NARUC
National Association of Regulatory Utility Commissioners

NASEO
National Association of State Energy Officials

EXECUTIVE SUMMARY

User Objectives and Design Approaches for Microgrids: Options for Delivering Reliability and Resilience, Clean Energy, Energy Savings, and Other Priorities

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In fall 2019, the National Association of Regulatory Utility Commissioners (NARUC) and the National Association of State Energy Officials (NASEO) initiated a joint Microgrids State Working Group (MSWG), funded by the U.S. Department of Energy (DOE) Office of Electricity (OE). The MSWG aimed to bring together NARUC and NASEO members to explore the capabilities, costs, and benefits of microgrids; discuss barriers to microgrid development; and develop strategies to plan, finance, and deploy microgrids to improve resilience.

Based on member input, the MSWG developed two companion briefing papers to answer key questions about microgrids: (1) User Objectives and Design Approaches for Microgrids: Options for Delivering Reliability and Resilience, Clean Energy, Energy Savings, and Other Priorities and (2) Private Sector, State, and Federal Funding and Financing Options to Enable Resilient, Affordable, and Clean Microgrids. Read together, these resources provide readers with an understanding of both why and how customers—whether an investor-owned, cooperative, or municipal utility; federal, state, or local government entity; individual or group of residential, commercial, and/or industrial customers; or other organization—select, design, and pay for microgrid projects.

Microgrids are both a compelling and challenging investment for potential customers seeking solutions to energy supply issues. DOE's Microgrid Exchange Group offers a helpful definition: "[A microgrid is] a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode." As a highly customized solution requiring significant study and expertise, customers need to fully analyze the design and operation of a microgrid prior to development.

A microgrid involves four distinct components:

1. **Load(s):** The consumer(s) of electricity. Load can be designated as critical, high-priority, or low-priority. Critical load is uninterruptible, meaning that any disruption of electric service, regardless of duration, is highly costly or may impact human life and safety.
2. **Distributed energy resources (DERs):** The supply of electricity. DERs are generation, storage, and load control (i.e., energy efficiency or demand response) technologies located at the distribution system. DERs can be powered by a range of fuels including diesel, natural gas, and solar power.
3. **Controls:** The management system of the microgrid. A microgrid controller performs multiple functions, including: (a) identifying when and how to connect and disconnect from the grid; (b) maintaining real and reactive power balance when the microgrid is disconnected and operating in islanded mode, and (c) dispatching DERs to support load.
4. **Interconnection/point of common coupling (PCC):** The point at which the microgrid connects to the distribution network. It is at this point that the microgrid controller connects and disconnects to the larger grid.

Customers choose to install microgrids based on a wide range of motivations, which often include increasing reliability and resilience, decreasing electricity costs, expanding access to clean energy, and/or providing power to remote communities (e.g., when extending the existing transmission/distribution grid is infeasible or too costly). Customer motivations are not mutually exclusive; in fact, customers often have multiple motivations for installing a microgrid, such as increasing renewable generation while improving reliability and resilience. This paper cites numerous examples of operational microgrids across the country that represent one or more of these objectives.

After the end user comes to an understanding of why a microgrid or other energy investment may be needed, there are four general steps to arrive at an operational microgrid:

1. Feasibility study;
2. Engineering, design, and business planning;
3. Construction; and
4. Operation.

While construction can occur very quickly, even in a matter of days, steps 1 and 2 require substantial time and data, as these stages entail the majority of a customer's decisions about the microgrid's design. Designating critical loads, generation source(s), interconnection to the larger grid, and control systems are key elements of these initial phases. Decisions around each element are heavily dependent on the characteristics of the customer, local distribution system, and area in which the potential microgrid is to be located, as well as the customer's overarching objectives and motivations for procuring a microgrid. This paper explores each of these motivations and discusses how each one impacts the design of a microgrid, offering multiple case studies of how each objective has translated into currently operational microgrid projects. Across all of these objectives, questions influencing key decision points include:

1. Designating critical loads and energy efficiency investment options, classifying loads across four tiers of prioritization and accounting for opportunities to reduce energy needs through pre-microgrid efficiency measures;

2. Considering a microgrid that connects to multiple facilities and/or across multiple meters and public rights-of-way, recognizing that multi-facility microgrids add complexity but may deliver additional benefits;

3. Selecting generation and storage resources, accounting for policies incentivizing renewable generation, combined heat and power, and biofuels; reliability of liquid/gaseous fuel delivery and availability of fuel storage; availability of wind and solar resources; and environmental considerations;

4. Considering cost drivers, including retail electricity rate structures, energy export prices, non-wires alternatives, and access to competitive energy services markets;

5. Selecting software, inverters, communication, and control systems, considering the impacts of systems on the microgrid's capabilities and overall costs; and

6. Exploring interconnection options and considering where and how to interconnect to the distribution grid in order to minimize added costs.

