White Paper: Enabling Regulatory and Business Models for Broad Microgrid Deployment

Owen Zinaman,[1] Joseph Eto,[2] Brooke Garcia,[3] Jhi-Young Joo,[4] Robert Jeffers,[1] Kevin Schneider[5]

1 National Renewable Energy Laboratory
2 Lawrence Berkeley National Laboratory
3 Sandia National Laboratories
4 Lawrence Livermore National Laboratory
5 Pacific Northwest National Laboratory

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-5R00-84818
December 2022

White Paper: Enabling Regulatory and Business Models for Broad Microgrid Deployment

Owen Zinaman,[1] Joseph Eto,[2] Brooke Garcia,[3] Jhi-Young Joo,[4] Robert Jeffers,[1] Kevin Schneider[5]

1 National Renewable Energy Laboratory
2 Lawrence Berkeley National Laboratory
3 Sandia National Laboratories
4 Lawrence Livermore National Laboratory
5 Pacific Northwest National Laboratory

Suggested Citation
Zinaman, Owen, Joseph Eto, Brooke Marshall-Garcia, Jhi-Young Joo, Robert Jeffers, Kevin Schneider. 2021. *White Paper: Enabling Regulatory and Business Models for Broad Microgrid Deployment*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5R00-84818.

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-5R00-84818
December 2022

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

NOTICE

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by Department of Energy Office of Electricity. The views expressed herein do not necessarily represent the views of the DOE or the U.S. Government.

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

U.S. Department of Energy (DOE) reports produced after 1991 and a growing number of pre-1991 documents are available free via www.OSTI.gov.

Cover Photos by Dennis Schroeder: (clockwise, left to right) NREL 51934, NREL 45897, NREL 42160, NREL 45891, NREL 48097, NREL 46526.

NREL prints on paper that contains recycled content.

Acknowledgments

The authors would like to acknowledge Dan Ton (U.S. Department of Energy) for his continued support and leadership in the development of high impact microgrid research in the United States. The authors would like to offer special thanks to our Industry Review Board, who provided valuable insights during an interview process as well as valuable technical reviews of this white paper. The Industry Review Board included (listed alphabetically by last name):

Sam Cramer, Program Director – National Association of State Energy Officials
Larisa Dobriansky, Chief Business & Policy Innovation Officer – General Microgrids
Forest Kaser, Supervisor of Resiliency and Microgrids – California Public Utilities Commission
Daniel Kushner, Senior Manager of Smart Grid Programs – Commonwealth Edison
Robert Panora, President and Chief Operating Officer – Tecogen
Jennifer Potter, Commissioner – Hawaii Public Utilities Commission
Tom Stanton, Principal Researcher – National Regulatory Research Institute
Kirsten Verclas, Senior Program Director – National Association of State Energy Officials
Kiera Zitelman, Senior Manager – National Association of Regulatory Utility Commissioners.

Finally, inputs from the Industry Review Board and other reviewers do not constitute an endorsement of this report or its contents. Furthermore, the views expressed herein do not necessarily represent the views of the DOE or the U.S. Government. The authors take sole responsibility for the contents of this report.

List of Acronyms

BLR	Blue Lake Rancheria
CHP	combined heat and power
CPUC	California Public Utilities Commission
DER	distributed energy resource
DOE	Department of Energy
DOE-OE	Department of Energy Office of Electricity
EaaS	Energy-as-a-Service
EDS	Energy Delivery System
kV	kilovolt
EPIC	Electric Program Investment Charge
HECO	Hawaiian Electric Company
HPUC	Hawaii Public Utilities Commission
ICC	Illinois Commerce Commission
ICE	Interruption Cost Estimate
IOU	investor-owned utility
MEA	Maryland Energy Administration
NARUC	National Association of Regulatory Utility Commissioners
NRRI	National Regulatory Research Institute
NREL	National Renewable Energy Laboratory
NELHA	National Energy Laboratory of Hawaii Authority
MaaS	Microgrid-as-a-Service
MGS	microgrid service
MW	megawatt
NASEO	National Association of State Energy Officials
NWA	non-wires alternative
OEMHS	Office of Emergency Management and Homeland Security
PCC	point of common coupling
PG&E	Pacific Gas & Electric
PPA	power purchase agreement
PRS	partial requirements service
PSHQ	Public Safety Headquarters
PSPS	Public Safety Power Shutoff
PUC	public utilities commission
RFP	request for proposals
R&D	research and development
RD&D	research, development & deployment
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric

Executive Summary

Microgrids as a Building Block for Future Electricity Systems

The United States electricity sector is moving to a more distributed future. Microgrids offer a pathway to this future by providing opportunities to reduce costs and emissions while bolstering the resilience of the nation's electricity system. Microgrids can be a fundamental building block for power system planning and operations, serving simultaneously as an "orchestra conductor" for a suite of distributed energy resources under their purview, as an aggregated, nodal point of control for bulk power system operators, and as an electrical peer networking and sharing resources with adjacent microgrids. Furthermore, in a future with increasingly frequent and severe climate-related natural disasters and greater electrification, microgrids may serve as a valuable resource in support of community resilience. However, microgrids also pose risks to the public interest – including safety, consumer protections and equity – and the regulatory environment for microgrids must balance these risks prudently and justly in order to maximize benefits to society.

In this context, the DOE Microgrid Research and Development (R&D) Program vision is to facilitate the nation's transition to a (1) more resilient and reliable, (2) more decarbonized electricity infrastructure, in which (3) microgrids have reduced cost and implementation times, while ensuring that microgrids support an equitable energy transition through prioritized provision of at least 40% of microgrid benefits going to disadvantaged communities in a secure manner. These three enumerated strategic goals are developed in the context that the United States' electricity system is becoming more distributed in nature, and that disruptions to the electricity delivery system are occurring more frequently and with greater severity. The vision statement follows.

> *By 2035, microgrids are envisioned to be essential building blocks of the future electricity delivery system to support resilience, decarbonization, and affordability. Microgrids will be increasingly important for integration and aggregation of high penetration distributed energy resources. Microgrids will accelerate the transformation toward a more distributed and flexible architecture in a socially equitable and secure manner.*

The vision assumes a significant increase of Distributed Energy Resource (DER) penetration during the next decade, reaching 30-50% of the total generation capacity. In that context, the Microgrid R&D program seeks to accomplish these three goals:

Goal 1: Promote microgrids as a core solution for increasing the **resilience and reliability** of the energy delivery system (EDS), supporting critical infrastructure, and reducing social burdens during blue and black sky events.

Goal 2: Ensure that microgrids serve as a driver of **decarbonization** for the US EDS by acting as a point of aggregation for larger number of DERs, with 50% of new installed DER capacity within microgrids coming from carbon-free energy sources by 2030.

Goal 3: **Decrease microgrid capital costs** by 15% by 2031, while reducing **project development, construction, and commissioning** times by 20%.

These goals additionally have cross-cutting topics of focus on equity and security in both R&D and partnered demonstrations. From an equity perspective, there will be a focus on supporting an **equitable energy transition** through prioritized provision of at least 40% of microgrid benefits going to disadvantaged communities for regulatory R&D and demonstration projects. From a security perspective, consideration of physical and cybersecurity research, as well as leveraging or teaming with appropriate entities advancing security through R&D, will be considered.

What is This White Paper?

This white paper is one of seven being prepared for the Department of Energy (DOE) Microgrid Research & Development (R&D) program as part of a strategy development effort for the next 10 years. The seven white papers focus on the following areas:

1. Program vision, objectives, and R&D targets in 5 and 10 years
2. T&D co-simulation of microgrid impacts and benefits
3. Building blocks for microgrids
4. Microgrids as a building block for the future grid
5. Advanced microgrid control and protection
6. Integrated models and tools for microgrid planning, designs, and operations
7. **Enabling regulatory and business models for broad microgrid deployment.**

This white paper is focused on Topic 7, as a sustainable regulatory and business environment for microgrid development is a foundational element for securing DOE's vision for the future role of microgrids in the U.S. electric sector.[1] The objective of this white paper is to systematically characterize regulatory issues involved in microgrid deployment and microgrid business models, and from this evidence identify a robust and well-justified set of research recommendations for the Department of Energy Office of Electricity, informing programmatic vision, objectives and activities for the DOE Microgrid R&D Program.

Recommendations to DOE Microgrid R&D Program

In summary, the U.S. DOE – with assistance from National Laboratories and working closely with strategic public- and private-sector partners – seeks a future in which utility regulatory frameworks and approaches enable prudent microgrid investment from the private sector, regulated utilities, communities, and states. This future will see microgrids as not only an essential resilience solution, but also as a core building block for power system planning and operations featuring higher penetrations of DER.

Through an extensive effort that involved both literature reviews and interviews with leading industry practitioners and experts, this report systematically identifies a variety of regulatory and institutional issues involved in microgrid deployment across a variety of microgrid use cases and business models. Given DOE's stated interest in seeing microgrids evolve from self-contained entities to modern networked systems, as well as a desire to focus on microgrid applications where there is high market potential but currently low deployment due to these regulatory and institutional issues, the authors focus specifically on the issues facing multi-property microgrids. Multi-property microgrids – and the regulatory and institutional frameworks which govern them – are only beginning to emerge in the U.S. Yet, they are a clear steppingstone toward a future that includes community-based, and networked microgrids. Furthermore, there are currently formidable regulatory challenges to multi-property microgrids, whether they are developed by utilities, communities, or third parties.

[1] While the focus of this report is primarily on utility regulatory issues, related legal, institutional and policy issues are also discussed to varying extents.

A summary of recommended activities for the DOE Microgrid R&D Program is listed below in Table ES-1, with a focus on addressing regulatory and institutional issues for multi-property microgrids.

Table ES-1 - Summary of Proposed DOE Microgrid R&D Program Activities for Reduction of Regulatory/Institutional Barriers

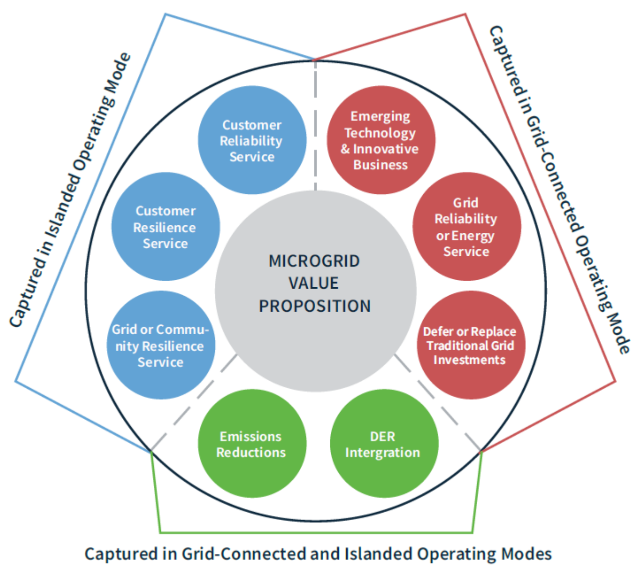
Category	*Activity*	*Impact Potential*	*Level of Effort*	*Project Duration*	*Collaboration w/ Other DOE Programs*
Training and Direct Institutional Support Programs	**Direct Technical Assistance to Regulators on Multi-property Microgrid Regulatory Framework Development**	*High*	*Low*	*Medium*	*Yes*
	Support for "Regulatory Sandbox" Microgrid Pilots	*High*	*High*	*Long*	*Yes*
	Multi-property Microgrid Regulation "Boot Camp"	*Medium*	*Low*	*Short*	*Yes*
Tools and Methods	**Quantifying the Value of Resilience of Microgrids in Regulatory Proceedings**	*High*	*High*	*Medium-Long*	*Yes*
New Information Resources	**Model Interconnection Procedures for Multi-property Microgrids**	*Medium-High*	*Low-Medium*	*Medium*	*Yes*
	Standardized Microgrid System Designs for Interconnection of Multi-Property Microgrid Resiliency Projects	*Medium*	*Medium*	*Medium*	*No*
	Reference Book on Microgrid Services Tariff Design, including Compensation for Resilience	*Low-Medium*	*Low*	*Short*	*No*
	Systematic Development and Improved Dissemination of Regulatory Case Studies for Multi-property Microgrids	*Low-Medium*	*Low*	*Short*	*No*
	Handbook on Integrating Microgrids into Utility Planning	*Low-Medium*	*Low*	*Short*	*Yes*
Forward Looking Activities	**New Coordination and Communication Architectures for a Privately-owned Multi-property Networked Microgrid Future**	*Low-Medium*	*High*	*Long*	*Maybe*
	"Future of Microgrid Regulation" Workshop	*Low*	*Low*	*Short*	*No*
	Expanded Collaborative Strategy Development to Find Market-Based Solutions	*Medium-High*	*Medium*	*Medium*	*Yes*
	Exploration of State and Local Technical Assistance to Support Policy Decision-Making Enabling Microgrids	*Medium-High*	*Medium*	*Medium*	*Maybe*
Collation of Existing Resources	**Improved Dissemination Efforts on Energy Resilience for Local Governments**	*Low-Medium*	*Low*	*Medium*	*Yes*
	Curated Information Library on Microgrid Regulation	*Low*	*Low*	*Short*	*No*
	Microgrid Modeling Tools Usability and Usefulness Improvements	*Low*	*Low*	*Short*	*Yes*

Table of Contents

1 Introduction

The United States electricity sector is moving rapidly into a more distributed future. In particular, trends in policy, regulation, technology, and consumer demands are driving the deployment of distributed energy resources (DER) at scale, leading to expectations that as much as 30-50% of all generation assets could be connected to the distribution network by mid-century. Such a future would result in relatively more complex architectures, operations, and enabling regulatory environments. Microgrids, however, offer a clear pathway forward through this additional complexity, offering a flexible and scalable opportunity to achieve this transition, enabling a *lower emissions* and *lower cost* energy future while bolstering the *resilience* of the nation's electricity system. In such a future, microgrids can be used as a fundamental building block of system planning and operations. Each microgrid can serve as the "orchestra conductor" for a suite of DERs under its purview while serving as an aggregated, nodal point of control for bulk power system operators and simultaneously networking and sharing resources with adjacent microgrids. Furthermore, in a future with increasingly frequent climate-related natural disasters, microgrids will serve as a valuable contributor to community resilience.

Motivations for microgrids are diverse and can vary by region, customer, utility, and the regulatory environment encompassing them. This diversity is also reflected in the many use cases and applications that microgrids can potentially have (see Chapter 3). However, one common thread across use cases is the ability of microgrids to "island" and maintain electric service, at least to some essential loads, during outages or when otherwise isolated from a larger power system. However, microgrids can also provide a range of services[2] while in a grid-connected mode of operation, provided that there is adequate control and communication infrastructure in place, as well as an enabling regulatory environment to support service provision. Such services include, among others, providing "non-wires alternative" solutions to conventional network investments and providing on-demand energy and ancillary services to the bulk power system. Figure 1 summarizes the categories of value streams that microgrids may provide by operating mode.



Source: *Smart Electric Power Alliance, 2020*

Figure 1 – Microgrid Value Streams by Operating Mode

The last decade has seen rapid expansion of the microgrid market, and a wide variety of use cases have emerged, ranging from *inter alia (a)* non-exporting, single customer behind-the-meter microgrids to (b) campus-level microgrids to (c) multi-property community microgrids, with many utilities attempting to pilot/demonstrate more innovative applications (Stanton 2020). The landscape of microgrid applications

[2] The value of these services is not uncertain and can vary significantly by market context.

is rapidly evolving, and while the value of microgrids is known at a conceptual level, there is still significant uncertainty as to the exact magnitude of their various value streams. Furthermore, regulatory environments are not necessarily currently organized to quantify or monetize these value streams, given the novel nature of technology and the potential risks that microgrids pose to the public interest surrounding safety, consumer protection, and equity.

