail service provider. The export energy for a multi-user microgrid during island mode will be governed by the existing CAISO wholesale distribution tariff and treated as "in-market" for settlement purposes. Similarly, exporting resources under a retail community solar program will also be settled under the retail tariff as in blue sky mode. This effectively keeps all the various parties' indifferent in relation to the energy transactions and distribution delivery services.

In non-restructured states, the issue of retail wheeling will need to be addressed, or alternatives found, to avoid prolonged discussions around open access for retail competition. In Hawaii, the draft microgrid tariff addressed this issue through a work around by maintaining the purchasing of export energy from the microgrid resources under existing tariffs and reselling under existing retail tariffs to allow multi-user microgrids without the need for retail wheeling. This is possible in Hawaii as HECO is the purchaser of retail and wholesale energy and provider under retail rates.

Another concept proposed by some developers is to lease the segment of distribution circuit from the utility for the microgrid. This arrangement may be viable only if distribution secondary lines or a short primary tap line is involved. Use of a larger segment of distribution will significantly increase the complexity of coordinated operation to ensure public safety. The lease arrangement would also require the microgrid operator to compensate the utility for the use. The compensation should not require utility ratepayers' subsidizing this use. If there is societal value, then a resilience grid service can address the incremental value.

Additional Considerations

Additional key areas to consider, include microgrid development, community interest, purview of a commission over microgrid development and related customer resilience services, definition of a utility, cross subsidization and monetization of societal benefits.

Microgrid Development

A multi-user microgrid tariff should also address the project development phase that will involve the microgrid developer's activity to install project distributed resources or upgrade existing resources, as well as the necessary controls and related systems. Concurrently, the utility will install the necessary isolation switch/breaker and related protection and controls to enable safe operation in parallel and island modes and transition back and forth. Multi-user microgrid development also involves extensive acceptance testing of the protection and control systems in laboratory testing and in the field prior to commercial operations. A multi-user microgrid tariff will reflect this phase through reference to the provisions in a pro forma interconnection agreement (modified for microgrids), microgrid operating agreement, or a microgrid services agreement (if grid resilience service is provided). Additionally, given that microgrid resources and the project itself may be assigned a place in a queue for available hosting capacity, consideration should be given for a project development time limit to avoid projects blocking other potential projects in the same location from advancing. This issue has occurred in some jurisdictions as competitors seek control of the best locations for development.

Future Material Changes

Multi-user microgrids may experience material changes within the electrical boundary over its lifespan related to resources and customer loads. Material changes to the composition and scale of microgrid project resources and participating customer loads and resources may necessitate a new engineering study to reassess the viability of the microgrid islanding capability, distribution upgrades and/or changes to protection and controls requirements. Additionally, material changes impacting the distribution system outside the microgrid boundary may also have implications on the viability and operation of a multi-user microgrid. For example, future development of distributed resources by customers within and outside the microgrid boundary independent of the microgrid project may require reconfiguration of a distribution circuit such that it may require changing the microgrid islanding point or even that an electrical boundary cannot be effectively reestablished with the project resources available. Therefore, a key consideration arises regarding the primacy of the distribution system to provide service to all customers pursuant to the statutory and regulatory requirements for the utility distribution provider. The primacy of distribution service to support all customers may affect the future operation of a multi-user microgrid if and when material changes occur.

Community Interest

Community based multi-user microgrid projects will often require funding from a local community and participating customers for development, as blue-sky revenues are insufficient to cover all development costs. In this case, the additional resource and distribution upgrade costs to support islanded mode are above what would otherwise be required to provide wholesale and/or retail energy and grid services. Additionally, the societal and individual customer benefits that are in the public interest are often recognized as better funded from public funding sources as opposed to utility rates, as it otherwise could place undue increased rate pressure on non-participating customers. However, this requires a certain level of community wide buy-in, and legislative and regulatory support. The availability of grant programs, PACE financing and other incentives can facilitate the development of multi-user microgrids. Several states are addressing these issues.

