U.S. DEPARTMENT
of ENERGY

DRAFT REPORT

Microgrids R&D Strategic Plan

Topic 9 – Enabling Regulatory and Business Models for Broad Microgrid Deployment

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Disclaimer

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List of Acronyms

(From Executive Summary)

AI	Artificial Intelligence
CHP	Combined Heat and Power
DOE	U.S. Department of Energy
LBNL	Lawrence Berkeley National Laboratory
LEL	Large Electric Loads
LLNL	Lawrence Livermore National Laboratory
MRC	Microgrid Resource Center
ML	Machine Learning
NARUC	National Association of Regulatory Utility Commissioners
NASEO	National Association of State Energy Officials
NCSL	National Council of State Legislatures
NLR	National Laboratory of the Rockies
NWA	Non-Wires Alternative
OE	(U.S. DOE) Office of Electricity
OECC	Ozarks Electric Coop
ORNL	Oak Ridge National Laboratory
PCC	Point of Common Coupling
PPA	Power Purchase Agreement
PUC	Public Utility Commission
RD&D	Research, Development, and Deployment
SMR	Small Modular (Nuclear) Reactor
T&D	Transmission and Distribution
TA	Technical Assistance

Executive Summary

As the electric grid ages, demand for electricity rises, and natural and human-made threats proliferate, microgrid-based solutions have come to play an increasingly central role in the design and operation of a secure and reliable power grid. A microgrid is a collection of local generation and load sources that can disconnect from the grid and operate autonomously when needed. Microgrids can assure power to systems that are critical to our nation's prosperity and security, such as military bases, hospitals, and interdependent infrastructures like compressor stations in the natural gas transmission system. Microgrids can also facilitate the rapid interconnection of economically important new loads, like datacenters, by reducing their reliance on the grid, thereby increasing the operational abundance of the American energy system.

By optimally aggregating, integrating, and leveraging a wide portfolio of local generation[1] such as natural gas-fueled combined heat and power (CHP) systems, small modular reactors (SMRs), geothermal, fuel cells, and responsive loads, microgrids will enable a more flexible grid system architecture than we have today. Microgrid systems will support local resilience while also efficiently and securely orchestrating energy additions at the grid edge and supporting overall grid reliability and energy affordability.

This strategy document is one of nine that describes the vision and objectives of the U.S. Department of Energy (DOE) Office of Electricity (OE) Microgrid Program. The nine strategy documents focus on the following areas:

1. Program vision, objectives, and R&D targets in 5 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. Small Nuclear Reactors in Future Microgrids
8. Artificial Intelligence and Machine Learning for Microgrid Applications
9. **Enabling regulatory and business models for broad microgrid deployment**

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[1] Local distributed energy assets generally refer to a wide range of behind-the-meter technologies and assets that generate, store, distribute, or consume electrical energy; thus, local and distributed generation, storage, and dynamic load assets are covered by this term. They are generally designed to be (1) decentralized or distributed and located closer to the point of energy consumption, unlike traditional power plants that are often located far from population centers; (2) smaller in capacity compared to large-scale power plants, allowing for more flexibility and adaptability in energy system design; and (3) inclusive of various technologies, such as CHP, geothermal, energy storage (e.g., batteries, pumped hydro storage), fuel cells, and other local energy technologies.

This strategic document addresses the market, policy, and regulatory challenges that hinder microgrids and their associated business models from improving the reliability and affordability of the US power system, accelerating new load interconnection to the grid, and unlocking the full resilience potential of readily deployable energy assets such as natural gas emergency generators. The business case for microgrids is built on three main value streams: targeted reliability and resilience, flexible capacity expansion, and reduced operational complexity. These value streams are not efficiently realized by many stakeholders due to the policy and regulatory challenges described below. Overcoming these constraints will help secure the reliability of the US energy system while maintaining prosperity that affordable energy ensures. Crucially, microgrid-ready business models and regulatory structures are essential for building an energy system resilient to regionally significant natural and man-made threats by precisely targeting localized vulnerabilities and greatly accelerating recovery from outages.

The program vision is that *microgrids will become essential building blocks of the future electric grid, leveraging all sources of affordable, reliable, and secure energy*. Specifically, through catalyzing American innovation in next-generation microgrid systems and architectures, the program envisions to support:

- ***Enhanced Resilience***: Microgrids that protect communities and critical facilities from outages.
- ***Reliable and Secure Operations***: Advanced controls and cybersecurity to handle threats and changing grid conditions.
- ***Energy Abundance***: Adding local, flexible energy sources to meet rising electricity demand.