Regulatory environments that enable a range of enabling business models across microgrid use cases will be critical in realizing the market potential of microgrids. While the term regulation can have a variety of meanings, for the purpose of this document, regulation is defined as a set of rules and standards which govern ownership, investment, financing, operation, remuneration, and participation in microgrids at any jurisdictional level, including local, municipal, state, and federal. In particular, economic and safety-related regulation of the electric utility operating environment via state public utility regulatory commissions and self-regulating utilities (e.g., electric co-operatives[3], municipal electric utilities, public utility districts) play a critical role in all microgrids that are embedded within or connected to the existing utility system.

U.S. DOE has long-recognized the importance of regulations in microgrid market development, and has made several recent investments in addressing key regulatory issues and supporting the development of innovative regulatory frameworks for microgrids. This includes:

- Supporting the National Association of Regulatory Utility Commissioners' (NARUC) and the National Association of State Energy Officials (NASEO) Microgrids State Working Group to improve the ability of states to plan for and develop microgrid projects, regulations, and policies.[4]
- Supporting a Voices of Experience industry engagement project focused on microgrids, which included discussion of policy and regulatory issues that affect microgrid development (VOE 2020).
- Supporting research reports by NREL focused on regulatory and business model environment for networked microgrids (Flores-Espino, Giraldez, and Pratt, 2020), microgrid costs (Giraldez et al. 2018), and enabling policy frameworks for community microgrids (Cook et al. 2018).
- Funding an industry consultant to track key state regulatory developments in the microgrid space.

Supporting the evolution of regulatory environments toward full and balanced consideration of microgrid costs and benefits, including risks, is critically important for reaching DOE's vision for the future role of microgrids in the U.S. electric sector. The DOE recognizes that regulatory frameworks are evolving to enable consideration of the benefits of microgrids in modern power systems, while taking due account of costs and risks of microgrids related to safety, consumer protection, and equity.

The objective of this white paper is to systematically characterize the known regulatory issues involved in microgrid deployment and microgrid business model innovation, and from this evidence identify a robust and well-justified set of research recommendations for the Department of Energy Office of Electricity (DOE-OE), as well as to inform DOE Microgrid R&D program vision and objectives. Chapter 2 provides the vision for the future of microgrids. Chapter 3 discusses microgrid use cases and business models, and

[3] Many electric co-operatives are not entirely self-regulating and may be subject to certain dimensions of state regulatory oversight (e.g., for safety or consumer protection)
[4] For more information, see: https://www.naruc.org/cpi-1/critical-infrastructure-cybersecurity-and-resilience/microgrids/#:~:text=NARUC%2C%20the%20U.S.%20Department%20of,projects%2C%20regulations%2C%20and%20policies.

provides three case studies of successful microgrid business models. With these discussions as a backdrop, Chapter 4 lays out the key regulatory considerations, issues, and challenges for a few prevalent microgrid use cases. Chapter 5 offers insights from emerging regulatory practices in Hawaii and California. A proposed set of activities and interventions for DOE to consider for the next 5 to 10 years are summarized in Chapter 6. Chapter 7 concludes the document, describing justifications for the set of prospective investments by DOE-OE.

All of the considerations examined in this whitepaper relate to supporting the regulatory community and industry in developing a structure conducive to appropriately capturing the value of advanced microgrids. However, there may be additional R&D support for policy considerations or more transformative regulatory structures that will also be necessary for DOE to achieve the Microgrid R&D program vision and objectives. These deep structural changes are not the topic of this whitepaper, but could be explored by DOE and partners with a more focused and collaborative effort. Chapter 6 includes a recommended activity to explore such a transformational strategy, as well as recommendations to support policy decision-making that may be needed for this strategy.

2 Vision for the Future

U.S. DOE – with assistance from National Laboratories and working closely with strategic public- and private-sector partners – seeks a future in which utility regulatory frameworks and approaches enable prudent microgrid investment from the private sector, regulated utilities, communities, and states.. This future will see microgrids as not only a common resilience solution, but also as a core building block of power system planning and operations featuring higher penetrations of DER.

More detailed characteristics of the regulatory aspects of the future vision include:

- Confident development of system-appropriate and cost-effective microgrids supported by a fair and just regulatory environment;
- Regulatory constructs that appropriately value microgrids for their ability to safely provide reliable, resilient, sustainable and affordable energy, while also ensuring that microgrids pay their fair share for the services they use;
- Regulatory constructs that do not preclude microgrid solutions for reasons other than sound technical objection, equity considerations, or consumer protection concerns (not necessarily because of lack of precedent or of pre-existing regulatory processes);
- "Future-proofed" electricity policy and regulatory frameworks that can accommodate the pace of technological advancement;
- Technical standards and interconnection processes for microgrids that allow stakeholders to integrate systems within and, at times, across utility service territories; and,
- An overarching framework that ensures investments in the electrical system continue to equitably benefit and protect the public.

According to Vanadzina et al., the " global microgrid market is expected to increase by a factor of five in the period between 2019 and 2028, from roughly $8 billion to $40 billion." By some estimates, "annual growth in microgrid capacity in the United States among municipal utilities could reach 320 MW per year by 2024, and 85 MW per year for private investor-owned utilities (IOUs)" (Vanadzina et al., 2019). Furthermore, there is growing evidence that microgrids can have a "positive impact on the power system in general, such as deferral of power system infrastructure investment, improved resilience, mitigation of risks associated with construction of big power plants, reduction in power losses, power quality improvement, ancillary services, and energy efficiency." (Lenhart and Araújo, 2021)

However, in order to secure the locally-appropriate opportunities presented by microgrids, from a business model and regulatory standpoint, a holistic approach is needed to fully integrate microgrids into the electric grid. At the same time, there is no single business or regulatory model that can accommodate all microgrid use cases, ownership and investment constructs, or applications, and establishing effective and balanced regulatory frameworks takes great care to achieve.

Through targeted activities supported by the DOE, in tandem with local regulatory dialogues surrounding the appropriate role of microgrids, the DOE is seeking a future in which regulators and utilities have the tools and resources needed to enable the market potential of microgrids. Furthermore, as microgrids evolve from self-contained to modern networked systems, regulatory environments must evolve to take due consideration, not only of new technology but also of new business strategies that may require new forms of oversight to protect the public interest. DOE can play an important role in these efforts. In general, we are seeking to promote a future in which cost-effective and locally-appropriate microgrid projects are enabled by a robust and modern regulatory environment capable of leveraging new technology while efficiently and effectively mitigating new potential risks to society surrounding consumer protection, safety, and equity.

3 Review of Successful Microgrid Business Models

There are a variety of emergent experiences with successful microgrid business models across the United States, as enabled by intelligently designed and effectively implemented regulation. Given the diversity of use cases for microgrids, as well as the modular nature of microgrid components and the highly customized configurations that each microgrid use case necessitates, there is no one-size-fits-all business model for microgrids. Nevertheless, key lessons are emerging on what makes a microgrid business model successful.

3.1 What is a Microgrid Use Case?

For the purposes of this white paper, a microgrid "use case" can be understood as a major category of application for microgrids, describing the primary function of the microgrid (which influences its design, cost and appropriate business model) and the intended microgrid customer(s) for the project. While there are many ways that microgrid use cases can be organized, we draw primarily but not solely from Stanton (2020) to offer the following set of key use cases described in Table 1[5] for the purposes of this white paper.

Table 1 Major Microgrid Use Cases

Major Microgrid Use Cases	
1 - Facility-level Microgrids	A microgrid designed for an individual customer (e.g., a data center) connected to a central utility system for enhanced service quality and resiliency. Microgrid assets would be located "behind" the utility meter. Such microgrids can be owned and operated by the customer, utility (i.e., under a fee-for-service arrangement), or a third party microgrid developer, or some combination thereof.[6]
2 - Campus-level Microgrids	A microgrid serving a single- or multi-owner contiguous set of facilities (i.e., a campus) typically behind-the-meter of a utility grid. These systems may serve customer load on a full-time basis and/or be designed to provide back-up islanding services. Department of Defense bases, universities and airports are common sites for campus-level microgrids. Utilities may or may not be involved in campus-level microgrid operation beyond the point of common coupling.
3 - "Public Purpose" Microgrids	A microgrid that serves one or more customers designed specifically to provide uninterrupted service to critical infrastructure and vitally important community assets. Government- or ratepayer-funded investments in these microgrids are common due to the social values associated with maintaining critical services during power outages.
4 - Remote Microgrids	A fully operational microgrid, sometimes referred to as a mini-grid, serving an electrically isolated community without connection to a larger electricity grid . Remote microgrids are a "one-stop shop" for all services, from provision of energy to maintaining stability and power quality. These are already common for service to islands and geographically remote/rural settings.
5- Community Microgrids	A microgrid serving energy to two or more different properties nested within the service territory of a utility. Community microgrids can operate independently from the grid but are otherwise connected to the utility network through a point of common coupling (PCC). They are a means to increase local energy independence and resilience.

[5] Notably, not all of these use cases are mutually exclusive.
[6] Notably, for facility-level microgrids, it is entirely plausible that only certain individual loads or circuits within the facility would remain energized during an intentional islanding, with less critical loads being shed. As well, some facility-level microgrids may export electricity to the utility system, whereas others never do so.

6 - Non-wires Alternative (NWA) "Anchor" Microgrids	A type of community microgrid operating a feeder segment or substation balancing area to provide non-wires alternative services as a primary use, while simultaneously offering partial or full resiliency services to customers during utility grid outages.
7 - Temporary Microgrids	Feeder segments or substations configured to be islandable microgrid hubs with all hardware installed except generation. Portable generators are staged at islanding point by truck, rail, boat or helicopter, and configured to plug into feeder segment or substation microgrid hubs when needed. Temporary microgrids are a resilience-only application (i.e., no value stacking opportunities) but do provide flexibility for where microgrids can be quickly deployed and is thus a form of "flexible resilience."
8 - Networked Microgrids[7,8] (Future Use Case)	A prospective future microgrid application in which sub-service-territory balancing areas, substations, feeder segments, or transformers act as clustered and nested microgrids, maximizing reliability and resilience among them. Most likely, this use case would consist of a series of community microgrids that also provide NWA characteristics in order to justify their investment.
9 - Utility Pilots	Utilities sometimes receive special regulatory approval to build-own-operate microgrids because of their novel and unique nature for the jurisdiction and the need to foster learning in the utility and regulatory environment. Realistically, a utility pilot will attempt to pursue one of the above use cases.

3.2 What is a Microgrid Business Model?

For the purposes of this white paper, we define a microgrid business model as the means by which a microgrid project is planned, developed and operated, covering both technical and commercial aspects. The business model includes dimensions such as:

1. The 'Use Case' of the microgrid
2. The nature of regulatory oversight (if any) that the microgrid is subject to, including terms and conditions for regulatory approval of the project
3. Applicable safety standards
4. Ownership arrangements of various microgrid assets
5. Financing model for the microgrid
6. Nature of applicable consumer protections
7. Cost recovery and revenue collection model for the microgrid
8. Other value-seeking activities of the microgrid that derive value for the microgrid owner and its customers
9. Responsibility for operation of the microgrid
10. Responsibility for maintenance of various microgrid components

Table 2 - Major Microgrid Business Models

Business Model Archetype	Applicable Use Cases	Business Model Description
Owner Financing, Operation and	1, 2, 3, 4	A single customer finances, procures, operates and maintains the microgrid for the purposes of additional resiliency and/or reduced operational costs (i.e., utility bill savings). This model sometimes

[7] https://www.nrel.gov/docs/fy20osti/70944.pdf
[8] This is considered a prospective future use case because it has not yet been demonstrated at scale. Phase II of the Bronzeville Microgrid will attempt to enable two electrically adjacent microgrids to interact to share resource.

Maintenance (Single Customer)		includes leveraging legacy on-site assets (e.g., generation resources, distribution network). These transactions do not typically require state regulatory approval but the microgrid developer must comply with relevant utility interconnection rules.
Owner Financing with Utility/Private Operation and Maintenance (Single Customer)	1, 2, 3, 4	Similar to previous business model but with private company or utility enrolled to operate and maintain the grid. This model is growing more common as microgrids focus more on the complex task of integrating fleets of DER (as opposed to operating only a handful of dispatchable generation resources). These transactions typically would not require state regulatory approval.
Privately-Owned Microgrid-as-a-Service or Power Purchase Agreement (PPA) (Single Customer)	1, 2, 3	With no upfront capital expenditure for the customer, a long-term contract involving structured monthly payments (often included a capacity payment and a volumetric energy charge) is signed between the customer and a private enterprise who will build-own-operate the microgrid. This business model allows customers to stabilize long-term energy costs and ensure resiliency without a major capital outlay. These transactions typically do not require state regulatory approval, provided that there is no prohibition against third party ownership of customer-sited distributed generation resources, but the microgrid developer must comply with relevant utility interconnection rules.
Utility Financed (Single Customer)	1, 2, 3	With no upfront capital expenditure for the customer, the utility develops a microgrid for an individual customer to boost resiliency. This may be a particular attractive option for customers with high reliability and power quality requirements (e.g., data centers). The customer pays a fixed monthly payment – typically under a long-term contract agreement – to the utility in order to support cost recovery. State regulators typically need to approve broader microgrid fee-for-service programs proposed by utilities, but not typically individual projects.
Utility Rate Base Multi-Property Microgrid	3; 4; 5; 6; 7; 8; 9	A microgrid developed with ratepayer funding and owned and operated by the utility to support community resilience and potentially also provide other monetizable services. Generation and storage resources may be utility-owned and/or be contracted to private developers. Such a utility investment will be carefully reviewed by state regulators for investment prudency, given that costs are passed through to ratepayers.
Privately-owned Multi-Property Microgrid	3; 4; 5; 6; 7; 8; 9	A microgrid developed with private funding to support community resilience, serve local load and potentially also seek value through service provision to the local utility or wholesale market. Such microgrids will likely be subject to a regulated bi-directional utility tariff approved by a regulator. Regulatory approval may also be required to protect consumers within the service territory of the microgrid.
Publicly-owned Multi-Property Microgrid	3; 4; 5; 7; 8	A microgrid developed with public funding (e.g., state grant funding, local budget funding) to support community resilience, serve local load and potentially also seek value through service provision to the local utility or wholesale market. Such microgrids are owned by a local government entity that self-regulates. This business model may involve outright purchase of a portion of the utility distribution network by a government on behalf of its citizens.

3.3 Case Studies of Representative Business Models

The following sub-sections contain short case studies of representative microgrid business models. The first two case studies (*Blue Lake Rancheria Microgrid* and *Bronzeville Microgrid*) have been selected because they represent early cases of potentially scalable business models for multi-property microgrids. The third case study (*Montgomery County Maryland Public Safety Microgrids*) was selected because it represents a business model that demonstrates very little regulatory or institutional barriers, yet market development has not yet taken off due to low levels of stakeholder familiarity with this approach.