Legislative and Regulatory Insights

- **California:** S.B. 1215[22] was introduced in February 2020 with the intention to create a Local Government De-energization Event Resiliency Program to provide grant funding to local governments, joint power authorities and special districts to deploy resiliency projects such as microgrids. In June 2020, the CPUC approved PG&E's Community Microgrid Enablement Program[23] that will provide incentives in the form of credits to offset the distribution upgrades to enable community based multi-user microgrids.
- **Massachusetts:** The Massachusetts House passed H.B. 3997[24] in July 2019, establishing an allocation of funds to provide technical assistance for municipalities developing microgrids. It also creates a Green Resiliency Fund for local governments to make resiliency investments. Massachusetts legislatures also proposed H.B. 2831[25] and S.B. 1941 which makes commercial PACE financing available for microgrids that incorporate clean energy resources.
- **New Jersey:** A.B. 2374 and S.B. 1953 were proposed[26] on January 27, 2020 to make microgrids eligible for PACE financing.
- **New York:** A.B. 2452 and S.B. 1535 were proposed on January 22, 2019 to create the Takecharge New York Power program to award funding to qualified businesses for microgrid projects.

22 http://leginfo.legislature.ca.gov/faces/billHistoryClient.xhtml?bill_id=201920200SB1215

23 CPUC, Decision Adopting Short-term Actions to Accelerate Microgrid Deployment and Related Resiliency Solutions. Rulemaking 19-09-009. June 11, 2020. Available at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M340/K748/340748922.PDF

24 https://malegislature.gov/Bills/191/H3997

25 https://malegislature.gov/Bills/191/H2831

26 https://www.njleg.state.nj.us/bills/BillView.asp?BillNumber=A2374

Legislative and Regulatory Insights, continued

- **Oregon:** Oregon Legislature passed S.B. 1537[27], which is directing focus and attention towards how microgrids can provide emergency response and preparedness. Additionally, the Oregon Department of Energy is also investigating resilience threats and how microgrids fit into the consideration of solutions in the "Oregon Guidebook for Local Energy Resilience"[28] published in 2019. The Oregon Legislature also passed H.B. 2193[29], which directed the utilities to find potential projects and ultimately procure an energy storage system. After gauging customer interest and engaging in a rigorous selection process with local governments, Portland General Electric partnered with the City of Beaverton to jointly invest in a microgrid at the Beaverton Public Safety Center for police and emergency management.

Purview of Commission & Definition of Utility

Several issues exist around the purview of the Commission towards third-party operators of multi-user microgrids in island mode. During blue sky normal conditions, microgrids are subject to applicable tariffs and market participation rules that may apply as well as the respective regulatory jurisdiction. However, issues arise during island mode when resources are no longer able to participate in markets or provide grid services under utility programs and tariffs. Instead, the normal mode relationships change. For example, there are usually commercial agreements between the microgrid operator and participating customers regarding the provision of energy and/or resilience service. Those customers or entities with energy producing resources or load modifying resources may contract with the microgrid operator to sell energy and grid services to form the island microgrid. These bi-lateral

Legislative and Regulatory Insights

- **District of Columbia:** On May 31, 2019, the D.C. Public Service Commission MEDSIS Stakeholder Working Groups released a final report of recommendations[30] addressing microgrid development. One recommendation was for the DCPSC to establish a new regulated entity of "microgrid operator" for any entity that operates a microgrid serving multiple customers. Stakeholder positions vary on this issue and range from heavy to light regulatory oversight on topics such as consumer protections, quality of service, and emissions requirements.
- **California:** Electric Rule 24 (for PG&E and SCE) and 32 (for SDG&E) are a set of rules that define the roles and responsibilities of third-party demand response providers and DER aggregators. This is an important consideration for determining regulatory rules that apply to microgrid operators who are also operating as DER aggregators. It may make sense to apply such existing rules to multi-user microgrid operators as they are effectively performing similar functions as DER Aggregators under blue-skies.
- **Maine:** The Maine Legislature took steps towards clarity by approving L.D. 13 in March 2020, which declared that microgrid operators would not be deemed public utilities under Maine statute thus not being held to the same regulatory scrutiny of utilities by the Maine Public Utilities Commission (MPUC).
- **New York:** In New York, several microgrid developers have petitioned the NYPSC against being subject to the Commission's jurisdiction, including most recently in April 2019. Despite several petitions, there has yet to be a precedent ruling on whether multi-user microgrids are or aren't subject to the Commission's jurisdiction. However, in January 2020, the New York Legislature proposed a bill—A.B. 6429 - that would require the NYPSC to develop recommendations regarding the establishment of microgrids.

27 https://olis.oregonlegislature.gov/liz/2020R1/Downloads/MeasureDocument/SB1537
28 https://www.oregon.gov/energy/safety-resiliency/Documents/Oregon-Resilience-Guidebook-COUs.pdf
29 https://olis.leg.state.or.us/liz/2015R1/Downloads/MeasureDocument/HB2193
30 https://dcpsc.org/PSCDC/media/PDFFiles/HotTopics/GridModernizationFinalReport.pdf

contracts are often outside the purview of a commission and rules governing consumer protection and electricity quality of service.