To achieve these goals, the program includes research, development, and demonstration (RD&D) and technical assistance (TA) targets for a 5-year horizon in three broad RD&D/TA domains:

- ***Infrastructure, Operations, and Control***: Contains RD&D goals associated with the operational aspects of microgrid technologies, including microgrid monitoring, control, optimization, communication, and protection.
- ***Multi-Domain Analysis and Decision-Making Tools***: Contains RD&D goals associated with the design, planning, and analysis aspects of microgrid technologies, including tools, computational methods and models, and corresponding simulation approaches.
- ***Engagement and Institutional Frameworks***: Contains goals associated with market, regulatory, and institutional barriers to microgrid system adoption.

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1 Introduction

Traditional power system design involves large generation stations connected to distant electric customers via transmission and distribution grids. The operation of these grids involves the management of interdependent complex systems that need to be balanced to sustain the flow of power. Microgrids can connected to traditional power systems in a way that precisely stabilizes and optimizes the wider area grid. As building blocks of the evolving electric grid, microgrids can help all grid stakeholders mitigate some of the most pressing challenges in the power system, including worsening reliability, resource inadequacy in meeting accelerating AI-driven demand, and difficulty improving affordability for consumers. In fact, microgrids can address some classes of grid operational risks that few other technologies can mitigate: stabilizing the impact that new customers can have on the grid, optimizing the use of onsite and offsite generation assets, and rapidly growing the overall scale of the US grid and the economy it supports.

Current trends show increasing adoption of microgrid technologies for specialized use cases, such as reducing peak load at commercial facilities and meeting mission-critical needs at military installations. Furthermore, proliferation of large electric loads (LELs), such as datacenter and advanced manufacturing facilities, motivates utilities, customers, and regulators to leverage microgrids to affordably and quickly solve LEL integration challenges. According to current market forecasts, the global microgrid market is expected to experience significant growth between 2025 and 2030, with estimates suggesting a market size between $45.39 billion and $59.74 billion by 2030 (Allied Market Research 2022). Growing concerns about grid instability and outages are pushing businesses and communities to adopt microgrids to improve energy resilience. Microgrids can also provide a viable, cost-effective solution for powering electrically remote areas with limited grid access (O’Neil 2023). However, widespread adoption of microgrids (and therefore the realization of the 2030 projection) is currently hindered by long commissioning times of commercially available microgrid solutions, a lack of interoperability and modularity, and challenges with energy asset integration (Walton 2024). A combination of foundational and applied research and innovation are necessary to strengthen the position of microgrids as key enabling technologies for a more affordable, reliable, resilient and secure grid.

Realizing a vision of microgrids as core building blocks within standardized widespread grid architectures requires new approaches to planning and new market mechanisms that cut across traditional infrastructure boundaries. This strategic plan deals with the market and regulatory challenges of advancing microgrid business models to improve the reliability and affordability of the US power system, accelerate the new loads it can support, and realize the full resilience potential of energy resources that are already available and readily deployable in American communities.

The United States power system is predominately owned and operated by competitive and regulated entities that plan, invest, construct, manage, monitor, control, and repair grid infrastructure. Traditional grid planning practices are settled and sometimes siloed disciplines that consider safe, adequate, and affordable power from the perspective of generation, transmission, and distribution. While efforts are underway to encourage integrated approaches to planning, the fundamental building blocks of these plans tend to remain differentiated, separating bulk system network development and generation deployment from substation operation and, in turn, differentiating substation design from the design of reliable distribution circuits. Microgrids, in contrast, incorporate multiple elements that work across these boundaries, bridging at least generation and distribution operational considerations, often extending to serving the bulk system, as well.

The business case for microgrids rests on three central value streams: targeted reliability and resilience, efficient and firm capacity expansion, and reduction in operational complexity of an increasingly controllable distribution system. Targeted reliability and resilience captures the subset of grid customers that realize the most significant economic and public benefits from guaranteed uptime. For example, industrial and commercial customers can experience significant losses in productivity and inventory during outages, yielding serious economic consequences for businesses and employees. Customers that require enhanced resilience are a beachhead opportunity for microgrids, particularly in areas that suffer frequent or long-duration outages.

The microgrid value of flexible capacity expansion arises from the bulk system's often sluggish response to highly localized capacity needs. In places where business opportunities rest upon timely electrical connection, microgrids may accelerate the operational readiness of data centers and other high-density loads that would otherwise wait several years for a load request to be met. These scenarios are increasingly common given the rapid acceleration of both inference and training AI datacenter loads. To ensure America's competitiveness in AI adoption, grid operators and regulators are having to rethink traditional planning timelines. One approach to doing so without risking the stability of the wider area grid is to prescribe behaviors of datacenter loads that conform to the needs of the grids to which they are connected. This mode of capacity expansion requires significant adjustments in the dominant mode of grid regulation that, for microgrid applications, would involve new norms for customers and grid operators alike.