Table 3 - Summary of Successful Business Model Case Studies

Blue Lake Rancheria Microgrid
Use Case(s): Community Microgrid; Public Purpose Microgrids **Business Model: Publicly-owned Multi-Property Microgrid** **Key Issues: Limited transmission interconnection; Frequent power interruptions; No regulatory framework to develop microgrid in collaboration with local utility and/or private developer** **Implemented Solutions: Direct purchase of distribution network using public funding** **Replicability Potential: Possible to replicate this development pathway in settings with limited connection, low reliability network segments with high social value of resilience. More likely in states that offer supplemental grant funding for network infrastructure purchase.**
Bronzeville Microgrid
Use Case(s): Community Microgrid; Public Purpose Microgrid; Networked Microgrid; Utility Pilot **Business Model: Utility Rate Base Multi-Property Microgrid** **Key Issues: Low reliability area; lack of regulatory precedent for utility development and ratepayer financing of multi-property microgrids; low levels of utility experience in developing/enabling multi-property microgrids** **Implemented Solutions: Technology pilot support from DOE; one-off regulatory approval for ratepayer-financed microgrid on basis of "learning value"** **Replicability Potential: Possible to replicate this development pathway in settings where utility pilots for multi-property community microgrids have not yet been pursued. More likely in states where state legislatures and/or regulators have signaled openness, but utility-led initiatives may become more feasible as demonstrable use cases for such projects grow throughout the United States, lending comfort to otherwise tentative regulatory bodies.**
Montgomery County Maryland Public Safety Microgrids
Use Case(s): Facility-level Microgrid; Public Purpose Microgrid **Business Model: Privately-Owned Microgrid-as-a-Service or PPA (Single Customer)** **Key Issues: High energy costs for public facilities; Historic widespread outages; Stated public need for resilience in specific public buildings; Lack of availability of financing from government** **Implemented Solutions: Government signed long-term contract for energy and resilience services; private developers comply with existing utility interconnection rules and utilize long-term contract with creditworthy offtaker to secure project financing** **Replicability Potential: Possible to replicate development pathway in settings featuring creditworthy government- or privately-owned facilities with desire for resilience services. Because this is a facility-level project, there are few (if any) regulatory barriers, and thus replicability potential is quite high.**

3.3.1 Blue Lake Rancheria Microgrid

The Blue Lake Rancheria (BLR) Microgrid project is a case where a state-run grant program established using ratepayer funds was used to support resilience and sustainability of a tribal community. The project is funded by the Electric Program Investment Charge (EPIC) program established by the California Public Utilities Commission (CPUC) and administered by the California Energy Commission. The Blue Lake Rancheria in California is a federally recognized tribal government and community, located on about 100 acres of trust land in Humboldt County. The County is a geographically isolated region served by limited transmission infrastructure. This area experiences frequent power interruptions and outages due to technical and natural factors such as floods and storms. Energy resilience was therefore a strong motivator for this project, and a microgrid was identified as a technology that can serve the need for providing high-reliability and resilient energy resources for critical needs facilities.

In this microgrid model, the BLR tribe purchased a portion of the distribution network in their jurisdiction directly from the utility Pacific Gas & Electric (PG&E), which required regulatory approval from CPUC of a purchase and sale agreement. The process began with PG&E taking an inventory of the assets that would be sold to the BLR tribe, and then PG&E assigned a value to each of the assets. PG&E then prepared a purchase and sale agreement and the required advice letter filing to the CPUC, and thereafter the sale to the BLR tribe was approved. Ultimately, the decision to directly purchase PG&E distribution network assets helped to circumvent many common regulatory barriers to multi-property microgrids embedded within utility service territories. However, the sale of utility-owned distribution assets as a pathway to multi-property microgrid development may not be a widely replicable option for microgrid development.

The project was granted $5,000,000 through the EPIC program with a match fund of $1,318,000, and as of the time of writing, the BLR tribe reports substantial economic benefits for the site host and the region. The BLR tribe reduced its energy costs in the microgrid campus between $160,000 to $200,000 a year, approximately a 25-30% reduction. In this microgrid's case, about 39% of this savings was attributed to switching from more expensive secondary voltage tariffs to lower-cost primary voltage (i.e., wholesale) tariffs, since the tribe owned the microgrid and the service point (PCC of the microgrid) changed to a higher 12.5 kV level. The project also increased employment for the tribal government, and local small businesses and contractors worked directly for the project. Approximately $9,500,000of both direct and indirect economic benefits was ultimately created from this project. With respect to resilience-related benefits, during a public safety power shutoff – a power shutoff initiated by a utility during extreme weather to reduce the risk of wildfire – in October 2019, the microgrid served about 10,000 people (10% of the County population) during the outage, including people who rely on medical devices that needed electricity to operate (CEC, 2019).

3.3.2 Bronzeville Microgrid

The Bronzeville Microgrid, deployed in a neighborhood on the south side of Chicago, represents an early case of a ratepayer-funded community-level microgrid with public purpose features, which is serving a historically underserved community. The microgrid is being implemented by the local utility company Commonwealth Edison (ComEd) and will provide service to approximately 1,000 customers, including facilities that provide critical services (e.g., Chicago Police Department headquarters). The broader process to select Bronzeville involved a holistic, data-driven analysis that ComEd undertook for its entire service territory to determine which portions of its network would most benefit from resiliency enabled by a microgrid. The Bronzeville area regularly experiences extreme weather events that have historically impacted electricity distribution in the community, and ComEd identified this portion of its service territory as being well-positioned to benefit from additional resilience services. Additionally, the

Bronzeville site allowed ComEd to demonstrate a capability of its microgrid master controller, to operate a microgrid "cluster" which includes both the Bronzeville Community Microgrid as well as an electrically adjacent microgrid that already had been serving facilities on the Illinois Institute of Technology (IIT) campus. At a high level, ComEd had two primary motivations to pursue this microgrid project. First, to demonstrate how microgrids could provide higher levels of resiliency, not only to the microgrid footprint, but to the surrounding area as well. Second, to enable ComEd to demonstrate tools and approaches for integrating clean energy technologies throughout the grid.

The project has been designed to use a mix of natural gas generation assets along with distributed solar photovoltaics and a battery energy storage system to provide resilience services to the community, and the project received grant funding from the U.S. Department of Energy to test various innovative technologies within the microgrid. A second phase of the project will expand the microgrid and pilot coordinated operational strategies with the IIT microgrid. The Illinois Commerce Commission (ICC) approved the project proposal in February 2018. Because the ICC determined that the benefits to all of the utility's customers will exceed the project costs, the cost is being recovered as part of the base distribution charge that is paid by all ComEd ratepayers (~$0.11 per month for 10 years).

. The most prominent issue that arose during the proceeding was related to procurement and ownership of the DER (with the backdrop being that Illinois is a competitive retail supply state). ComEd initially proposed to procure all DER from third parties through a competitive RFP, but if the RFP results were not acceptable, to then build and own the DER. In the final decision, ComEd was directed to conduct an RFP and only lease the DER, if the RFP results were not acceptable.

Another key issue was how to evaluate whether or not this proposed ratepayer-funded investment was prudent and reasonable, and whether or not non-participating customers should pay for the Bronzeville microgrid. Ultimately, the value of resilience was never formally quantified in any regulatory cost-benefit assessment[9], but the ICC determined that the experience and learnings gained from the project would nevertheless benefit all customers and the public generally by advancing distribution grid design and operation, therefore making the project prudent and reasonable for all ratepayers.

3.3.3 Montgomery County Maryland Public Safety Microgrids

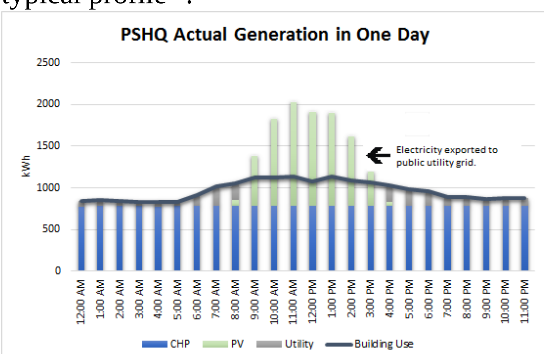
This case study describes a pair of privately-owned and operated facility-level public purpose microgrids in Montgomery County, Maryland under a 'Microgrid-as-a-Service or PPA' business model. The first microgrid in Gaithersburg, Maryland, serves the Public Safety Headquarters (PSHQ). PSHQ is nearly 400,000 sq ft and houses central County Police and County Fire and Rescue Services functions, the Office of Emergency Management and Homeland Security (OEMHS), the 1st District Police Station, and some Department of Transportation functions. The second is in Boyds, Maryland, serving the Montgomery County Corrections Facility. Both microgrids are fully constructed and operational, and though not located on a shared site, were bundled together as a single project from a financial standpoint. The microgrids were justified in response to historic widespread outages combined with aging infrastructure. Both microgrids are designed to function in islanded modes in response to grid disruptions. During normal operations, the microgrids supply 90% to 95% of the facilities' average energy needs, and

[9] ComEd stated that it could only quantify the value of the Bronzeville microgrid after the project was deployed, and agreed to report valuation results regularly to the ICC.

there are periods where the microgrids generate more electricity than what is needed to serve the site. In these cases, the agreement allows for these overages to feed back to the grid.

Through a Request for Proposals (RFP) process, the county selected Schneider Electric (solutions provider) and Duke Energy Renewables (microgrids owner) to develop an innovative private-public partnership. Energy-as-a-Service (EaaS) or, more specifically, Microgrid-as-a-Service (MaaS), was the enabling business model. Montgomery County lacked the upfront capital to fund the project and thus chose to establish a 25-year service life and corresponding power purchase agreement with Duke Energy Renewables (Maloney, 2017). Schneider constructed the microgrids and will maintain the equipment. Duke Energy Renewables owns and operates the energy generation equipment. The county pays fixed-rate capacity and energy fees comparable to rates previously paid to the local utility. (Walker, 2021)

The PSHQ microgrid is comprised of two megawatts of solar photovoltaic arrays installed over the parking lot, as well as an 800-kilowatt combined heat and power (CHP) system fueled by natural gas. The CHP captures waste heat created during electricity production via the combustion of natural gas and uses it to regulate heating and cooling. The installation includes an electric vehicle charging station. And a significant effort was made to install an advanced cybersecurity system. The PSHQ installation is estimated to reduce greenhouse gas emissions by nearly 6,000 metric tons annually through both the improved efficiency of the CHP system and the PV-generated electricity, as shown in the following typical profile[10]:



The second microgrid installed at the corrections facility includes a 240-kilowatt CHP system added to the existing diesel generators. This system decreases annual greenhouse gas emissions by an estimated 950 metric tons due to the CHP technology, compared to present-day grid-supplied energy and onsite diesel generation. (Walker, 2021)

The project was able to utilize applicable incentives that the Maryland Energy Administration (MEA) made available to private developers, as well as several state energy incentives. For example, MEA's Parking Lot Solar PV Canopy and Combined Heat and Power grant programs provided an estimated $500k[11] in project funding. State policies like net metering, renewable energy credits, and aggregate net metering were also utilized (Walker, 2021) Without these grants, credits, and renewables incentives, this high-visibility, path-breaking project would have been much harder to finance and develop.

As a facility-level behind-the-meter project that was not funded by ratepayers, the microgrid did not require public utility commission approval and did not involve the regulatory issues faced by projects

[10] https://www.montgomerycountymd.gov/dgs-oes/Microgrids.html
[11] https://naseo.org/news-article?NewsID=3346

involving ratepayer funding. (Wood, 2018) However, the project did have to comply with various utility interconnection requirements and standards established by the Maryland Public Service Commission. (Asmus, Forni, & Vogel, 2018)

4 Key Regulatory Considerations, Issues and Challenges for Major Microgrid Use Cases

Microgrids are by their nature site-specific solutions. Each microgrid is designed to meet a specific set of goals and is unique in its technical configuration and hardware requirements, as well its use case and supporting business model (VOE 2021). Each microgrid may also pose new or different risks to utility workers, the public, and system safety. The regulatory frameworks that govern microgrid deployment – including aspects such as asset ownership, compensation, investment justification, safety, consumer protection, and others – vary by state (and oftentimes by utility service territory), suggesting a need for highly localized knowledge by developers to build projects. Furthermore, most states in the U.S. do not have regulatory frameworks that explicitly address microgrids – and, because of this, each microgrid may need to address a unique set of sometimes opaque utility- and regulator-imposed requirements (NREL 2020). Put differently, not all regulatory requirements apply in all circumstances, and rather, they are differentiated by *inter alia* microgrid use case, business model, ownership structure, market organization, state policy objectives and regulatory frameworks. Compounding this lack of a consistent regulatory framework is a clear disincentive for most utilities to enable non-utility owned microgrids, as many non-utility microgrid business models would lead to erosion of their revenue base. Furthermore, utilities are financially and legally responsible for the safety of the electric system, and managing the risks associated with non-utility microgrids may be new and administratively cumbersome. As a result of these dynamics and the resulting regulatory uncertainties which are present across the U.S., project bankability and replicability continue to be major challenges for microgrid market development (Navigant 2016), especially for multi-property microgrids where new types of safety and consumer protection risks necessitate the evolution of utility and state regulatory oversight to protect consumers, workers, and the public.[12] The key to future market growth and an environment of business model innovation requires the development of holistically designed, flexible, transparent and fair policy and regulatory frameworks for microgrids which remove utility disincentives and promote safe, orderly and predictable interconnection, operation and maintenance of microgrid assets. In particular, frameworks that allow regulatory bodies and developers to move beyond laborious evaluations of "one-off" microgrid projects and into streamlined interconnection, operation and maintenance of portfolios of microgrids will enable the market to further develop while unlocking financing.

In reality, regulatory considerations and challenges can be quite distinct depending on the ownership structure and use case of the microgrid. While all microgrid applications experience deployment barriers to different extents, for the purposes of this white paper we aim to focus on combinations of business models and use cases that present a significant potential but currently demonstrate low deployment.[13] This includes the following combinations (see definitions in previous sections):

1. **Utility Rate Base Multi-Property Microgrid**
    a. Community-level Microgrids
    b. "NWA Anchor" Microgrids
    c. Networked Microgrids
2. **Privately-owned Multi-Property Microgrids**
    a. Community-level Microgrids
    b. Networked Microgrid

[12] This is also especially true in jurisdictions where the outright purchasing of utility distribution assets may not be administratively or financially feasible, such as in the Blue Lake Rancheria case study.
[13] The omitted use cases and business models are already experiencing, to varying extents, non-pilot scale deployment.

The remainder of this section summarize key regulatory issues for the five permutations of business models and use cases detailed above, as well as potential solutions and interventions to address these issues.

Note that our listing of potential solutions does not represent a conclusion that there is only one solution or that the listed solution is a preferred solution. It is only a statement that solutions are available to address the issues that are being described. The practicality and desirability of what would be appropriate solution is situation-specific; it depends on the interests, preferences, and abilities of those who must pursue them.

Furthermore, these potential solutions are not fully transformational. In many cases they represent incremental solutions to existing electricity regulation challenges that may be necessary, but not sufficient to create a holistic and integrated approach that incorporates all the various value streams, stakeholders, and potential business models that will be necessary to achieve the stated microgrid vision. Additional steps to support the industry in achieving a more integrated approach are left for future strategy development, as indicated in Section 6.

4.1 Key Regulatory Issues for All Multi-property Microgrids

Regulatory issues face by multi-property microgrids will vary based on the local context. However, there are certain key issues that apply to multi-property microgrids of all ownership types and applications that can be discussed in general terms. These issues are particularly prominent in U.S. states without a regulatory framework in place that explicitly addresses multi-property microgrids, which as of the time of writing is nearly all U.S. states.