Any multi-user tariff proceeding and market settlement discussions should address these island mode aspects with the market operator as applicable. Only a handful of jurisdictions have begun addressing this issue.

Cross Subsidization & Monetization of Societal Benefits

A challenge for multi-user microgrid developers and utilities investing in these projects is how to effectively demonstrate and quantify the societal benefits beyond those for the microgrid participants. The underlying issues relate to cross-subsidy of microgrid development by other non-benefiting customers, and the monetization of potential societal resilience benefits through utility compensation. Several states have begun to address these issues.

Legislative and Regulatory Insights

- **California:** In 2018, California legislation S.B. 1339 directed the California Public Utilities Commission to take several actions surrounding the commercialization of microgrids without shifting costs between ratepayers, prohibiting cross-subsidization of microgrid deployment.
- **Hawaii:** In 2018, Hawaii legislation H.B. 2110[31] directed the Hawaii Public Utilities Commission to open up a proceeding to establish a microgrid services tariff, citing the importance of avoiding weakening the overall system and increasing costs for other utility customers. Within HECO's draft microgrid services tariff filed on March 30th, 2020, it states that the onus to make the case for societal and resiliency benefits for monetization falls on the microgrid operator consistent with the Hawaii commission's microgrid order.
- **Maryland:** The Maryland Public Service Commission was presented with two multi-customer microgrid proposals - one from Pepco[32] and the other from Baltimore Gas & Electric[33] —and rejected both on the grounds of unequal distribution of benefits to ratepayers and the inability to quantify resilience benefits.
- **Maine:** The approved legislature in Maine, L.D. 13, also directed the MPUC to approve microgrid proposals of up to 25 MW if they are in the public interest, which may provide more direction in Maine as it relates to rate recovery for microgrids that act in the public's best interest. L.D. 13 also gives the MPUC leeway in evaluating rate payer impacts of microgrid proposals.
- **Michigan:** On April 29, 2019 the Michigan House of Representatives proposed a piece of legislation—H.B. 4477[34]—which will require the Michigan Public Service Commission to prepare a report evaluating the costs and benefits of using microgrids to supply electricity to critical facilities.

Key Takeaways

This paper discusses key considerations to address in the development of a multi-user microgrid tariff based on initial legislative and regulatory developments in several states to-date. However, this paper does not attempt to comprehensively address all the issues in depth, or may be unique to each locale. The framework should be considered a starting point to guide development of a multi-user microgrid tariff and the many issues to resolve.

It is critical to start with a common vocabulary for any stakeholder discussions. A structured process employing

31 https://www.capitol.hawaii.gov/session2018/bills/HB2110_.HTM
32 https://www.psc.state.md.us/wp-content/uploads/Order-No.-88836-Case-No.-9361-Pepco-Microgrid-Order.pdf
33 https://www.utilitydive.com/news/maryland-psc-rejects-baltimore-microgrid-proposal/423063/
34 http://www.legislature.mi.gov/documents/2019-2020/billintroduced/House/pdf/2019-HIB-4477.pdf

the SEPA framework is necessary to effectively engage stakeholders. Significant miscommunication and lack of common understanding still exists around microgrids in general, which is particularly true of multi-user (community) microgrids. Common vocabulary and a structured process are prerequisites to enable common understanding of the legislative and/or regulatory tariff objectives and requirements leading to tariff development. This will enable determination of the focus of the tariff based on customer demand and commercial readiness of microgrids in the jurisdiction. The variation of microgrid types based on number of customers, technical capabilities, and physical location on the grid makes it critical to define the scope up-front. Additionally, these initial discussions should seek to align third-party/customer objectives for developing multi-user microgrids for resilience, economics, and sustainability with electric grid statutory and regulatory requirements for maintaining the safety, reliability and affordability of the electric power system.

It is highly recommended to focus a multi-user microgrid tariff on the lifecycle of a microgrid from eligibility through commercial operations and the related enabling agreements (i.e., interconnection, special facilities and operating/service agreements).

The tariff should also focus on island mode operation and the interrelationship with existing tariffs, programs, procurements, and wholesale opportunities under blue sky grid connected mode. Services that the microgrid operators provide to their microgrid participants are typically not covered within a microgrid tariff, and can be handled through separate bi-lateral agreement including participation and disclosures between the microgrid operator and the participating customer. Regulators will need to consider appropriate oversight of these 3rd party resilience service contracts.