Finally, microgrids provide reductions in operational complexity for both bulk and distribution system operators. This value stems from a microgrid's ability to aggregate several distributed energy supply and demand resources and technologies into a single controllable interface for the operator. What increases complexity in the implementation of the microgrid on the distribution circuit has the opposite effect on the bulk power system, enabling a more modular approach to grid operation and outage restoration.

In advancing grid capabilities for critical customers and urgent expansion of localized capacity, a more universal business opportunity for microgrids begins to emerge. As planners, developers, regulators, and policymakers gain familiarity with microgrids, additional use cases gain traction. For instance, microgrids can serve rural customers whose connection to the main grid is unreliable and lacks critical contingency plans and whose restoration may be delayed by the logistical complexity of restoring damaged system assets. Microgrids can also provide backup power in populous regions for services that are important to public stability, including access to fuel, provisions, and healthcare services, significantly improving public safety during outages. In time, modular and cost-effective regulatory and business processes for microgrids have the potential to become a standard design approach rather than an exception in the development of distribution systems.

This strategic plan describes specific challenges and opportunities in this regulatory and policy space where US DOE investment most likely to achieve impact. To apply a practical lens, the strategic document outlines use cases and case studies of microgrids that either show promise toward these challenges or highlight a challenge in a unique way. Finally, the strategic plan concludes with a clear framework for how US DOE investment could deliver the impacts in this space, with a summary tying an effective path forward to the challenges faced by stakeholders.

2 State of Microgrid Regulatory and Business Model Research and Development

2.1 Review of Existing R&D

The U.S. Department of Energy (DOE) has long recognized the importance of local, state, and federal microgrid programs, policy, and regulation as key drivers of microgrid deployment. In recent years, DOE has launched several research, demonstration, technical assistance, and institutional support activities to inform policy and programs while supporting the development of innovative regulatory frameworks and business models for microgrids. The DOE Office of Electricity (OE) Microgrid Program sponsors research, development, and demonstration (RD&D) and technical assistance (TA) related to institutional coordination and knowledge sharing on microgrids, the valuation of microgrid benefits, and analysis of regulatory and business model alternatives. The Microgrid Program supported a NASEO-NARUC (National Association of State Energy Officials-National Association of Regulatory Utility Commissioners) virtual microgrid workshop in July 2024, which provided a key opportunity to identify operational challenges in the development and implementation of the microgrid business landscape. The challenges and opportunities, as well as the impact of DOE support for tackling these challenges, are outlined herein as informed by this workshop and additional interactions with key stakeholders.

In the microgrid space, DOE's efforts span both technical and institutional domains. On the technical side, the program has developed new modeling and analytical capabilities to help distribution utilities plan and operate microgrids and distributed energy supply and demand resources under normal and abnormal or contingency scenarios. These capabilities provide foundational research that supports emerging quantitative approaches to valuing microgrid assets. On the institutional side, DOE has provided support to state energy offices and to regulatory bodies responsible for oversight of a safe and economical electric utility environment, including public utility commissions and self-regulating entities such as electric cooperatives, municipal utilities, and public utility districts. These institutions play a critical role in enabling microgrids that are embedded within or connected to existing utility systems.

The recent DOE-sponsored activities in this space can be grouped as follows:

- Develop tools to design microgrids and assess their economic and operational benefits to microgrid owners and stakeholders (MDT n.d.)(DER-CAM n.d.)(Mishra et al. 2021).
- Develop innovative concepts and methodologies to help utilities plan and analyze distribution systems under uncertainty and understand the value of local energy supply and demand resources in power grid applications (Moreira et al. 2024)(Heleno et al. 2020)(CADET n.d.).
- Support technical assistance to accelerate microgrid deployment in remote communities (ETIPP n.d.)(CMAP n.d.).

- Support the National Association of Regulatory Utility Commissioners (NARUC) and the National Association of State Energy Officials (NASEO) Microgrids State Working Group (MSWG n.d.) to improve the ability of states to plan for and develop microgrid programs, regulations, and policies.
- Promote knowledge sharing across state energy offices, regulatory agencies, utilities, and other microgrid stakeholders by producing reports, webinars, and conferences focused on emerging microgrid applications and evolving challenges.

On an ongoing basis, the Microgrid Program is sponsoring the development of a DOE Microgrid Resource Center (MRC) as well as a value of resilience framework. The Microgrid Program also supports ongoing training programs related to microgrids for regulators and state authorities.