Efforts to develop structured regulatory frameworks related to multi-property microgrids are just at the beginning stages in U.S. states, if they have started at all. Enabling more administratively and technologically complex multi-property microgrids requires regulators to address aspects including safety, cyber security, consumer protection, equitable cost allocation, ownership, interconnection and compensation for microgrids. Rules governing franchises and rights-of-way, along with building and electrical codes and siting/zoning rules, may also need to be addressed. While microgrids can provide a range of valuable services to the power system, they tend to be perceived by regulators today as an incremental investment to support resiliency. As a result, compensation-related discussions tend to gravitate around (1) appropriately valuing resiliency and (2) synchronizing existing DER compensation schemes (e.g., net metering, demand response programs, etc.) with more recent resilience compensation schemes.

In that context, key regulatory issues for multi-property microgrids of all use cases include the following.

Lack of Clarity on Microgrid Ownership Rules: Uncertainties are present in many jurisdictions surrounding who is allowed to own and operate a multi-property microgrid, and under what circumstances that ownership is allowed. This can create obstacles to microgrid project development and financing.

This can be addressed through legislation or regulatory decisions which clearly define these various elements.

Lack of Clarity on Microgrid Component Ownership Rules: Uncertainties are present in many jurisdictions surrounding who is allowed to own and control different kinds of assets and resources within a microgrid (e.g., network infrastructure, switch gear, storage, non-storage distributed energy resources, etc.). Similar to above, a lack of clarity here can create obstacles to microgrid developers entering a market being able to secure financing or generate revenue.

Similar to above, this can be addressed through clarifying legislation or regulatory decisions.

Traditional Interconnection Standards, Rules and Procedures Do Not Address Issues Unique to Multi-Property Microgrids: At a high level, the deployment of a multi-property microgrid into the utility system necessitates changes to the traditional framework for interconnection of all resources connected within that microgrid, as well as the connection of that microgrid to the larger utility grid in cases where it is not owned by the utility.

This can be addressed by regulatory and utility efforts to augment existing interconnection requirements for DER to better account for islanding requirements (e.g., for microgrid formation and black start), and in situations where advanced microgrid control features are to be implemented such that individual DER can be controlled by the microgrid operator during islanding, entirely new provisions of interconnection requirements may be required (e.g., requirements related to resource availability and scheduling, protection, relaying, and controls).

Lack of Clear Definition for Resilience: In general, regulators today see multi-property microgrids as a resilience solution for the grid. Therefore, many issues related to the value of microgrids are, in practice, related to the resilience value of microgrids. However, in that context, there tends to be lack of clear definition about what resilience means in a detailed sense, such that the definition can be applied to a proposed microgrid project and a concrete monetary value for resilience services can be quantified to inform cost-benefit tests or third-party compensation.

This can be addressed by regulators or legislatures establishing a clear definition of microgrid-derived resilience including: (1) defining the event (or set thereof) for which resilience is required; (2) defining the level and duration of service required of the microgrid to adequately address that event; and (3) defining a site- or area-based "scope" over which this resilience value is assumed to accrue[14], among other aspects.

Lack of Standardized, Accessible and Credible Methods to Quantify the Value of Resilience: Resilience is a highly multi-dimensional metric which – in the context of a microgrid – hinges on inherently subjective local values and priorities. It is consistently identified as being an important yet intangible benefit of microgrids, and to-date it typically goes unquantified in regulatory proceedings.[15] Unless the benefits of resiliency can be valued and monetized and included in various regulatory assessments, microgrids are difficult to justify economically (VOE 2021).

[14] With respect to geographic scope, among the most important definitional questions is whether or not the resilience benefits of the microgrid extend or may be extendable to non-microgrid customers. While obviously those directly connected to the microgrid will benefit, can adjacent local residents travel during various events to use microgrid-supported services during a power interruption? Or might underlying conditions resulting from a natural disaster or other critical event prevent such travel, which might diminish the microgrid's value during a power interruption?

[15] The ability to place a financial value for resilience on individual proposed microgrid projects can help utilities and regulators (1) characterize the costs and benefits of proposed ratepayer-funded projects to evaluate their reasonableness and prudence for ratepayers; and (2) design value-reflective resilience compensation schemes (i.e., microgrid service tariffs) for privately-owned microgrids.

This can be addressed by establishing a clearly defined, locationally-differentiated valuation methodology for the resilience value of microgrids which can be used for economically justifying and ultimately deploying multi-property microgrids in the future. As of the time of writing, no standard has been established for determining the resilience value of microgrids, nor have credible tools or methods been developed that have been widely adopted during regulatory proceedings. Thus, regulators and utilities may need to work with national laboratories and industry experts to establish publicly available tools and methods for quantifying the value of resilience to surmount this barrier.

Lack of Institutional Experience with Microgrids: The majority of regulatory bodies and utilities in the U.S. have limited to no experience proposing and evaluating multi-property microgrids of any kind. Similar to experiences with other innovative technologies and approaches entering regulated electricity markets, low levels of institutional knowledge combined with a lack of clear objectives, processes, expectations, and project evaluation practices, is likely to make efforts to propose and evaluate microgrids daunting and cumbersome relative to business-as-usual operations.

Utilities and regulators can pursue pilot projects to help promote institutional familiarization with multi-property microgrids. Regulators or self-governed utilities may need to grant temporary flexibilities that enable deviations from typical rules and practices in order to enable pilots.

One-off Evaluation of Projects: Due to the novel nature of and new risks posed by multi-property microgrids, low levels of experience among regulators and utilities, a lack of standardized approaches for technical design and evaluation, and the inherently customized nature of many microgrid solutions, regulators tend to evaluate individual project proposals for multi-property microgrids in a “one-off” manner. Without systems and processes in place for more standardized project evaluation by regulators and state/local governments, as well as standardized compensation and dependable oversight schemes for non-utility microgrid owners, market development may be significantly impeded, or could risk undermining safety, security, and affordability of the electric grid.

This can be addressed by the use of piloting activities to evaluate various project evaluation metrics and systematize such metrics for future use by regulators and utilities in the early stages of familiarization with microgrid project evaluation. .

4.2 Key Regulatory Issues for Utility Rate Base Multi-property Microgrids

In early-mover markets for multi-property microgrids, utility ownership tends to be more prominent. This reflects the fact that regulators already have some level of familiarity in evaluating utility investments, as well as the radical nature of the proposal that non-utilities should own poles and wires presenting a novel set of regulatory issues to navigate. Furthermore, under current regulatory paradigms, utility ownership of multi-property microgrids offers a less administratively burdensome, centralized approach to the design, development and financing of resilient microgrids for U.S. communities. Yet, because most utilities and their regulators are in a familiarization phase with microgrids, and there are many unresolved regulatory issues across U.S. jurisdictions related to utility ownership of microgrid, deployment under this model is in a nascent stage.

Known and potential regulatory issues surrounding utility ownership of microgrids assets are offered in the subsequent sections.

4.2.1 Key Issues for Utility Rate Base Multi-property Microgrids Across Use Cases

The following regulatory issues apply to all utility-owned, ratepayer-financed multi-property microgrid use cases. While this section attempts to segment many of these issues into distinct issues to enhance reader understanding, in reality, they are all closely integrated with one another and would need to be pursued in parallel.

Lack of Clear Incentives to Deploy Microgrids: The development of multi-property utility-owned microgrids represents a novel and innovative activity for the large majority of the U.S. utilities and may require new technical staff, new administrative procedures, and/or new and complex discussions with and decisions by regulatory bodies. In theory, microgrids represent a capital expenditure opportunity for utilities (and thus a new opportunity to seek returns on equity). Under traditional cost-of-service regulatory paradigms, there can be a clear financial incentive for utilities to pursue these projects. However, in practice, many utilities lack technical expertise with microgrid development and see significant risk in investing the time and financial resources to propose these projects to regulators with uncertain outcomes. As well, the inability to rate base utility RD&D efforts could serve as a barrier for utilities who are in a familiarization stage with microgrids to propose multi-property microgrid pilots.

This can be addressed by legislative or regulatory mandates for utilities to pursue microgrids. As well, the implementation of performance-based regulatory constructs which offer incentive mechanisms for resilience would also help to re-align utility incentives and encourage institutional interest in microgrids.

Lack of Clear Conditions for Regulatory Approval: Similar to other capital investments, utility-owned microgrid investments would be reasonably expected to clear a combination of quantitative and qualitative regulatory hurdles surrounding investment prudence and economic/public policy benefits to customers before a project and its required rate increase would be approved. At the moment, the absence of clear regulatory standards for microgrid investment prudence, as well as a lack of clarity on what utility microgrid costs might be allowed and how they might be recovered, serves as a clear barrier to utilities who might otherwise consider proposing microgrid projects. Furthermore, early experiences in Hawaii, California, and elsewhere suggest that regulators may need to provide upfront guidance on their expectations for the fuel mix of proposed microgrids in light of policy commitments to greenhouse gas and criteria air pollutant reduction and equity, as well as expected reliability/resiliency performance levels, in light of upward pressure on rates and a policy commitment to maintaining affordability.

This can be addressed by regulators clearly specifying the conditions for microgrid investment prudence. This could be informed by public inquiries or regulatory dockets exploring the topic with key stakeholders and experts in order to systematically identify the conditions under which a microgrid may have sufficient public benefit to justify ratepayer funding.

Storage Asset Ownership: In many states, utilities are prevented from owning or controlling storage resources. This may serve as a barrier to deploying utility-driven multi-property microgrids for several reasons. First, utilities may insist that it is not operationally practical – especially at an early or familiarization stage of microgrid deployment – for anyone other than the utility to control and operate the storage devices intended to serve microgrid customers. As well, most utilities do not have established practices for contracting with any third-party owned, distribution-connected front-of-the-meter storage devices, let alone those intended to serve in a microgrid.

This can be addressed through legislative or regulatory clarification on the various conditions for utility ownership of storage ownership. In the event that utilities are explicitly disallowed from owning storage, regulators and utilities may need to collaborate to structure a standard contract offering facilitates utility procurement and utilization of third-party owned storage devices functioning within a microgrid. Such a contract would need to address a variety of novel issues, including but not limited to minimum state-of-

charge levels, dispatch rights and constraints during islanding, and permitted non-microgrid uses of the storage asset.

Lack of Established Consumer Protections for Participating Customer-owned DER: In most circumstances, including one in which the utility owns all microgrid network assets (e.g., wires, islanding equipment), utilities are not likely to own many or any of the DER interconnected within their individual microgrids. While some multi-property microgrids may be able to function without direct control over customer DER, over time the utility may ultimately need direct control over customer-owned DER, especially during islanding events (and, if a future of networked microgrids ever comes to pass, during normal operations). However, in most settings there is a lack of precedent for establishing consumer protections for utility direct control of customer-owned DER.

This barrier can be addressed by regulatory efforts to draft standardized consumer protection conditions for customer-owned DER under direct utility control, in order to prevent misuse of DER (e.g., unreasonable levels of cycling of behind-the-meter storage causing accelerated degradation) and address customer cyber security and privacy concerns. These additional consumer protection conditions would likely be included as amendments to existing utility DER program terms and conditions.

4.2.2 Key Regulatory Issues Specific to Utility-owned Community Microgrids

In addition to the issues discussed in Section 4.2.1, the following key regulatory issues are relevant for developing utility-owned, ratepayer-financed community microgrids.

Regulatory Concerns Surrounding Equity: Ratepayer-funded community microgrids raise valid regulatory questions surrounding equity, and in particular, whether or not community microgrids which are rate-based give preferential treatment to a subset of customers. Some regulators have determined that customers inside microgrid service territories would disproportionately benefit from that microgrid relative to other ratepayers, and furthermore that customers who are closer to the microgrid (especially if there is a "public purpose" benefits from the project) would experience greater benefits than those located farther away (NARUC/Converge 2019). Put broadly, social equity concerns, compounded by a lack of clarity around the social value of microgrids and the most equitable way to distribute those values (as well as microgrid costs), may serve as a significant impediment for regulatory approval of ratepayer-funded microgrids.

This can be addressed through improved tools and methods for establishing geographically differentiated values of resilience which can help to quantify the social value of microgrid projects to various groups of ratepayers. Regulators may also need to determine rules and procedures governing the opt-in and opt-out of participation of community microgrids, especially in situations where community microgrid participants are expected to pay directly for resilience services.

Lack of Standard Methods to Determine Fair Cost, Benefit and Risk Allocations: To date, there are a lack of established methods and practices for regulators to determine how to understand and ultimately allocate the costs and benefits of community microgrids among consenting microgrid participants, non-consenting microgrid participants, and non-participants through tariffs and rate riders. The lack of precedent and established practice to answer these questions, underpinned by a lack of ability to quantify the geographically granular benefits of resilience in microgrids, can serve as a significant barrier to deployment.

Similar to the previous issue, this can be addressed by improved tools and methods for quantifying the geographically differentiated benefits of resilience to different groups of ratepayers. Without such *fundamental information, it may be difficult to establish standard methods for cost, benefit, and risk allocation.*

Lack of Regulatory Requirements for Utilities to Consider Microgrids During Planning: Utilities are typically neither asked nor required to compare multi-property microgrids during planning exercises on a fair and consistent basis with conventional generation, transmission or distribution system investments. Without such direction from policymakers or regulators, utilities may lack the motivation to understand this innovative technology option, let alone formulate microgrid proposals as possible lower-cost means of meeting system requirements.

This can be addressed through legislative or regulatory requirements for utilities to consider microgrids in various planning exercises.

Lack of Technical Performance Standards During Islanding Conditions: The standard that defines what counts as "utility-grade electrical service" is clearly specified for utility customers under normal grid operations. Such standards help to ensure power quality which allows safe operation of customers' equipment and devices to operate safely. However, in most cases, performance standards do not exist for quality of service during islanding conditions.

This can be addressed by joint efforts of regulators and utilities to define clear, reasonable, cost-effective and enforceable performance standards for service provision during islanding.

Treatment of Partial Requirements Service (PRS) Customers: In the event that a utility-owned community microgrid is being developed, and participating customers are assigned an additional tariff rider or monthly fee for resilience service, there may not be established practices for designing differentiated fees for customers who rely on the utility for only a portion of their electricity needs (often referred to by utilities as 'Partial Requirements Service' customers).

This can be addressed by engaging in public regulatory processes to consider whether or not differentiated treatment of PRS customers is merited, and potentially designing differentiated fees or riders if so. In order to pursue this effort, regulators can hold public inquiries or open regulatory dockets which can discuss whether or not PRS customers should pay the full fee for resilience services, and/or if that is an unfair burden given their potential contribution to the community microgrid. Ultimately, proposals for resilience fees can be structured in a customized manner, if merited, to ensure fair treatment of PRS customers.

4.2.3 Key Regulatory Issues Specific to Utility-owned "NWA Anchor" Microgrids

Combining two emerging grid solutions – non-wires alternatives and microgrids – presents a unique market opportunity for utilities to leverage existing economic investments in network infrastructure to provide valuable resilience services through microgrid solutions. While from a technological perspective this application is relatively feasible, there are important regulatory issues to consider for this potential application. Issues noted in Sections 4.2.1 and 4.2.2 also apply to this use case.

Lack of Existing Practice or Regulatory Requirements for Utilities to Consider Non-Wires Alternatives During Planning: NWAs are still an emerging technology solution in the U.S. electricity industry, and many utilities and regulatory bodies do not yet actively consider NWA in their infrastructure planning exercises. Utilities are typically neither asked nor required to compare NWAs during planning exercises on a fair and consistent basis with conventional transmission or distribution system investments. Without such requests from policymakers or regulators, utilities may lack the motivation to understand this innovative technology option, let alone formulate NWA proposals (with the additional design feature of serving as a microgrid) as possible lower-cost means of meeting system requirements.