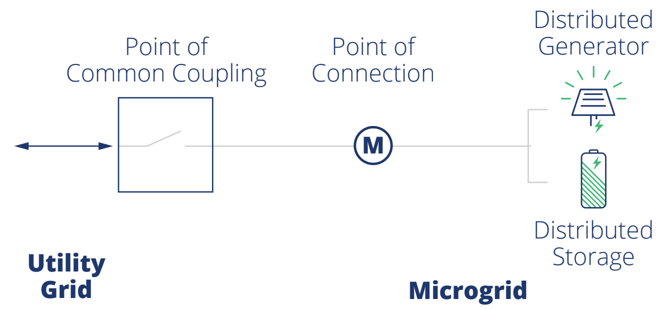
Utilities will need to coordinate across the different utility functional areas—customer programs, DER interconnection, grid planning, and operations—to ensure the completeness of the tariff and subsequent execution to successfully enable multi-user microgrid development and operations.

Appendix A: Microgrid Terminology & Archetypes

Microgrid Terminology

- **Aggregator** is an entity that operates a portfolio of distributed energy resources on behalf of others to provide energy, ancillary and/or grid services in blue-sky normal conditions as well as during island operation.
- **Asset Owner** is an entity or person that owns distributed generation, storage or demand management resources, or electric infrastructure used to form and operate a microgrid.
- **Interconnections:** There are two key reference points for microgrids when considering interconnection requirements and operational boundaries with the utility grid, Point of Connection and Point of Common Coupling defined in IEEE Standard 1547-2018 and related standards such as IEEE 2030.7/8.
  - **Point of Connection** (PoC) is the point where a distributed generator or storage unit is interconnected to an electrical distribution system which may be a customer distribution network or utility distribution grid as in the case of certain multi-user microgrids. This may also be referred to as a point of interconnection when referring to DER connected directly to a utility grid.
  - **Point of Common Coupling** (PCC) is the point where a microgrid is connected to the utility power system. This may be at the point of interconnection or another location on the utility distribution grid.
- **Microgrid Forming Service** is a grid resilience service that provides frequency, voltage and other power quality services necessary to maintain electric service to customers.
- **Microgrid Operator** is an independent entity or utility customer that is responsible for the safe operation of a multi-user or customer microgrid consistent with applicable interconnection rules and any operating agreement. A microgrid operator may also act as an aggregator for the purpose of providing services from the microgrid related DER to wholesale markets and/or utility grid services in normal blue-sky mode.
- **Multi-User Microgrid Participant** is an entity or person that contributes to and/or uses the services provided by the microgrid.

Figure 8: Microgrid Reference Points



Source: P. De Martini, 2020.

Additional Microgrid Archetypes

The following type of microgrids and related definitions/ diagrams are adapted from stakeholder discussions in California, the District of Columbia, Hawaii and Illinois. They are provided to help clarify the several archetypes that can be a part of strategic discussions of scoping out a tariff.