These activities have supported a gradual maturation in regulatory awareness of microgrid options. According to the National Council of State Legislatures (NCSL), 21 states have laws that address microgrids. While sixteen of these states make reference to microgrids in their legislation, but only five have developed substantive microgrid laws: California, Connecticut, Hawaii, Maine, and Massachusetts. In some cases, regulatory policies have advanced to support microgrid deployment as an additional service that utilities offer to their customers. These approaches most often involve a service adder for a single customer; cases of multi-customer microgrids that encompass components of a distribution system are much less common.

2.2 Challenges and Opportunities

There are three major categories of regulatory and policy challenges that continue to pose barriers to widespread and effective microgrid deployment. These challenges span stakeholder coordination, policy and regulatory alignment, and viable business model development. Opportunities to address these challenges are also summarized to inform actionable next steps across public, private, and community-based actors.

2.2.1 Stakeholder engagement, coordination, and knowledge transfer

Many U.S. states and territories have made significant progress in the microgrid policy and regulatory space throughout the last decades via impactful microgrid initiatives and programs. Despite the success of these experiences, hurdles remain, particularly due to inconsistencies in how microgrids are permitted, owned, and incentivized across multiple stakeholders. Coordination is a central regulatory and policy challenge for widespread microgrid adoption. Regulators, state energy offices, utilities, and their customers must synthesize various, often competing interests and complex cost-benefit allocations among a broad array of stakeholders. The following are specific coordination challenges that can be addressed:

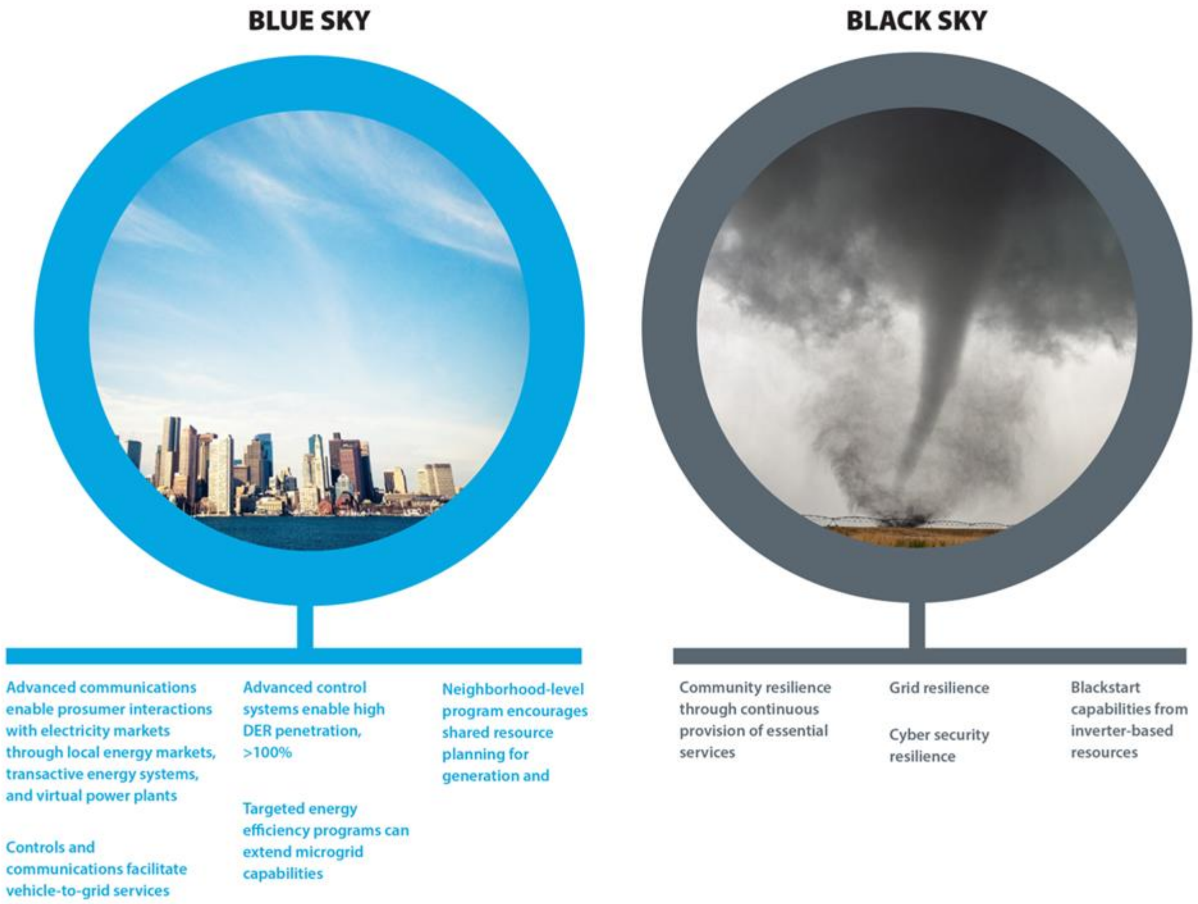
- Project approval and timeline risk associated with multi-party collaboration including multi-stage procurement processes, interconnection processes, regulatory approval processes for onsite generation, and underground construction processes.