This can be addressed through legislative or regulatory requirements for utilities to consider NWAs during various planning exercises. Oftentimes, the lead time for identifying potential NWAs can be longer and more analytically complex than identifying appropriate traditional network investments, and thus such legislative or regulatory requirements may also need to motivate more proactive planning practices by utilities to preliminarily identify prospective NWAs.

Lack of Standardized Approaches, Business Models and Roles for Designing Non-wires Alternatives: Even if utilities are allowed or encouraged to propose non-wires alternatives to address grid constraints or other challenges, NWAs do not yet enjoy standard design procedures or business model and investment arrangements. This creates a need for case-by-case evaluations of each proposed NWA, which can discourage investment and slow development. While this is a more general regulatory barrier for NWAs rather than specific to microgrids, it is nevertheless an important influencing factor.

This can be addressed by creating more standardized design features and exploration of various business models through the experiences gained through NWA piloting activities. In general, the systematization of NWA project design and evaluation practices can help to inform standardized, streamlined approaches to NWA project identification and development.

Lack of Alignment Between Optimal NWA Design and Optimal Microgrid Design: Though they utilize many of the same technologies, NWAs and microgrids are two separate technology applications with distinct operational goals. NWAs seek to defer or avoid traditional network investment costs by reducing congestion during certain times of day and providing other network services, whereas microgrids can be designed to provide a specific set of resilience services for a particular application and set of needs. Thus, the cost-optimal design of these two applications may or may not align to varying extents, and the incremental costs of turning an NWA concept into a microgrid, or vice versa, may be difficult for regulators to confidently evaluate and thus justify.

This can be addressed through more integrated planning approaches by utilities and regulators which characterize the costs and benefits of multi-purpose projects like NWA anchor microgrids. This can be enabled by integrated tools and methods that can simultaneously evaluate resilience value an network investment deferral value.

Lack of Clear Regulatory Standard for Incremental Investment Justification: Even if an NWA's design is perfectly aligned with the design requirements of a microgrid, some amount of additional utility investment will still be needed to enable the investment. Due to the broader lack of standardized, accessible and credible methods to quantify the benefits of resilience, formulating a regulatory justification for the additional cost required to island may be difficult.

Similar to the previous issue, this can be addressed through new tools and methods to design and evaluate such multi-purpose project proposals.

Lack of Unified Regulatory Treatment: Issues related to utility investments in NWAs and microgrids tend to be treated in separate regulatory proceedings (if they are treated at all). This is perhaps due to the fact that the primary driver of microgrid deployment within utility service territories tend to be resilience, whereas the primary driver of NWAs is network service provision to defer or avoid traditional network investments. These separate "swimlanes" of regulatory treatment thus reflect the distinct value streams that these technology applications provide. However, this distinct regulatory treatment may serve as a barrier to identifying such dual use projects.

This can be addressed by establishing unified performance-based regulatory constructs which streamline regulatory treatment and reward multiple benefit streams in order for integrated NWA-microgrid projects to develop.

4.2.4 Key Regulatory Issues Specific to Utility-owned Networked Microgrids

Networking two or more microgrids has the potential – from a technical standpoint - to significantly increase reliability and resilience while reducing operational costs by facilitating the sharing of resources (e.g., generation assets, dispatchable loads) across systems (NREL 2020). This is considered a prospective future use case for microgrids, and there is not any existing development or regulatory experience to draw upon.[16] Thus, all prospective regulatory issues for utility-owned networked microgrids offered below are speculative in nature. Issues noted in Sections 4.2.1 and 4.2.2 also apply to this use case.

Addressing Fair Compensation for Customer-owned DER under Direct Utility Control: In most circumstances, including one in which the utility owns all microgrid network assets (e.g., wires, islanding equipment), utilities are not likely to own many or any of the DER interconnected within their individual microgrids. As networked microgrids begin to depend upon one another more systematically for energy and reliability services, the utility may need to exercise significantly more control over customer-owned DER, not only during times when their microgrid is islanded, but also when multiple microgrids have islanded and clustered together, and/or even during normal grid operations. However, there is not yet any precedent for how such compensation will be designed.

This can be addressed by regulators reviewing and approving proposals from utilities to compensate DER owners for services provided specifically during islanding. Ultimately, a value-based, temporally and spatially detailed, yet sufficiently simple and understandable compensation scheme for DER owners will need to be developed to offer appropriate compensation under different networked microgrid islanding conditions.

Lack of Peer-to-Peer Energy Trading and Distribution Network Wheeling Framework: Depending on the exact objectives and dispositions of policymakers, regulators and utilities, a future of networked microgrids may include more peer-to-peer exchanges of energy, both during normal operations and when microgrids are islanded and/or clustered together. Such a framework could be based off of a network of bilateral contracts, or could include a market-based system for determining the value and cost of energy over time and space for retail customers (both those who own DER and those who do not), as well as a technical and financial framework to facilitate wheeling of energy within and between microgrids. However, across the U.S., utilizing distribution networks for bilateral energy transactions is in violation of some combination of laws, regulations and/or customer-utility service agreements.

This can be addressed by legislative and regulatory efforts to explicitly enable and set the terms and conditions for distribution network wheeling. Such efforts may need to empower the utility and other microgrid owners to specify reasonable safety standards governing the energy flows underlying bilateral energy transactions, while also providing a mandate to various actors to establish market-based financial frameworks.

4.3 Key Regulatory Issues for Privately-owned Multi-property Microgrids

If regulatory explorations of utility-owned multi-property microgrids are still considered a "frontier" issue in most markets, then regulatory frameworks facilitating privately-owned multi-property microgrid development are, as of the time of this writing, even farther off. Only one U.S. jurisdiction – the State of Hawaii– is undergoing a public process to develop a microgrid service (MGS) tariff governing both interconnection and compensation for resilience services from privately-owned multi-property microgrids

[16] The Bronzeville microgrid in Chicago will soon begin exploring networked operations with the neighboring Illinois Institute of Technology microgrid.

that span multiple properties and/or rights of way.[17] However, utility and regulatory experience in developing such tariffs is low, which is underpinned by a variety of issues, not the least of which is an inability to appropriately quantify the value of the resilience which an MGS tariff seeks to compensate, as well as the radical nature of (and associated required regulatory and legal paradigm shifts associated with) privately owned wires traveling multiple property boundaries and public rights of way. Furthermore, early experiences with MGS tariffs tend to arise in regulatory proceedings in response to statutory mandates and/or requests from stakeholders objecting to utility ownership of multi-property microgrids – put differently, regulatory frameworks for privately-owned multi-property microgrids may require additional outside "stimulus" to move forward. Ultimately, the development of markets for multi-property microgrids necessitates improved frameworks for non-utility actors to participate, create value and seek remuneration, while also ensuring safety, consumer protection and equity for the public.

4.3.1 Key Regulatory Issues for Privately-owned Multi-property Microgrids Across Use Cases

The following are issues for all private multi-property microgrids. While this section attempts to segment many of these issues to enhance reader understanding, in reality, these issues are all closely integrated and would need to be pursued in parallel.

Utility Economic Disincentives under Cost-of-Service Regulation: Similar to energy efficiency and customer-owned distributed generation, privately-owned multi-property microgrids tend to reduce electricity sales revenue and/or utility capital investment opportunities. Under existing cost-of-service regulatory constructs, utilities have a disincentive built into their regulatory frameworks to allow these projects to move forward, let alone invest institutional energy into creating participation frameworks for private microgrids under MGS tariffs.

This can be addressed through revenue decoupling, a mechanism which makes utilities indifferent to their sales volume by providing them with a pre-approved amount of revenue regardless of how much electricity they sale. As of the time of writing, eighteen states have adopted decoupling for electric utilities in the United States (RAP, 2020). Performance-based regulatory constructs (see e.g., Littell and Zinaman et al. 2020) can also be utilized to put in place direct financial incentives (i.e., performance incentive mechanisms) to promote resilience solutions, which could serve as an impetus for utility facilitation of multi-property microgrids.

Lack of Institutional Experience Designing Microgrid Services Tariffs for Resilience: In today's regulatory and utility environments, there are only a limited number of efforts related to creating structured, regulated compensation schemes for privately-owned multi-property microgrids. These efforts tend to be focused on creating compensation schemes to value the *resilience services* these microgrids can provide, whereas other services that a microgrid might provide (e.g., energy, capacity, frequency support) are often already compensated to varying extent under existing DER compensation mechanisms and are thus less of an initial focus for regulators[18]. To-date, there is a strong lack of institutional experience in

---

[17] There are also a limited number of cases where a utility has sold a segment of their distribution network outright to a non-utility entity to develop a multi-user microgrid, such as the Blue Lake Rancheria Microgrid (see Section 3.3.1).

[18] For instance, in Hawaii's MGS tariff proceedings, it was noted that in order to "avoid unwarranted cost-shifting, the MGS tariff should compensate for services that benefit the grid above and beyond those servics already compensated under existing tariffs. Most of the services that can be provided by [privately-owned microgrids] are covered by existing tariffs and programs" and that those services which are not already covered were being discussed in various dockets. Thus, HPUC determined that "compensation for resiliency" should be the focus of the MGS tariff. Full text available at: https://dms.puc.hawaii.gov/dms/DocumentViewer?pid=A1001001A19B11A94101H00414

designing microgrid services tariffs which compensate for resilience value. As of the time of writing, no jurisdiction in the U.S. has designed a compensation for resilience under an MGS tariff.

This can be addressed by new tools and methods to quantify the value of resilience. As well, early-mover regulators may require new information resources or direct institutional support from national laboratories and other industry experts to design a first-of-its-kind, geographically differentiated, project-specific MGS tariff for privately-owned multi-property microgrids.

Lack of Clarity on Jurisdiction/Applicability of Public Utility Regulation: A key issue related to privately-owned multi-property microgrid development is the question of regulatory jurisdiction. What does it mean to be considered a regulated public utility in a particular jurisdiction, and do privately-owned multi-property microgrids fall under this definition? If microgrid developers are subject to the exact same regulatory requirements as public utilities, this could potentially result in significant regulatory burdens on many private companies offering microgrids services (NREL 2020). On the other hand, subjecting microgrid developers to public utility regulation would also ensure utility-grade service, regulated pricing, and other key consumer protections using existing institutional mechanisms and standards. In any case, this lack of clarity can be a significant impediment to the microgrid market developing in a manner that is aligned with the public interest.

This can be addressed by legislative or regulatory clarifications to define whether and to what extent private multi-property microgrid developers will be regulated as electric utilities, or if they are exempt altogether. In making these clarifications, policymakers and regulators may need to determine the exact scope and quality of services a non-utility microgrid developer can offer to customers without triggering public utility regulation (NRRI, 2012), or to develop new forms of regulation altogether which ensure the public interest is maintained while enabling non-utility actors to participate

Lack of Clarity on Terms, Conditions, Tariffs, and Consumer Protection Rules: Another regulatory issue is a lack of clarity surrounding the scope and nature of terms, conditions, consumer protection rules and related performance expectations for privately-owned multi-property microgrids. This can be influenced by whether or not these microgrid are subject to public utility regulation (see 'Lack of Clarity on Jurisdiction/Applicability of Public Utility Regulation'). However, there is a wider lack of clarity as to what terms, conditions, and associated consumer tariffs should be associated with privately-owned multi-property microgrid service provision. This lack of clarity can be a significant impediment to market development.

This can be addressed by regulators – through a public process – reviewing and evaluating the various dimensions of consumer protections (e.g., quality-of-service, cost-of-service, work safety, cyber security, etc.) that may be worthwhile to impose and what level of protection is reasonable for microgrid developers to comply with. In some circumstances, regulators may not need to be promulgate any consumer protection requirements whatsoever (as is the case for most facility-and campus-level microgrids). In other cases, certain requirements may be merited and should be clearly specified.

Exclusivity of Franchise Agreements: While more of a policy issue, it is common for regulated utilities to be granted exclusive franchise rights for their service territories within state statutes, meaning that no other entity is legally allowed to sell electricity to retail customers in their jurisdiction. Furthermore, in many cases, non-utility distribution wires may be explicitly forbidden. Thus, franchise agreements can generally limit the ability of non-utility multi-property microgrid owners to provide energy to customers altogether, and/or without becoming a fully regulated utility (Flores-Espino, Giraldez and Pratt, 2020). Furthermore, franchise agreements oftentimes grant legal permission for distribution lines to cross public rights-of-way, which non-utility microgrid developers may not explicitly have.

This can be addressed by, reform efforts that are pursued within state courts or legislatures, or at the local level[19]*, in order to secure an appropriate form of franchise for non-utility multi-property microgrid owners.*

Lack of Rules Governing Electricity Retailing by Non-Utility Microgrid Owners: Many private microgrid developers claim that in order to see the development of a viable market for multi-property microgrids, they will need to be able to sell electricity to retail customers within their microgrids, as opposed to just selling resilience services during the limited times when islanding is necessary. Per the previous issues, such a model would inevitably encounter significant utility resistance, questions of regulatory jurisdiction, tariff applicability and consumer protections, and even legal barriers related to franchise rights.

This can be addressed by establishing a framework set of rules governing electricity retailing within private multi-property microgrid applications. Such a framework may require clarifications on aspects including terms and conditions of non-utility retail service, opt-in and opt-out provisions, conditions and charges for use of utility lines by non-utility retailers, and other aspects.

Lack of Rules Governing Utilization of Utility Distribution Network Lines: Some privately-owned multi-property microgrids may be 'hybrids' in nature, using some combination of utility distribution network infrastructure and privately-owned network infrastructure. Many preliminary hybrid concepts include the use of utility lines in combination with privately-owned infrastructure at the PCC to facilitate islanding, plus privately-owned local generation. In these cases, there is generally a lack of clarity governing how or under what circumstances utility wires might be used within a microgrid, as well as whether private wires, islanding equipment and other infrastructure can be constructed and used in conjunction with utility wires. Furthermore, utilities are often resistant to leasing or selling sections of their distribution network.

This can be addressed by establishing the terms, conditions and charges for utilization of utility distribution network lines by private microgrid developers under both normal and islanded conditions. This also involves specifying clear technical interconnection procedures (see next issue).

Lack of Clear Technical Interconnection Procedures: Privately-owned multi-property microgrids – especially those embedded within the utility network with multiple points of connection and/or utilizing some degree of utility lines through a 'hybrid' model – typically lack standard procedures to apply and ultimately interconnect microgrids to the utility system in a safe, predictable and orderly manner. In the absence of standard interconnection procedures, utilities often have sole discretion over interconnection and can require microgrid developers to pay for expensive equipment upgrades – these potential costs, and the associated uncertainty around them, can be a significant barrier to deployment.

This can be addressed by establishing well-designed technical interconnection standards and processes that help to ensure that privately-owned multi-property microgrids can operate in both grid-connected and islanded modes of operation without adversely affecting the operation of the utility grid, presenting a safety issue to utility line workers, or negatively impacting consumer-owned equipment through power quality or reliability issues. The circumstances governing when utility control of microgrid assets is merited, as well as limitation of liability in the event that damages or losses are caused due to mismanagement by the private microgrid owner, may be of particular interest to address. Given that such interconnection procedures are unprecedented, early-mover jurisdictions may require novel information

[19] Franchise agreements may be signed with municipalities or other local political subdivisions.

resources or direct institutional support from national laboratories or industry experts to pursue such efforts.