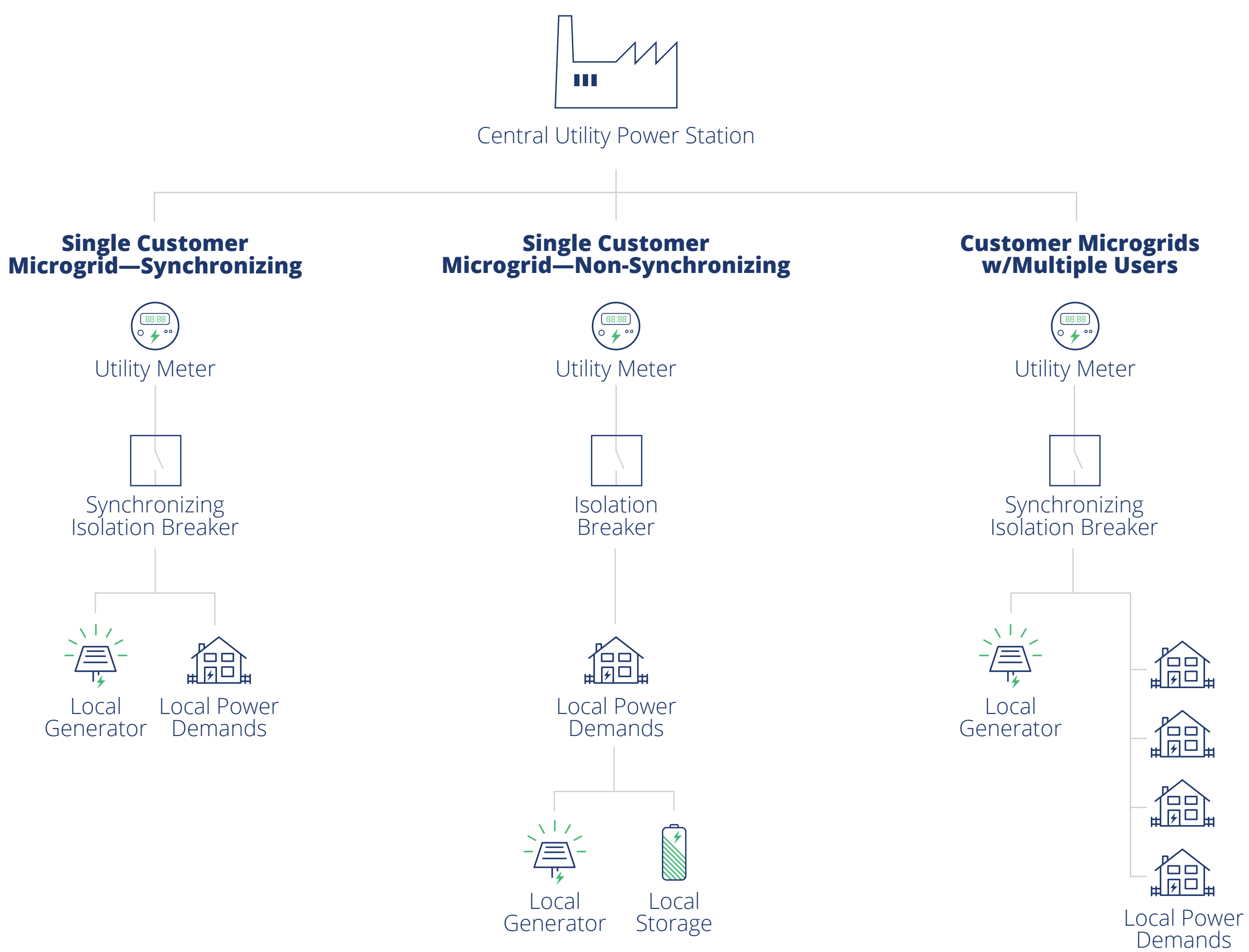
Customer Microgrids

Customer Microgrids are customer or independently developed microgrids involving a single utility customer location. They are self-governed, acting as a single controllable entity normally operated in utility grid-connected mode and can disconnect from the grid to operate in island mode for resiliency. Customer microgrids are downstream of a point/s of common coupling (PCC) with an electric utility, utilizing either (i) own distribution infrastructure, or (ii) lease or otherwise obtain use of non-utility distribution wires and other internal infrastructure of the microgrid from non-utility third parties. Customer microgrids may be one of two distinct archetypes:

How to Design Multi-User Microgrid Tariffs

- **Single Customer Microgrids** are customer or independently developed microgrids involving a single utility customer location with energy producing resources behind the customer's meter. The descriptions below include the two possible interconnections:[35]
  - **Unsynchronized Customer Microgrid** that disconnects on grid outage via an isolation breaker and requires an "open transition" involving de-energizing all generation/storage units in the microgrid, and then closing the isolation breaker to reconnect to the utility grid. Once reconnected, the generation/storage units can then be restarted as desired. This is the simplest option for reconnecting a microgrid back to the grid. However, it does require dropping load before reconnecting to the grid, resulting in a momentary outage to the house/building/facility.
  - **Synchronizing Customer Microgrid** that seamlessly islands on grid outage and reconnects via a synchronizing isolation breaker after grid is restored. This type of interconnection enables seamless reconnection of a microgrid's loads and resources after the grid is restored. That is, no loss of load during transition back to grid connection.
- **Customer Microgrid w/Tenants**—this type of microgrid is another form of a customer microgrid that has multiple submetered tenants interconnected. This

Figure 9: Customer Microgrid Archetypes



Source: P. De Martini, Adapted from Microgrid Resource Center, 2020.