- Information asymmetries between various parties regarding critical infrastructure needs; critical community needs; grid infrastructure capabilities, vulnerabilities, and development plans; emergency response coordination; and regulatory constraints on microgrid development.
- A mismatch between increasing community interest in microgrids and the maturity of the public policies, funding models, and utility procedures available for communities to pursue microgrid development.

More work is required to build the resources to help harmonize community and public interest in microgrids with the operational concerns of utilities and generation owners and the long-term oversight and guidance provided by public utility commissions and legislation.

2.2.2 Policy and Regulatory barriers

Existing policy and market designs for the power sector were shaped during an era of centralized generation. New policy goals, technological advancements, and evolving customer expectations now demand rethinking how microgrids can participate and provide value in the modern power systems. Most rule changes and market initiatives to date focus on the grid's normal operating conditions, also called “blue sky”. However, these assumptions must be revisited to include the role of microgrids during “black sky” scenarios and its reliability and resilience value.



Key policy and regulatory barriers to the microgrid deployment are described below.

- The role of the distribution utility is changing. It is expected that distribution utilities will have a more active role in mobilizing behind-the-meter local distributed resources to participate in the market and provide flexibility services to the bulk power system. Defining the roles and responsibilities of microgrids (both third party and utility owned) in this new paradigm remains an open question that requires specific research and integration into existing policy frameworks.
- The control systems and interactions between different types of technologies, such as types and control settings of power-electronics integrated resources, creates new regulatory challenges. Given the divergent responsibility for testing, commissioning, maintaining, and operating these systems, state jurisdictions must revisit regulatory and policy matters to determine the scope of microgrids, the types of entities that can develop and participate in them, and the way that these entities are best coordinated to achieve system performance.

- The compensation structure to pay for emergency operations and grid services during both blue sky and black sky operation requires additional clarification, particularly where demand response and variable or dynamic pricing is used to manage flexible loads. Identifying ways to sustain service for diverse customers while differentiating loads based on criticality is a challenge in the deployment of microgrids. Prioritization of loads is crucial, and without this capability, there is a significant risk that microgrids will be cost prohibitive and potentially unstable when faced with too much variability and heterogeneity in the loads that they serve.
- Path-dependence within governance models for interconnection severely constrains microgrid adoption by undermining efficient transmission, distribution, and generation planning and policy. The existing interconnection process, designed for stable load growth and predictable technology change, is ill-equipped to handle the current challenge of heterogenous, rapid, and high-value load growth. This inflexibility is magnified as new large loads commit to spatially removed generation resources, leading to churn in transmission planning. Consequently, a disconnect arises between the utility's goal of reliable and cost-effective service with customer goals of speed-to-power. Ultimately, misaligned governance prevents the technical feasibility of microgrid solutions from being harmonized with rapidly evolving grid needs, thereby severely limiting viable paths to cost recovery.

2.2.3 Business Models and Market Uncertainty

Widespread deployment of microgrids depends on enterprises that can effectively plan, market, and maintain these systems. While examples of successful microgrid deployments with defined business models exist, best practices remain unclear due to variations in scale, investment size and regulation. The main barriers in terms microgrid business models can be classified into four categories.

- Scale and complexity of microgrid applications. Microgrids can range from a handful of customers to thousands on a substation, requiring different ownership, coordination, and regulatory strategies. This diversity makes it difficult to define a universal business model.
- Unclear value proposition. Many customers, both commercial and residential, do not fully understand the costs of outages or the resilience value microgrids can offer, which may lead to a limited predisposition to invest in microgrid assets.
- High indirect costs. Microgrid deployment requires utilities and developers to manage new responsibilities such as cyber-secure control systems, local energy supply and demand resources coordination, and load management. These capabilities are often costly and not widely standardized, both from a technological and regulatory perspective.

- Cost and pricing uncertainty. Microgrid project costs vary widely across utilities and developers, especially when retrofitting existing local energy supply and demand resources. Limited industry experience and transparency make it difficult to benchmark and reduce costs.

2.2.4 Microgrid-enabling and Opportunities

Table 1 outlines opportunities that respond to each barrier identified above, along with proposed timelines to execute. Figure 1 provides a visual representation of the proposed timelines. These opportunities cover potential R&D actions in the policy, regulatory, and developer/operator space to advancing microgrid deployment across diverse contexts. While this list of opportunities is not comprehensive, it addresses common thematic elements that are most salient in current policy and regulatory initiatives, elements that can be translated into technical activities for the Office of Electricity.