Lack of Precedent or Framework for Intra-Microgrid Peer Trading: Depending on the exact business case and technical design of the privately-owned multi-property microgrid, there may be a need to determine the circumstances in which locally generated electricity by individual DER can be delivered and sold to neighboring customers within the microgrid. A lack of precedent or framework governing intra-microgrid peer trading could be a secondary but still significant barrier to deployment.

This can be addressed, a participation framework and set of rules would need to be developed to determine the circumstances under which locally generated electricity could be sold to other microgrid customers, and if this electricity would be sold at pre-determined regulated rates, market-based rates, or at a freely negotiated bilateral rate. Legislative changes may be required to explicitly allow such trading, and regulatory efforts may be needed to sync up such activity with existing utility DER compensation programs.

Lack of Clarity on Ability to Seek Remuneration During "Blue Sky" Conditions: Another barrier to potential microgrid developers is the lack of framework which might allow microgrids to provide energy and grid services under "blue-sky" conditions, or the vast majority of the time when the grid is up and running. Only a limited number of states and utilities have regulated and competitive demand response programs, as well as DER aggregation participation frameworks where microgrids might be able to participate as a single node. Without such frameworks in place, microgrids may not be able to seek remuneration for the range of services they are technically capable of providing.

This can be addressed by creating remuneration frameworks which explicitly allow aggregated DER services from microgrids in order to enable economic privately-owned multi-property microgrid projects.

Lack of Clarity on Ownership of Microgrid Equipment: In many states, there is a lack of clarity on who is authorized to own the switchgear at the point of common coupling between private microgrids and utilities (both for greenfield microgrids and 'hybrid' microgrids using utility lines), and how costs should be allocated between the utility and the microgrid owner. Without such frameworks in place, privately-owned multi-property microgrids may be impeded from development.

This can be addressed through legislation or regulatory decisions which clearly define the allowed ownership arrangements for microgrid equipment, as well as frameworks for allocating network upgrade costs between private microgrid developers and regulated utilities.

4.3.2 Key Issues for Privately-owned Networked Microgrids

In addition to the issues raised in the previous sub-section, the following regulatory issues may arise for the prospective future use case of privately-owned networked microgrids. All barriers and issues mentioned below are purely speculative in nature.

Lack of Precedent or Framework for Inter-Microgrid Peer-to-Peer Trading: A future of networked microgrids may include more peer-to-peer exchanges of energy between microgrids, both during normal operations and when microgrids are islanded and/or clustered together. Some private microgrids may be electrically adjacent and able to bilaterally coordinate and interact without the need for a formal framework, but when private microgrids are not electrically adjacent, some form of energy wheeling – either utilizing the utility network and/or other private microgrids – would be necessary to facilitate the exchange of energy services. In general, utilizing distribution networks for bilateral energy transactions in the U.S. is in violation of a combination of laws, regulations and/or customer-utility service agreements, depending on the state/utility.

This can be addressed through various legal and administrative reforms that might implicitly or explicitly disallow inter-microgrid peer-to-peer trading., Regulatory bodies may also need to design and implement a market-based system or other standardized participation framework to enable peer-to-peer transactions where private or utility network infrastructure wheeling is required.

Lack of Institutional Experience Regulating Cyber Security: Given the importance of secure communication and coordination among networked microgrids, regulators may have an amplified role to play in promulgating cyber security requirements in a future where privately owned networked microgrids are the norm.[20] Without such requirements in place, there may be resistance to networked microgrids from utilities, regulators, consumer advocates, or other organizations.

This can be addressed through the design and promulgated of standard cyber security requirements governing microgrid operation and networked microgrid coordination and communication.

[20] In cases where the utility owns the networked microgrids, the utility may be able to drive forward cyber security efforts using existing practices and standards with less regulatory intervention.

5 Emerging Regulatory Practices

Efforts by regulatory bodies in the states of Hawaii and California represent two examples of jurisdictions in the U.S. pursuing frameworks for multi-property microgrids to address the regulatory issues discussed in Section 4. Each jurisdiction currently has a distinct institutional focus. The Hawaii Public Utilities Commission is focused on creating a regulatory framework to support the development of privately-owned multi-property microgrids, both when new segments of the distribution network are constructed and when existing utility network infrastructure is used. The California Public Utilities Commission is focused on providing immediate-term microgrid resilience solutions to address wildfire-related reliability issues, while at the same time pursuing a more generalized approach to microgrids that might eventually allow a range of use cases and supporting business models. What is common to both institutional efforts is undertakings to promulgate interconnection standards for microgrids that promote safe and reliable microgrid operation while also balancing cost considerations.

5.1 Hawaii Public Utilities Commission Docket 2018-0163

An open regulatory docket aiming to formulate an interconnection and compensation framework for privately-owned multi-property community microgrids.

In mid-2018, Hawaii's legislature passed Act 200 into law, which recognized microgrids as being a significant resilience solution for Hawaii and a key tool in achieving Hawaii's clean energy policies. Furthermore, the act also directed the Hawaii Public Utilities Commission (HPUC) to establish a workable regulatory structure around microgrid interconnection and the value of microgrid services through a 'microgrid services (MGS) tariff'. The act specified that an MGS tariff should attempt to provide fair compensation for services provided to, or by, Hawaiian Electric Company (HECO)[21], the microgrid operator and other ratepayers. As well, to the extent possible, Act 200 asked HPUC to standardize and streamline interconnection processes for microgrid projects. In July 2018, the HPUC opened Docket 2018-0163 to investigate the establishment of an MGS tariff for HECO Companies. After putting forth an initial set of questions to stakeholders, HPUC offered an initial set of observations and determinations which helped to further focus the proceeding. These included the following:

- *Purpose of MGS Tariff:* The initial purpose of an MGS tariff should be facilitating multi-customer microgrids that improve resiliency by providing fair compensation to microgrid owners for the net useful public benefits of providing resilience services.
- *Treatment of Single-customer Microgrids*: Revisions to existing DER programs/tariffs combined with interconnection process changes may be more appropriate to support single-customer microgrids.
- *DER Compensation Issues:* Issues related to DER compensation were acknowledged as having significant implications for the economics of third-party microgrids – however, HPUC noted that these items were being addressed in other open dockets and through existing DER programs.
- *Source of MGS Tariff Funding:* The MGS tariff should not provide compensation for resilience from those not participating in the microgrid if there is limited or no broader benefits to the public or non-participants. In cases with broad-based public benefits, HPUC may consider compensation through the MGS Tariff for resilience benefits, but the burden is on the developer to justify this benefit.
- *Technical Interconnection Framework for Microgrids*: Standardized interconnection language is very much needed to facilitate broader adoption of microgrids.

[21] HECO, through its subsidiaries, serves approximately 95% of the population in Hawaii, with Kauai Island Utility Cooperative (also regulated by HPUC) serving the rest.

- *Energy Wheeling on HECO Distribution Networks*: HPUC signaled an openness to allowing distribution-level wheeling during outages in cases where existing utility infrastructure is used in the microgrid; however, HPUC was not willing to consider wheeling outside of these circumstances.

Furthermore, HECO Companies indicated early in the regulatory proceeding that they are already subject to standards/requirements to build microgrids and can be compensated for installing microgrids under current ratemaking structures as well as via other dockets (e.g., Docket 2018-0088 on performance-based regulation), and thus that it likely does not make sense to apply the MGS tariff to them [link]. Instead, they argued, the MGS tariff should focus on facilitating third-party owned microgrids. This position was generally agreed upon by the parties to the proceeding, though the Commission has not taken any official position on ownership.

.

As of the time of writing, the microgrid tariff under development appears to be focused on facilitating third-party owned microgrids, including 'customer microgrids' which do not use any utility infrastructure (i.e., non-utility ownership of conductors that span multiple properties and/or rights of way) and 'hybrid microgrids' which utilize the utility distribution network. A Microgrid Working Group, involving all parties in the docket, is attempting to re-work draft MGS Tariff language prepared by HECO. Significant progress has been made in developing standardized interconnection language, but as of this writing (a) a concrete compensation scheme for microgrid owners for differentiated resilience services has yet to be developed, and (b) how HECO should be compensated for use of their network under a hybrid microgrid scheme must still be resolved.

5.2 California Public Utilities Commission Rulemaking 19-09-009

An open regulatory proceeding which has issued multiple decisions to-date aiming to: (1) accelerate deployment of microgrids and other resilience solutions in response to wildfire-driven public safety power shutoffs; (2) identify and address regulatory issues to facilitate the commercialization of a variety of microgrids, with an emphasis on multi-property microgrids.

California Senate Bill (SB) 1339 (Stern, 2018) directed the California Public Utilities Commission (CPUC), in consultation with the California Energy Commission and California Independent System Operator, to undertake a number of activities to further develop policies related to microgrids.[22] In response to SB 1339, the CPUC initiated Rulemaking 19-09-009 to facilitate the commercialization and deployment of microgrids while prioritizing system, public, and worker safety and avoiding shifting costs between ratepayers. As directed by SB 1339, the Rulemaking involves Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E). The Rulemaking consists of three sequential tracks.[23]

[22] SB 1339 statutorily defines a microgrid as: [A]n interconnected system of loads and energy resources, including, but not limited to, distributed energy resources, energy storage, demand response tools, or other management, forecasting, and analytical tools, appropriately sized to meet customer needs, within a clearly defined electrical boundary that can act as a single, controllable entity, and can connect to, disconnect from, or run in parallel with, larger portions of the electrical grid, or can be managed and isolated to withstand larger disturbances and maintain electrical supply to connected critical infrastructure.

[23] For additional context and background where CPUC Energy Division staff present recommendations for a ctions to facilitate the commercialization of microgrids, see '*Staff Proposal for Facilitating the Commercialization of Microgrids Pursuant to Senate Bill 1339*' available at: https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M344/K038/344038386.PDF

The Track 1 Decision[24], adopted in June 2020, ordered a suite of short-term solutions to accelerate deployment of microgrids and improve resiliency for the 2020 Public Safety Power Shutoff (PSPS) season[25], including: (a) standardized, pre-approved system designs for interconnection of microgrid resiliency projects that deliver energy services during grid outages; (b) methods to increase simplicity and transparency of the processes by which the utilities inspect and approve a microgrid project; and (c) prioritizing interconnection of microgrid projects for key locations, facilities, and/or customers.

The Track 2 Decision[26], adopted in January 2021, ordered six actions:

First, SCE was ordered to revise an existing rule to clarify that specialized equipment, which might be required to develop microgrid projects on behalf of a customer at the customer's request to its system, is permitted as part of the service SCE provides to its customers (Rule 2). The PG&E and SDG&E versions of Rule 2 did not pose a similar barrier.

Second, PG&E, SCE, and SDG&E were ordered to revise another of their existing rules to allow local government microgrids to provide electricity to critical needs customers[27] on adjacent parcels during emergency conditions (Rule 18 for PG&E and SCE; Rule 19 for SDG&E). The decision also requires utilities to update their lists of critical customers in response to community feedback. Currently, these rules do not allow retail customers in their service territories to provide electricity to other retail customers. Consistent with the provisional nature of the Decision, there is a subscription limit of ten such microgrid projects in each IOU's service territory in order for parties to gain experience with this unprecedented new ability and provide a basis for subsequent CPUC decisions.

Third, PG&E, SCE, and SDG&E were ordered to create a microgrid tariff. At this point, the tariff principally serves to simplify the tariff options available for behind-the-meter microgrids and to create an administrative means for separately identifying customers that operate such systems. Track 3 of the proceeding, which commenced in February 2021, is expected to address the applicability of stand-by charges for single-customer microgrids that, among other things, will prevent cost shifting from microgrids to other customers.[28]

---

[24] See the following link for more information: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M340/K748/340748922.PDF

[25] For more information about PSPS, see: https://www.cpuc.ca.gov/psps/

[26] https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M361/K442/361442167.PDF

[27] In Decision 19-05-042, the CPUC adopted the following interim list of critical facilities and critical infrastructure, as aligned with Department of Homeland Security's Critical Infrastructure Sectors: Emergency Services Sector (Police Stations, Fire Stations, Emergency Operations Centers); Government Facilities Sector (Schools, Jails and prisons); Healthcare and Public Health Sector (Public Health Departments, Medical facilities, including hospitals, skilled nursing facilities, nursing homes, blood banks, health care facilities, dialysis centers and hospice facilities); Energy Sector (Public and private utility facilities vital to maintaining or restoring normal service, including, but not limited to, interconnected publicly-owned utilities and electric cooperatives); Water and Wastewater Systems Sector (Facilities associated with the provision of drinking water or processing of wastewater including facilities used to pump, divert, transport, store, treat and deliver water or wastewater); Communications Sector (Communication carrier infrastructure including selective routers, central offices, head ends, cellular switches, remote terminals and cellular sites); and Chemical Sector (Facilities associated with the provision of manufacturing, maintaining, or distributing hazardous materials and chemicals).

[28] While not part of this decision, CPUC is actively considering tariffs for multi-property microgrids. The most developed efforts are for multi-property, multi-property microgrids in which generation and storage assets are privately owned and operated during blue sky conditions, but the poles and wires belong to the utility, and the utility operates the microgrid during islanded conditions. As well, the CPUC Resiliency and Microgrid Working Group has

Fourth, PG&E, SCE, and SDG&E were ordered jointly to develop a statewide Microgrid Incentive Program with a $200 million budget to fund clean energy microgrids to support the critical needs of vulnerable communities impacted by grid outages and test new technologies or regulatory approaches to inform future action. The funding will be drawn from all ratepayers served by the utility in which each community is located.

Fifth, PG&E, SCE, and SDG&E will develop pathways for the evaluation and approval of low-cost, reliable electrical isolation methods to evaluate safety and reliability. Current utility-approved methods for electrical isolation are relatively expensive and can require extensive reconfiguration of existing electrical service panels to meet applicable codes and standards, which serves as a significant barrier to microgrid market development.

Sixth, the Decision also resolved a number of administrative issues related to temporary generation resources procured following the Track 1 decision. These include adopting an interim approach for minimizing emissions from backup fossil fuel generation during utility Public Safety Power Shutoff (PSPS) and requiring the utilities to have ongoing consultation with local air quality agencies, aimed at ensuring the deployment of temporary generation complies with applicable air regulations.

Finally, the Track 2 Decision formalized the creation of a Resiliency and Microgrids Working Group to facilitate discussions to continue to support the goal of resiliency and the commercialization of microgrids within Track 3 of the proceeding. This continues the practice of encouraging discussions among stakeholders outside and in parallel with the development of the formal record upon which the Track 3 decision will be based.

an active track on multi-property microgrid tariff development. For more information, see: https://www.cpuc.ca.gov/resiliencyandmicrogrids/

6 Summary of Proposed DOE Microgrid R&D Program Activities for Subsequent 5 to 10 Years

6.1 Vision, Role and Philosophy for DOE Support for Multi-property Microgrids

Modest to fundamental changes in state regulations governing utility planning, procurement, operations, ratemaking, and investment will be required in order to realize a future in which multi-property microgrids are treated as critical grid modernization assets that serve as networked grid resources, integrators of DER, enablers of energy localization, contributors to greenhouse gas and air pollution reduction goals, and providers of resilience. We recommend activities and interventions by DOE designed to address regulatory barriers and support changes to state regulations which strike a balance among the following activities.