35 Con Edison, *Technical Requirements for Microgrid Systems Interconnected with the Con Edison Distribution System*, 2017 https://www.coned.com/-/media/files/coned/documents/save-energy-money/using-private-generation/specs-and-tariffs/eo-2161.pdf?la=en

type of microgrid archetype may involve a commercial building, research park, apartment complex, or commercial retail mall. A number of examples have been developed including Kings Plaza shopping mall in Brooklyn, New York[36] and Blue Lake Rancheria microgrid in California.[37] The main distinction is that this type of multi-user microgrid does not use the utility grid behind the PCC to form the microgrid and provide the energy to the multiple tenants. The interconnection at PCC may be unsynchronized or synchronized as described above.

Note that a customer microgrid may involve a single building (e.g., home, commercial or institutional) or a commercial or institutional campus, such as a university. The primary distinction is that the microgrid is wholly contained on a single customer's property using only non-utility infrastructure beyond the PCC. These three customer microgrid archetypes with the interconnection configurations are illustrated in Figure 9.

Additional Microgrid Archetypes

Several additional effective microgrid archetypes are being pursued, but generally fall outside the legislative intent of microgrid tariffs that have focused on enabling customers and independent development of microgrids with characteristics consistent with DOE's microgrid definition.

- **Utility Microgrid** is a microgrid with local distributed resources developed, owned (or contracted) and operated by a utility to serve a community or specific critical facilities. Examples include SDG&E's Borrego Springs and Alliant Energy's microgrid for the Department of Natural Resources at Sauk City, Wisconsin[38]
- **Utility Partnership Microgrid** is a microgrid developed and operated by a utility on their distribution system to serve a community or specific critical facilities that involves both utility resources (own or contracted) and customer resources providing services. Commonwealth Edison's Bronzeville Community Microgrid, Ft. Collins' microgrid and Hawaii's Schofield Barracks are examples.
- **Remote Microgrid** is a customer or multi-user microgrid that is not connected to the utility grid in normal mode and unable to connect to the utility grid. The Great Smoky Mountain Park[39] utilizes a simple remote microgrid for emergency use while the Steger Wilderness Center in Ely, Minnesota relies completely on its microgrid resources.[40]
- **Virtual Microgrid**—also known as a Virtual Power Plant (VPP) - is a set of aggregated resources that can provide energy and/or grid services under normal operating conditions. For example, Southern California Edison utilities 27 MW of distributed batteries as a VPP.[41] The term VPP has also been applied to resources and customers that are financially transacting within a small geographic area as in the Brooklyn Microgrid.[42] A VPP is not a microgrid unless there is a clear electrical boundary with a POC and the resources and loads are able to island consistent with the DOE microgrid definition.

As described, these types of microgrids are generally outside the scope of microgrid services tariffs that are intended to facilitate customer or independent development of microgrids. Utility microgrids and partnerships are often addressed through regulatory applications. Remote microgrids also either fall outside the jurisdiction of a regulator, or if developed by or in partnership with a utility, will be addressed through a regulatory application. Virtual power plants are primarily addressed through DER aggregation market rules, DER services procurements and programs, or transactive energy pilots.

36 The Kings Plaza microgrid utilizes a 12 MW oil- and gas-fired system interconnected with the Consolidated Edison grid. https://microgridknowledge.com/new-microgrid-kings-plaza-coned/

37 The Blue Lake Rancheria microgrid is owned by the Blue Lake Rancheria Tribe and utilizes distribution lines once owned by PG&E. https://schatzcenter.org/blrmicrogrid/ & https://microgridknowledge.com/blue-lake-rancheria-microgrid-outages/

38 Alliant Energy installed a 6 kW solar generation for a 800-acre park south of Sauk City instead of replacing old electrical lines https://www.power-grid.com/2020/04/28/alliant-energy-creates-solar-storage-microgrid-as-non-wires-alternative-for-wisconsin-park/#gref

39 The microgrid installation removed 3.5 miles of power lines and provides reliable power for park rangers in emergencies. https://microgridknowledge.com/great-smoky-mountains-national-park-microgrid/

40 https://www.stegerwildernesscenter.org/2017/01/12/steger-micro-grid-wins-international-award/

41 SCE's Preferred Resources Pilot. https://www.greentechmedia.com/articles/read/advanced-microgrid-solutions-breaks-2-gigawatt-hours-in-grid-services

42 Brooklyn Microgrid developed by LO3 is a peer-to-peer financial trading arrangement that doesn't involve any corresponding physical transaction. In effect, it is an energy derivatives trading platform for individual retail customers. https://www.brooklyn.energy/about

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