Table 1. Microgrid Barriers and Opportunities in the Policy, Regulatory, and Developer/Operator Space

Barrier	**Opportunity and Timelines**
Regulatory path-dependence	Recognizing the obligations that flow to grid operators at the time that new customers are interconnected and the regulatory structures from which these obligations flow, identify funding models and federal policies that can help to establish best practices in microgrid interconnection, thereby accelerating microgrid adoption for large electric loads (LELs) like AI datacenters. **[2026-2029]**
Civilian-defense coordination	Effective coordination of civilian and defense investments can improve national defense energy security posture while improving affordability and availability of dispatchable generations under adversarial threats. **[2026-2028]**
Coordination risk for project approval	Establish standards for project timelines and roles. Pilot expedited approvals. Define normative timelines for project phases.**[2026-2027]**
Information asymmetries	Define roles for coordination and expectation for participants in planning. Provide data access and define standard submittals for data sharing requirements. **[2026-2029]**
Unmet community enthusiasm	Develop a process for communities to access information from utilities to better understand expectations and challenges as they come up; and to harmonize and coordinate community planning and development with utility planning. **[2027-2029]**
Utilities' uncertain role	Pilot different utility roles; define detailed tasks associated with different operational roles, subject to different utility markets. **[2028-2031]**

Barrier	**Opportunity and Timelines**
Control and coordination between customers	Establish best practices in how relevant utility programs and market-based solutions (e.g. demand response, distributed generation, real time pricing, energy system market platforms) can interface with microgrid offerings. **[2028-2031]**
Cost recovery and load prioritization	Develop both cost-based and community- based load prioritization models and evaluate performance. Explore best practices in island-mode operations. **[2029-2032]**
Scope and scale uncertainty	Incorporate scalar considerations into microgrid initiatives to evaluate policy performance at different scales; standardize microgrid core architecture and functions to support scaling and replication. **[2029-2033]**
Use case and value uncertainty	Engage with customers, develop effective communications for customers, and ensure that utility programs adequately engage with known and potential use cases. Support “Sandbox Demonstrations” to align diverse stakeholder interests, promote a sound technical and regulatory handshake; generate lessons learned to inform policy development, decision-making and regulatory reform. **[2030-2031]**
Lack of control standardization	Establish operational standards for microgrids that can be implemented across regions; evolve the standardization of microgrid structural and functional “building blocks.” **[2030-2032]**
Cost uncertainty	Provide price transparency for microgrid projects receiving public or utility funding. Improve cost modeling. Establish consistent and systematic accounting methods and tools for evaluating the benefits and costs of microgrid systems, consistent with state policy goals and mandates. **[2031-2033]**