(a) Meeting regulatory bodies where they are today: This should be accomplished by offering the support required to both promote regulatory comfort and familiarization with multi-property microgrids and contribute to the resolution of today's regulatory challenges, which are significant and tangibly hamper multi-property microgrid market development. Notably, today's regulatory bodies – if they are focused on microgrids at all – tend to consider microgrids as principally a resilience solution rather than a broader grid modernization building block. This is because, in practice, current PUC proceedings to facilitate development of microgrids are responding to state legislative directions to address resilience. Thus, there is a need for DOE to help regulators get started with incorporating and, as appropriate, compensating microgrids as a resilience solution. DOE can also work with State Energy Officers and Governors to examine resilience and microgrids more broadly outside of discrete regulatory proceedings.

(b) Addressing regulatory barriers through technological innovation, when possible: There are many regulatory considerations and barriers surrounding microgrid interconnection, safety, cyber security, and consumer protections that could potentially be mitigated through new technological innovations and standards. DOE support for technological innovation should help to improve confidence among regulators in the ability of microgrids to be deployed without creating new concerns or requirements for additional regulatory oversight, which can help support the development of both utility-owned and privately-owned multi-property microgrids.

(c) Pushing the envelope forward with visions for the future role of microgrid in grid modernization: DOE should also play a role in offering visions and resources for the future evolution of microgrid markets. Here, DOE should play a convening role to help stakeholders chart the course for the future of microgrid regulation, and also put forward new information resources to support progress among state regulatory commissions and utilities.

In all cases, it is recommended that DOE Microgrid R&D Program focus its resources on scaling microgrid use cases which present high market potential but currently have low deployment, which in practice predominantly means the multi-property microgrid cases explored in Section 4. These microgrid use cases are also foundational to a future of networked microgrids, which further justifies this focus.

6.2 Proposed DOE R&D Program Activities

There are a variety of core activities that the DOE Microgrid R&D Program can consider funding, either unilaterally or in conjunction with other DOE offices and programs. The subsequent sub-section provides an organized list of recommended activities for DOE to consider supporting, which is also summarized in Table 4 along with key dimensions of these activities.

Training and Direct Institutional Support Programs

Given the low level of familiarity among many regulators with multi-property microgrids, along with the substantial suite of regulatory issues that these projects can face, institutional capacity-building and direct technical assistance to regulatory bodies may be critically important for DOE to support. Ideas include:

- **Direct Technical Assistance to Regulatory Commissions on Multi-property Microgrid Regulatory Framework Development** (*Impact Potential:* **High**) – Similar to the Grid Modernization Lab Consortium's institutional support activities, state regulatory bodies (as well as self-regulated utilities) could competitively apply for technical assistance support from DOE for assistance in developing microgrid services tariffs or other aspects of their regulatory framework for multi-property microgrids. This could potentially be facilitated through NARUC, the Public Power Association, or the National Rural Electric Cooperative Association. DOE should help build the foundational capacity of the key staff, and then bring laboratory resources and expertise to bear to help design and implement regulatory frameworks. Such in-depth TA also provides valuable feedback to DOE on future activities and investment opportunities that would prove most useful to regulators and self-regulated utilities, and creates opportunities to write demonstrable case studies that can be shared nationally to inspire further action.[29]

[29] Notably, there was a stated desire among many interviewed stakeholders for DOE to support the development of national standards for resilience which could be used by state and local stakeholders. As a practical matter, such an undertaking would require an incredibly significant amount of effort, and would be difficult to sufficiently differentiate for distinct regions and jurisdictions with distinct needs, risk profiles and values around resilience. Such a standard may require detailed policy input from a range of other Federal government departments (e.g., DOD, DHS, etc.), and may potentially require a legislative intervention to promulgate. As a result, developing a national resilience standard is not an undertaking recommended for the DOE R&D program. Instead, through direct technical assistance programming, DOE's national laboratories can support states and local governments in developing their own locally appropriate standards for resilience, and communicate insights yielded back to DOE for replication and broader sharing when possible.

Table 4 - Summary of Proposed DOE Microgrid R&D Program Activities for Reduction of Regulatory/Institutional Barriers

Category	***Activity***	***Impact Potential***	***Level of Effort***	***Project Duration***	***Collaboration w/ Other DOE Programs***
Training and Direct Institutional Support Programs	**Direct Technical Assistance to Regulators on Multi-property Microgrid Regulatory Framework Development**	*High*	*Low*	*Medium*	*Yes*
	Support for "Regulatory Sandbox" Microgrid Pilots	*High*	*High*	*Long*	*Yes*
	Multi-property Microgrid Regulation "Boot Camp"	*Medium*	*Low*	*Short*	*Yes*
Tools and Methods	**Quantifying the Value of Resilience of Microgrids in Regulatory Proceedings**	*High*	*High*	*Medium-Long*	*Yes*
New Information Resources	**Model Interconnection Procedures for Multi-property Microgrids**	*Medium-High*	*Low-Medium*	*Medium*	*Yes*
	Standardized Microgrid System Designs for Interconnection of Multi-Property Microgrid Resiliency Projects	*Medium*	*Medium*	*Medium*	*No*
	Reference Book on Microgrid Services Tariff Design, including Compensation for Resilience	*Low-Medium*	*Low*	*Short*	*No*
	Systematic Development and Improved Dissemination of Regulatory Case Studies for Multi-property Microgrids	*Low-Medium*	*Low*	*Short*	*No*
	Handbook on Integrating Microgrids into Utility Planning	*Low-Medium*	*Low*	*Short*	*Yes*
Forward Looking Activities	**New Coordination and Communication Architectures for a Privately-owned Multi-property Networked Microgrid Future**	*Low-Medium*	*High*	*Long*	*Maybe*
	"Future of Microgrid Regulation" Workshop	*Low*	*Low*	*Short*	*No*
	Expanded Collaborative Strategy Development to Find Market-Based Solutions	*Medium-High*	*Medium*	*Medium*	*Yes*
	Exploration of State and Local Technical Assistance to Support Policy Decision-Making Enabling Microgrids	*Medium-High*	*Medium*	*Medium*	*Maybe*
Collation of Existing Resources	**Improved Dissemination Efforts on Energy Resilience for Local Governments**	*Low-Medium*	*Low*	*Medium*	*Yes*
	Curated Information Library on Microgrid Regulation	*Low*	*Low*	*Short*	*No*
	Microgrid Modeling Tools Usability and Usefulness Improvements	*Low*	*Low*	*Short*	*Yes*

- **Support for "Regulatory Sandbox" Microgrid Pilots** (*Impact Potential:* **High**) – As a specialized form of direct technical assistance (as discussed above), DOE should work with specific regulatory bodies (or self-regulated utilities) and local governments[30] in designing and implementing microgrid pilots under "regulatory sandbox" frameworks. Such frameworks allow temporary, small-scale deviations from regulations to enable pilots that might otherwise challenge traditional regulatory frameworks. DOE should provide grants to cost-share high visibility projects within these jurisdictions that demonstrate advanced multi-property microgrid concepts and technologies as "living laboratories." The success of this approach is currently illustrated by ComEd's Bronzeville microgrid and by National Energy Laboratory of Hawaii Authority's (NELHA) microgrid on the Big Island of Hawaii. This would drive local regulatory and stakeholder familiarization and provide an opportunity to create demonstrable use cases for regulatory and business model innovations. A dedicated technical assistance intervention could be considered where a significant innovation is possible, replicability potential is high, and there is a commitment to lifecycle monitoring where learnings can be identified and systematically disseminated. Pursuit of this initiative would involve coordination with or leverage from related DOE activities outside the Microgrid R&D program, such as DOE Energy Efficiency and Renewable Energy's Connected Communities grants.

- **Multi-property Microgrid Regulation "Boot Camp"** (*Impact Potential:* **Medium**) – In collaboration with NARUC/NRRI, DOE should host a training series outlining key regulatory, legal, and institutional issues associated with multi-property microgrids, as well as best practices for development of regulatory frameworks. This training could include relevant staff from state regulatory commissions and energy offices, as well as interested local governments and self-regulated utilities. It should be repeated and continuously improved, potentially featuring regional cohorts to promote peer-to-peer learning and engagement.

Tools and Methods

- **Quantifying the Value of Resilience of Microgrids in Regulatory Proceedings** (*Impact Potential:* **High**) – An inability to concretely quantify the value of resilience of microgrid projects within regulatory proceedings and in planning activities by local governments creates significant barriers to deployment, both for utility-owned multi-property microgrids seeking to clear regulatory reasonable/prudence hurdles, as well as regulators looking to develop value-reflective tariffs for compensating resilience. NARUC is currently funded to discuss this issue with its members later this year, and has already published a brief overview of current analytical practices (NARUC 2019). However, there is a clear need to develop new tools and/or upgrade existing tools to more holistically quantify the resilience value (in both dollars and other measures of social welfare) of an individual microgrid within regulatory proceedings. While this would be a substantial undertaking that may need to leverage resources from other DOE offices and programs in a coordinated manner, the DOE Microgrid R&D Program could help to ensure that new tools and methods are backwards-designed to be useful within regulatory proceedings, while also helping to build confidence among regulators on the efficacy of the tool. One key pathway for this effort could be the expansion of Lawrence Berkeley National Laboratory's ICE Calculator tool to also include costs to customers and regions resulting from widespread long

[30] Local governments may need support in augmenting franchise agreements to enable a "legal sandbox" to pilot privately-owned multi-property microgrids.

duration power interruptions. Another pathway would be to upgrade Sandia National Laboratories' Resilience Node Cluster Analysis Tool (ReNCAT) to better account for social equity considerations and quantify the social welfare value of microgrid projects.

New Information Resources

Perhaps the most consist set of needs that were uncovered during research and communicated during stakeholder interviews was a need for DOE to generate new information resources related to microgrids.

- **Model Interconnection Procedures for Multi-property Microgrids** (*Impact Potential:* **Medium- High**) – In the few jurisdictions that are pursuing regulatory frameworks for multi-property microgrids, there has been a monumental amount of time and institutional energy invested in developing first-of-a-kind "interconnection procedures" for microgrids, which comprise, *inter alia*: drafting rules governing utility interconnection application evaluation; drafting interconnection applications; drafting standard microgrid interconnection agreements between developers and the utility; defining applicable electrical equipment standards related to technical performance, communication/telemetry, utility control and other aspects for the microgrid; and defining rules governing technical screening of proposed microgrids. In general, these interconnection procedures are a prerequisite to market development, and help to streamline interconnection outright while reducing regulatory risk of lengthy and uncertain interconnection processes. Promulgating "model" procedures for multi-property microgrids, which individual regulatory commissions could take and adapt to their own settings, could be a hugely impactful step for the large majority states. Similar to IREC's influential Model Interconnection Procedures for distributed generation interconnection promulgated in 2005 (and updated in 2009, 2013 and 2019), DOE should support the development of such procedures to streamline administrative efforts at state commissions and self-regulated utilities looking to develop regulatory frameworks for multi-property microgrids. Such model interconnection procedures could also be drafted in a way that ensures that state microgrid interconnection rules do not place artificial constraints on future microgrid applications, such as networked microgrids. This document could potentially also potentially include model *operational* procedures for multi-property microgrids which provide guidance on how distribution control operators and utility works understand and assess the status and risk of individual microgrids on the system during the course of ordinary maintenance and restoration activities.

- **Standardized Microgrid System Designs for Interconnection of Multi-Property Microgrid Resiliency Projects** (*Impact Potential:* **Medium**) – The use of pre-approved system designs for microgrids can help accelerate interconnection of resiliency projects and de-risk microgrid investments. DOE can consider supporting the development of such standardized microgrid system designs that could be used as a model for other states to adopt. Such standard designs would need to be generalizable to ensure that a diverse range of multi-property microgrid topographies could be accommodated, while also ensuring that system designs adhere to key safety and operational principles which promote coordinated operations and the safety of utility line crews. Importantly, DOE would need to work with one or more Public Utilities Commissions to develop exemplar cases, which could then be used by other regions to generate their own standard designs, as there is no true one-size-fits-all approach to multi-property microgrid design. However, the activity should include an examination of how the exemplar cases could be expanded in the future.

- **Reference Book on Microgrid Services Tariff Design Elements, including Compensation for Resilience** (*Impact Potential:* **Low-Medium**) – Microgrid services tariffs designed to compensate resilience, specifically for privately-owned multi-property microgrids, are under discussion in a few leading jurisdictions, and will be critically important for building a business case for third-party microgrids. These tariffs help to translate the quantified value of resilience into a structured compensation for microgrid developers to support project bankability. However, as of the time of writing, there is a widespread lack of precedent/experience among regulatory bodies and utilities to design these tariffs. DOE should work with NARUC/NRRI to design and develop a national reference handbook for regulators on the elements of and options for microgrid services tariff design. This guidebook could cover all aspects of tariff design, from input data requirements to analytical methods/tools to the design of the tariff itself. It would be promoted through NARUC and other relevant channels, and could potentially be accompanied by model spreadsheet tools and/or a series of high-visibility educational webinars or trainings on the topic.

- **Systematic Development and Improved Dissemination of Regulatory Case Studies for Multi-property Microgrids** (*Impact Potential:* **Low-Medium**) **–** There was a clearly expressed sentiment among the IAB that many regulatory bodies and utilities still lack basic familiarity with microgrids as a concept, as well as the potential costs and benefits of microgrids in their jurisdiction. There is a clear need to have credible, published cases that can be referenced to help build confidence among regulatory bodies and utilities on multi-property microgrids. DOE should develop a series of demonstrable case study write-ups for multi-property microgrids in the U.S., which emphasize the value proposition and business case for the microgrid, and also detail the relevant regulatory discussions and processes that ultimately led to project approval. These case studies could be accompanied by a webinar series that help promote and socialize the concept of multi-property microgrids across state regulatory and utility communities.

- **Handbook on Integrating Microgrids into Utility Planning** (*Impact Potential:* **Low-Medium**) – Another important pathway for microgrid deployment is the appropriate inclusion of microgrids into broader utility planning frameworks. There is a clear gap in the literature, as well as a large need among regulators and utilities, to understand how regulators/utilities can better align transmission, distribution and DER-related planning, including how best to incorporate consideration of microgrid projects. Broadly speaking, regulators do not currently have the information necessary to understand how microgrids might fit into the larger planning frameworks of the electricity system, or how microgrids can be used as a means to achieve high-priority state and local policy goals. Thus, DOE should work with NARUC/NRRI/NASEO[31] to develop a handbook on this topic, which covers technical methods for including microgrids in integrated resource planning, transmission planning, and integrated distribution system planning, among other processes. as well as more practical regulatory and implementation related dimensions of the topic.

[31] NARUC and NASEO recently completed a two-year comprehensive electricity planning task force with roadmaps for state implementation. This activity could build upon these roadmaps, as well as recent advances in comprehensive electricity planning by various states, in order to ensure that stakeholders are able to incorporate microgrids in planning processes. More information is available at: https://www.naruc.org/taskforce/.

Forward Looking Activities

As mentioned in Section 6.1, there is also a need for DOE to push the envelope forward with visions for the future of microgrid regulation. Promoting innovative ideas surrounding market reform and novel regulatory constructs for microgrids (and the electricity industry, more broadly) may be best accomplished through the DOE playing a "convening" role. DOE can play a catalyzing yet neutral role which seeks to facilitate new thinking on how to evolve regulation to respond to new risks while harnessing new opportunities presented by microgrids. Potential activities include:

- **Future of Microgrid Regulation Workshop** (*Impact Potential:* **Low**)– The DOE should work with NARUC to convene a high-profile multi-day workshop which focuses on key microgrid regulatory topics, including the future of resilience valuation, resilience within performance-based regulatory constructs, networked microgrid conceptual frameworks and pilots, inclusion of microgrids within integrated distribution planning, and other important topics. Such a workshop could also be an opportunity for DOE to showcase innovative work and insights derived from the above-suggested activities.