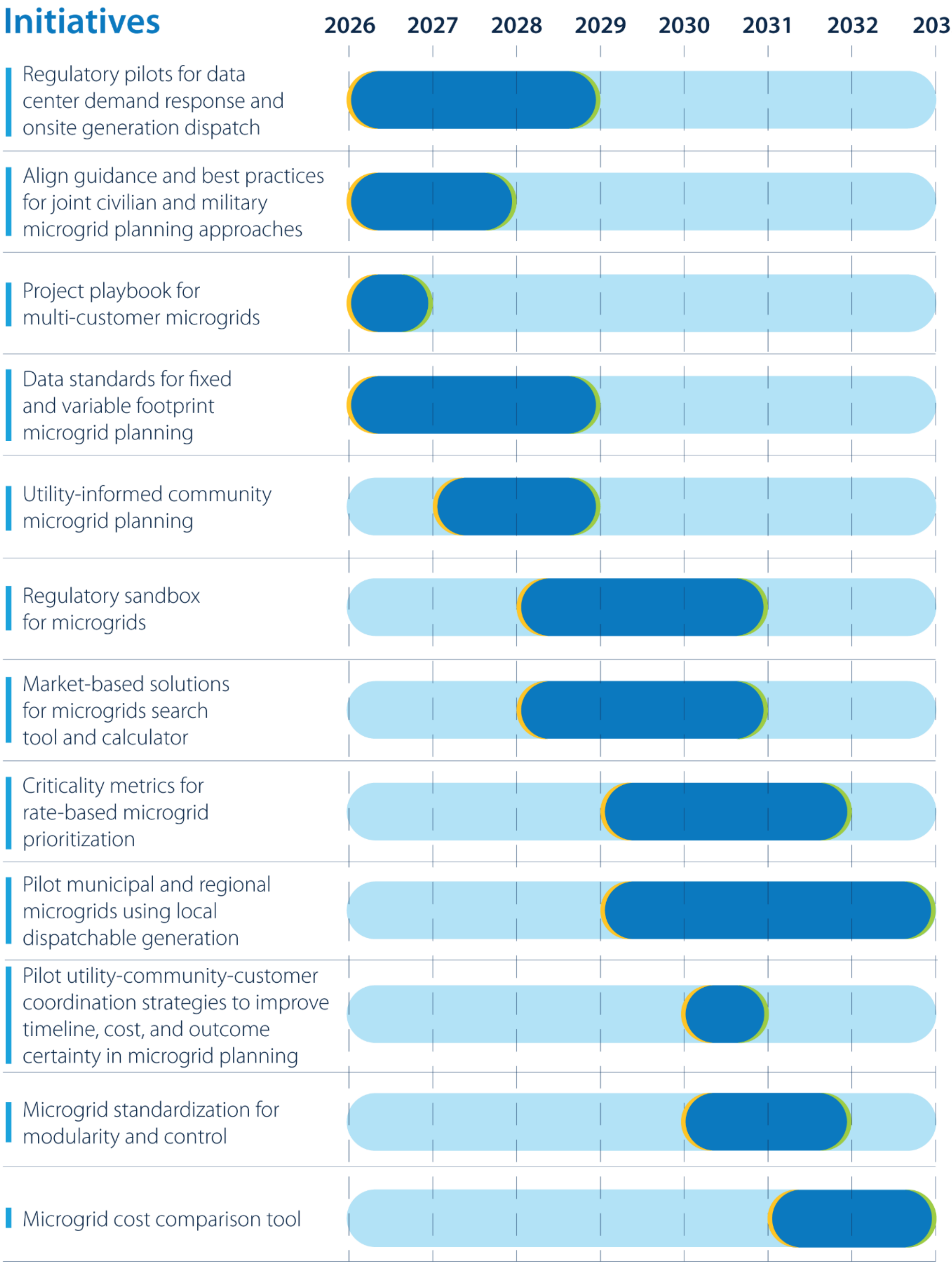


Figure 1. Proposed Initiatives and Timeline.

3 Use Cases and Case Studies

To document microgrid challenges and opportunities with respect to regulatory and business models, this section applies a practical lens with case studies of microgrid development. These highlight how regulatory and policy frameworks can be structured and informed by US DOE to overcome the primary challenges. The case studies also reveal the current state of the art for business models that often do not capture the full value proposition of microgrids.

3.1 What is a Microgrid Use Case?

Microgrid “use cases” are categories of applications for microgrids, which describe how the microgrid will be used and what its primary function will be. This dictates and influences the design, cost, business model, and expected customers for the project. These definitions are described in Table 2.

Table 2. 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 resilience. 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.[2]
	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 customers served and the spillover benefits across the rate base in 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

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[2] 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.

Major Microgrid Use Cases	
5- Community Microgrids	
7 - Temporary Microgrids	
9 - Utility Pilots	

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[3] https://www.nrel.gov/docs/fy20osti/70944.pdf

[4] 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.

3.2 What is a Microgrid Business Model?

Similarly to the microgrid use cases, microgrid business models are defined to be the mechanism in which a microgrid is planned, developed, and operated. These business models tend to cover both commercial and technical aspects of the microgrid, covering topics including, but not limited to:

1. The “Use Case” of the microgrid, as defined in Section 3.1
2. Any regulatory oversight (if relevant) necessary for approvals of the microgrid
3. Relevant safety standards
4. Ownership agreements for various assets in the microgrid
5. Financing options for the microgrid
6. Relevant consumer protections
7. Revenue collection models for the microgrid
8. Any other activities that derive value from the microgrid for the owner or customers
9. Responsible parties for operation of the microgrid
10. Responsible parties for the maintenance of the microgrid

These business models are built into a variety of archetypes, as described in Table 3. These are also repeated definitions from the March 2021 version of this report, as there have been no substantial changes in business model archetypes.

Table 3: Major Microgrid Business Models

Business Model Archetype	Applicable Use Cases	Business Model Description
Owner Financing, Operation and Maintenance (Single Customer)	1, 2, 3, 4	

Business Model Archetype	Applicable Use Cases	Business Model Description
Privately-Owned Microgrid-as-a-Service or Power Purchase Agreement (PPA) (Single Customer)	1, 2, 3	
Utility Rate Base Multi-Property Microgrid	3, 4, 5, 6, 7, 8, 9	
Publicly-owned Multi-Property Microgrid	3, 4, 5, 7, 8	

3.3 Case Studies for Microgrid Business Models

With both use cases and business models established, the following section discusses case studies for a subset of the business models. There are several cases; these are selected based on their representation of business models that demonstrate unique properties like scalability or possess unique factors that impede or enable development. While the microgrid projects discussed in the March 2021 version of this report are still relevant case studies that should be noted, several others have been listed that demonstrate unique generation sources not previously covered by the prior examples, adding to the complexity of the business model and use case.