- **New Coordination and Communication Architectures for a Privately-owned Multi-property Networked Microgrid Future** (*Impact Potential:* **Low-Medium**) – As indicated by stakeholder interviews, a future involving a community of privately-owned multi-property microgrids (i.e., a future of many independent local energy networks functioning in concert) could raise significant concerns around the reliability and safety of operations. DOE should continue funding for research on new coordination and communication architectures that will be needed to support the improved situational awareness and state estimation capabilities in a networked microgrid future. Federally sponsored R&D on these technologies and systems will help build confidence among regulators as to the safety of the system, mitigating reliability and consumer protection concerns that might otherwise require significant regulatory oversight and associated institutional burdens.

- **Expanded Collaborative Strategy Development to Find Market-Based Solutions** (*Impact Potential:* **Medium- High**): As alluded to in Section 4, many of the proposed R&D activities in this document are incremental and necessary, but perhaps not sufficient for an overall market and regulatory transformation to achieve the DOE microgrid vision. This transformation should acknowledge the multiple stakeholders that are increasingly willing and able to gain benefit from, and support the cost of advanced microgrids. To build a strategy for such a holistic approach to regulatory structure, significant strategy development is necessary with deeper feedback from stakeholders than has been possible through the development of this white paper. A key area of future need suggested by IAB members is to consider the role of multi-property microgrids within overall integrated system planning, addressing the reforms needed within the overall regulatory structure to properly assess the costs and benefits of these value-stacking technologies. This effort can better account for the multiple services that these microgrids provide to society, the economy, and national security.

- **Exploration of State and Local Technical Assistance to Support Policy Decision-Making Enabling Microgrids** (*Impact Potential:* **Medium- High**): State and local energy offices develop strategies and suggest policies that enable efficient regulatory structures that will be necessary for regulated industry to consider the true costs and benefits of advanced microgrids. This whitepaper did not consider the many policy considerations and the R&D support that may be necessary for those decisions. A forward-looking effort to focus on state and local energy policy development and the technical gaps therein is needed. Based on feedback from the IAB, this effort could include developing clear state-level legal definitions of microgrids, establishing a deeper library of feasibility studies for energy officers, providing technical clarity on the grid services that microgrids provide and the value of these services, and systemically assessing the links between state and local energy policy and hazard mitigation, decarbonization, social equity, and climate policies.

Collation of Existing Information Resources for Regulators

One key theme among the regulatory bodies that the Topic 7 team interviewed was a sense of the massive scale of the "information asymmetry" between their institutions and utilities on the topic of microgrids. Across the entire Topic 7 Industry Review Board, there was a sentiment expressed that access to more information was incredibly important to all stakeholders, but that many felt "lost" among the many resources that the U.S. Department of Energy and others have produced over the last decade related to microgrids. There was also an observed lack of clarity among stakeholders about what resources were available, which resources were most appropriate for various applications, where exactly one could access these resources, and how-best to learn about various topics of import.

As a result, the Topic 7 team recommends an effort to collate and promote existing microgrid information resources specifically for the state regulatory bodies and energy offices, as well as self-regulated utilities, local governments and communities. If conducted properly, this activity will not only amplify the impact of existing DOE investments by communicating to regulators what is already available to help inform their decisions, but it will also provide the DOE Microgrid R&D Program with actionable information on knowledge/resource gaps and regulatory needs. Specific activities include:

- **Improved Dissemination Efforts on Energy Resilience for Local Governments** (*Impact Potential:* **Low-Medium**): Another key message that was received was the need to educate key stakeholders and decision makers *beyond* state public utility commissions and energy offices about the topic of resilience and the potential value of microgrids. Namely, municipal and county governments may have a significant role to play in promoting publicly beneficial microgrids of all use cases, yet often do not have the information or technical capacity to move forward with exploring projects. DOE should explore high-leverage options (e.g., working with the US Conference of Mayors[32]) for providing information on the role of microgrids in enhancing community resilience to municipal and county governments.

- **Curated Information Library on Microgrid Regulation** (*Impact Potential:* **Low**)**:** DOE – in partnership with NARUC, the National Regulatory Research Institute (NRRI) and NASEO – should assemble an organized, readily and publicly accessible, curated library of resources for state regulators and other relevant government agencies related to multi-property microgrid deployment.[33] This library could be backwards-designed for usability among state regulatory commissions and state energy offices through a feedback process led by the NARUC/NASEO Microgrid State Working Group. The National Laboratories could serve as technical content partners along with key NARUC and NASEO staff to assemble an accessible and impactful library which could serve as a repository for both past and future information resources. NARUC

[32] https://www.usmayors.org/

[33] A legacy example of such a regulation library is the 21st Century Power Partnership's '*Distributed Generation Regulation Library*', available at: https://www.21stcenturypower.org/dglibrary.html

and NASEO have already begun posting microgrid-related information resources for their members on their respective websites, and could expand upon these existing libraries in partnership with DOE.

- **Microgrid Modeling Tools Usability and Usefulness Improvements** (*Impact Potential:* **Low**)**:** DOE should explore and where appropriate confirm the need for improvements in the usability of existing tools (e.g., ReNCAT, ICE, REopt, DER-CAM) that might support microgrid regulatory proceedings. DOE should work with NARUC and NASEO to seek feedback on the usability and usefulness of these tools within state regulatory bodies and energy offices. Such an activity could generate valuable information which could inform next steps for tool development that DOE could invest in, as well as help to build a robust and enthusiastic user base for DOE-supported tools.

7 Justification for DOE Investment

Microgrids, and multi-property microgrids in particular, offer both new opportunities and prospective benefits for society, as well novel risks to the public interest surrounding safety, consumer protection, and equity. Legal, regulatory and institutional ecosystems governing multi-property microgrids are in the beginning stages of a formidable task: to strike a socially acceptable balance of evolution to simultaneously mitigate societal risks while leveraging new opportunities presented by microgrids. This task must ultimately be addressed in a thoughtful and locally appropriate manner in order for DOE's vision for microgrid market development to be realized. A federal program aiming explicitly to address these barriers through engagement with state public utility commissions, state and local governments, and utilities is aligned with DOE's longstanding practice of support for these types of activities. Further, DOE's Microgrid R&D Program is already well-positioned through past engagements with key partners and stakeholders to move forward. In general, DOE approaches to supporting these stakeholders should be guided by several principles: transparency, equality of opportunity, inclusiveness, accountability, and leverage. Importantly, the details of activities – especially in the realm of institutional support – are defined and selected by stakeholders, not by DOE. DOE works with relevant, established, public-sector partners such as the National Association of Regulatory Utility Commissioners (NARUC) and the National Association of State Energy Officials (NASEO) to ensure that training and education for government officials is inclusive and tailored to provide value to stakeholders across jurisdictions and regions.

It is important to emphasize that DOE's role is not to participate as a "party" or an "advocate" within regulatory proceedings. Instead, DOE's role is to ensure that all stakeholders have access to the best information available to support informed and balanced decisions. DOE plays an important role in inspiring ideas and lending credibility to novel microgrid applications and business models, while also staying apprised of current market developments with the intention of staying "ahead of the curve" on emerging regulatory and institutional issues. DOE also plays an important role in providing critical information resources, education, and also in supporting direct institutional engagement with public utility commissions and other entities when a significant innovation is possible, replicability potential is high, and there is a commitment to lifecycle monitoring where learnings can be identified and systematically disseminated. Prudent DOE investments require alignment of existing government and regulator-led efforts, and the mobilization of resources from national labs, universities, and industry as appropriate.

Proposed activities for the DOE Microgrid R&D Program to assist in mitigating regulatory and institutional barriers to microgrid market development will provide a valuable and transparent platform for meaningful engagement with key stakeholders as they seek to develop frameworks for microgrid investment. This platform will also strengthen and inform the more technical R&D areas through understanding and responding to "on the ground" challenges, while also helping to facilitate and accelerate industry adoption of key DOE-supported tools and R&D results. As well, these activities can position the DOE Microgrid R&D Program to provide greater coordination, transparency, and a stakeholder-service orientation across the various DOE applied energy offices to both be responsive to stakeholder requests for technical assistance and information resources and to communicate useful information that results from DOEs many grid-related efforts.

Ultimately, it is challenging for state and local governments, regulators, and self-governed utilities to keep up with the technological capabilities and business model innovations offered by microgrids, as well as the new risks microgrids pose, leading to a low level of familiarity and confidence with the technology, and ultimately a lower prioritization among most institutions for microgrid-related regulatory efforts. Development and widespread utilization of key information resources and tools enables decision makers to move forward confidently with the development of regulatory and investment frameworks for multi-property microgrids. Furthermore, DOE-funded institutional support programs help accelerate progress in key jurisdictions and create demonstrable case studies for microgrid institutional and regulatory frameworks that build confidence among key stakeholders and inspire new efforts by key institutions. Investment by DOE in stakeholder-oriented analytical capabilities and tools for valuing and justifying microgrid investments fills a critical and much-needed gap (identified universally by all interviewed stakeholders) in the regulatory space, and will help accelerate deployment.

References

Asmus, P., Forni, A., & Vogel, L. (2018). *Microgrid Analysis and Case Studies Report.* San Francisco: Navigant Consulting via the California Energy Commission. Retrieved from https://ww2.energy.ca.gov/2018publications/CEC-500-2018-022/CEC-500-2018-022.pdf

Cook, J; Volpi, C.; Nobler, E.; Flanegin, K. (2018). *Check the Stack: An Enabling Framework for Resilient Microgrids.* NREL/TP-6A20-71594. Available at: https://www.nrel.gov/docs/fy19osti/71594.pdf

California Energy Commission (CEC). (2019). *Demonstrating a Secure, Reliable, Low-Carbon Community Microgrid at the Blue Lake Rancheria.* Prepared by Humboldt State University. CEC Report CEC-500-2019-011. Available at: https://ww2.energy.ca.gov/2019publications/CEC-500-2019-011/CEC-500-2019-011.pdf

California Public Utilities Commission (CPUC). (2021). *Press Release: CPUC Adopts Strategies to Help Facilitate Commercialization of Microgrids Statewide.* Docket No. R.19-09-009. Available at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M360/K370/360370887.pdf

CPUC. (2021). *Decision Adopting Rates, Tariffs, and Rules Facilitating the Commercialization of Microgrids Pursuant to Senate Bill 1339 and Resiliency Strategies.* Rulemaking 19-09-009. Available at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M359/K865/359865952.PDF

CPUC. (2021). *Proceeding 19-09-009.* Filing Date: September 12, 2019. Available at: https://apps.cpuc.ca.gov/apex/f?p=401:56:0::NO:RP,57,RIR:P5_PROCEEDING_SELECT:R1909009

Flores-Espino, F.; Giraldez, J.; Pratt, A. (2020). *Networked Microgrid Optimal Design and Operations Tool: Regulatory and Business Environment Study.* NREL/TP-5D00-70944. Available at: https://www.nrel.gov/docs/fy20osti/70944.pdf

Giraldez, J.; Flores-Espino, F.; MacAlpine, S.; Asmus, P. (2018). *Phase I Microgrid Cost Study: Data Collection and Analysis of Microgrid Costs in the United States*. NREL/TP-5D00-67281. Available at: https://www.nrel.gov/docs/fy19osti/67821.pdf

Hawaii Public Utilities Commission (HPUC). (2018). *Docket No. 2018-0163: Instituting a Proceeding to Investigate Establishment of a Microgrid Services Tariff*. Filed 07/10/2018. Available at: https://dms.puc.hawaii.gov/dms/dockets?action=details&docketNumber=2018-0163

Illinois Commerce Commission (ICC). (2018). *Order: Commonwealth Edison Company – Petition Concerning Implementation of A Demonstration Distribution Microgrid.* Docket 17-0331. Available at: https://www.icc.illinois.gov/docket/P2017-0331/documents/276063

King, D. (2008). *The regulatory environment for interconnected electric power micro-grids: insights from state regulatory officials*. Carnegie Mellon Electricity Inudstry Center Working Paper. Available at: https://www.cmu.edu/ceic/assets/docs/publications/working-papers/ceic-05-08.pdf

Lenhart, S. and Araújo, K. (2021). *Microgrid decision-making by public power utilities in the United States: A critical assessment of adoption and technological profiles.* Renewable and Sustainable Energy Reviews, vol. 139, no. 1364-0321. Availble at: https://www.sciencedirect.com/science/article/abs/pii/S136403212030976X

Littell, D.; Zinaman, O.; Kadoch, C.; Baker, P.; Bharvirkar, R.; Dupuy, M.; Hausauer, B.; Linvill, C.; Migden-Ostrander, J.; Rosenow, J.; Xuan, W.; Logan, J. (2017). *Next-Generation Performance-based Regulation – Emphasizing Utility Performance to Unlesh Power Sector Innovation.* NREL/TP-6A50-68512. Available at: https://www.nrel.gov/docs/fy17osti/68512.pdf

Maloney, P. (2017, Feb 2). Duke, Schneider pair up to build two microgrids in Maryland. *Utility Dive*. Retrieved from: https://www.utilitydive.com/news/duke-schneider-pair-up-to-build-two-microgrids-in-maryland/435398/

Navigant. (2016). *Emerging Microgrids Business Models*. Research Brief Published Q1 2016.

National Association of Regulatory Utility Commissioners. (NARUC). (2019). *The Value of Resilience for Distributed Energy Resources: An Overview of Current Analytical Practices*. Prepared by Converge Strategies, LLC. Available at: https://pubs.naruc.org/pub/531AD059-9CC0-BAF6-127B-99BCB5F02198

National Regulatory Research Institute (NRRI). (2012). *Are Smart Microgrids in Your Future? Exploring Challenges and Opportunities for State Public Utility Regulators.* Prepared by Tom Stanton. Available at: https://pubs.naruc.org/pub/FA86B620-F983-74B9-CC47-2C85B82CC3B5

Regulatory Assistance Project (RAP). (2020). *With the Shift Toward Electricifation, Decoupling Remains Key for Drivign Decarbonization.* Joint RAP/ACEE Blog Post by Rachel Gold and Jessica Shipley. Available at: https://www.raponline.org/blog/with-the-shift-toward-electrification-decoupling-remains-key-for-driving-decarbonization/

Stanton, Tom. (2020). *Microgrid Policy Progress in the States*. Presented at 8th Annual HOMER International Microgrid Conference.

Vanadzina, E. et al. (2019). *Business models for community microgrids.* 16th International Conference on the European Energy Market (EEM), Ljublijana, Slovenia.

Voices of Experience. (2020). *Microgrids for Resiliency.* Prepared by NREL and Smart Electric Power Alliance. Available at: https://www.smartgrid.gov/voices_of_experience

Walker, E. (2021, Feb 10). Bolstering Resilience: Maryland County Showcases the Power of Microgrids. *Environmental and Energy Study Institute*. Retrieved from https://www.eesi.org/articles/view/bolstering-resilience-maryland-county-showcases-the-power-of-microgrids

Wood, E. (2018, October 26). Montgomery County Microgrids Now Live and Leading. *Microgrid Knowledge*. Retrieved from https://microgridknowledge.com/montgomery-county-microgrids/