Blue Lake Rancheria Microgrid

Bronzeville Community Microgrid

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.

Cargill Protein Facility Microgrid (Springdale, Arkansas)

Houston Northeast Water Purification Plant Expansion Project

Use Case(s): Facility-level Microgrid; Public Purpose Microgrid

Business Model: Privately-Owned Microgrid-as-a-Service or Power Purchase Agreement (PPA) (Single Customer)

Key Issues: Resilience, wastewater environmental compliance during outages

Implemented Solutions: The City of Houston contracted with Enchanted Rock to install a 30MW natural gas microgrid to support continuous operation of the expanded water purification plant. The agreement, as amended in April of 2024, has a value of $25.4M, authorizing $2.2M per year of fuel storage and grid backup services onsite at the facility.

Replicability Potential: The scale of this system demonstrates the rapid maturation of microgrid solutions to serve larger loads and the use of natural gas infrastructure as a backup energy source during a grid outage. Texas has added to this momentum with the “backup power packages” funded through the $1.8B Texas Energy Fund. This microgrid-focused program supports modular grid backup solutions in units not to exceed 2.5MW, where these units can be aggregated. Both the wastewater treatment project and the microgrid fund could be implemented by water authorities and states, respectively, to advance microgrid development and critical facility resilience.

4 Impact of DOE Investment

DOE investment in the opportunities highlighted herein is critical to the successful development and national beneficial impact of microgrids.

4.1 Vision and strategic objectives

Microgrids are a fundamental component of a reliable, resilient, and affordable electricity system that enables energy abundance. Over the next decade, their deployment is expected to be shaped by community and industry needs supported by state and federal programs. As innovation accelerates across technology, policy, and regulatory domains, microgrids can capitalize on broader transformations in utility operations and local energy resources to set a new benchmark for targeted reliability and resilience. In this evolving landscape, the DOE Office of Electricity Microgrids R&D Program plays a pivotal role in bridging the gap between microgrid technology and policy. The program aims to generate and share critical knowledge with industry and regulators and to support DOE initiatives focused on community-based energy deployment and technical assistance. Figure 2 illustrates the program's interface with key stakeholders.

Figure 2. The Microgrid Program provides multiple pillars of support across DOE initiatives.

These goals weigh the availability of resources with the capabilities of key partners, the national laboratories, and academia. They are structured to achieve maximum impact in the near-term while acknowledging a longer-term roadmap:

- Support a new generation of microgrid-enabling programs, policies, and regulations. Actively collaborate with stakeholders to address existing policy barriers to microgrid deployment. Create and share knowledge, while providing training to public utility commissions (PUCs) and State Energy Offices on microgrid technologies, value streams, and their community impacts. Develop a quantitative connection between programmatic, policy, and regulatory alternatives with outcome-focused metrics that are meaningful to the public.

- Enhance DOE’s impact on community microgrid deployment. Serve as a knowledge center within DOE for the wide array of microgrid deployment and technical assistance initiatives by offering technical expertise, resources, and tools developed through the program over recent years.
- Capture the value of microgrids in alignment with stakeholder needs. Develop systematic accounting methodologies for assessing the benefits and costs of microgrids, consistent with state policies, to effectively translate their value to communities and the grid. Customize these valuation approaches for stakeholders including states, developers, utilities, and communities. Address and analyze alternative business models for microgrids tuned to each stakeholder.

4.2 Impact

The wide adoption of standardized architectures for large-scale grid systems with microgrids as core building blocks has the potential to reduce the real-time interdependency of the overall power system and to thereby improve local grid performance during various high-consequence grid disruptions. While the value of reliable power is well demonstrated in both commercial and residential contexts, the up-front investment required to establish critical redundancy is often cost prohibitive.

The selective adoption of microgrids at sites where existing generation capacity reduces microgrid deployment costs or critical loads increase microgrid value can eventually establish a new paradigm of distribution system planning. Within this new paradigm, system planners can option local generation resources that provide resilience against bulk power configurations that prioritize least cost generation options. This selection depends, in turn, on an accurate accounting of the value that microgrids provide to customers and the public, and on a market design and policy environment that can allocate these costs appropriately.

The Office of Electricity’s microgrids program has established key resources to inform policy and market design and is currently investing in activities that will make these resources more available and more useful. Likewise, the microgrid program is investing in approaches to microgrid resilience valuation that can inform a more consistent estimation and allocation of microgrid costs across the beneficiaries. This valuation methodology, and the engagement with active microgrid business development strategies that will follow, can address some of the lingering challenges in microgrid deployment to ensure that regulatory processes are prepared to enable the best infrastructure approaches in years to come.

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