Using Lawrence Berkeley National Laboratory's Distributed Energy Resources Customer Adoption Model (DER-CAM), the paper next details how various customer objectives results in different design and operational choices. DER-CAM demonstrates that different objectives result in varying combinations of generation and storage resources and operational decisions for an optimal microgrid solution. To illustrate differences in design choices, the DER-CAM model shows that a hypothetical Florida hospital that is focused on reliability and resilience might focus on procuring a solar+storage microgrid with a combined cold storage and flow battery if it needs to be able to operate islanded for three weeks following a hurricane. In another example, the DER-CAM model offers a far more complex configuration for a California warehouse seeking to achieve electricity bill savings: a combination of solar PV, solar thermal, cold storage, controllable central heating capacity, and controllable central cooling capacity to offsets 60 percent of annual electricity purchases. DER-CAM also demonstrates how different objectives influence operational choices and electricity dispatch decisions. For example, a hypothetical Maryland school hosting a microgrid primarily to integrate clean energy resources will pursue a different dispatch strategy for its generation and storage resources than a California warehouse interested in using a microgrid to lower peak demand charges. In all cases modeled, customers continue to partially rely on the local distribution utility under normal conditions, but make use of on-site renewable generation, storage, controllable load, and other investment options to achieve distinct objectives and deliver savings and/or revenue from on-site generation and, where allowed, electricity exports.

The optimal solutions modeled above demonstrate the feasibility of customer-sited microgrids to achieve customer objectives—currently with payback periods of between 16 and 20 years. The length of payback period generally depends on four main factors: (1) current on-site energy consumption and spending, (2) level of energy generation from the microgrid, (3) capital cost of the microgrid, and (4) funding and/or financing arrangements. Customers installing microgrids are diverse and there is significant variation in financial arrangements, ownership and operational structures, and interaction between the microgrid and the local distribution utility, where a utility is present. Readers are encouraged to consult the companion paper, Private Sector, State, and Federal Funding and Financing Options to Enable Resilient, Affordable, and Clean Microgrids, for a more in-depth discussion of funding and financing approaches to microgrids.

Finally, this paper discusses the role of State Energy Offices and Public Utility Commissions in furthering the development of microgrids to satisfy customer and system needs, emphasizing the important role of these entities as conveners to facilitate productive collaboration among diverse stakeholders. Many of the regulatory and policy barriers to microgrid development are complex and have no one-size-fits-all solution. Uncertainty over the regulatory treatment of microgrids, risk of added costs and delays from interconnection queues, lack of valuation methodologies for the full range of benefits provided by microgrids, challenges associated with stakeholder communication and collaboration all present barriers to microgrids. Addressing these barriers will require cooperation not only between State Energy Offices and Public Utility Commissions, but also from regulated utilities, municipalities, microgrid adopters, and other stakeholders. Initial actions State Energy Offices and Public Utility Commissions could consider taking to navigate these obstacles include:

1. **Clarifying the regulatory treatment of microgrids** by developing state-specific definitions reflective of jurisdictional characteristics, needs, and challenges. Multi-customer microgrids are particularly hindered by regulatory uncertainty. Ensuring consistent regulatory treatment of microgrids will remove uncertainty and enable fair consideration of microgrids alongside other energy investments.

2. **Encourage the provision of transparent and current interconnection information** to facilitate timely, cost-effective interconnection for microgrid customers. Several states use pre-application reports to offer information to prospective applicants. States may consider other strategies to help streamline interconnection processes.

3. **Continue to discuss and advance methodologies to value the full range of benefits that microgrids can offer**, particularly regarding energy resilience. Many Public Utility Commissions and State Energy Offices are already considering definitions and valuation methodologies for resilience that more fully account for the impacts of interruptions in energy service, particularly those driven by high-impact, low-frequency events. These efforts are generally outcome-based and not specific to any type of energy resource, which supports a more robust cost-benefit analysis process that will reflect more of the benefits provided by microgrids and other resilience investment options.

4. **Facilitate productive engagement between microgrid adopters and community/stakeholder groups** to identify opportunities for microgrids to provide greater energy, socioeconomic, and/or environmental benefits to both connected customers and the surrounding community. Customers and states have supported numerous examples of microgrids providing a higher level of benefits when multiple parties are involved in development.

The MSWG does not seek to offer prescriptive recommendations State Energy Offices and Public Utility Commissions. Many of the regulatory and policy barriers to microgrid development are complex and have no one-size-fits-all solution. Rather, this paper seeks to (1) illuminate microgrid adopter needs and challenges so that State Energy Offices and Public Utility Commissions can acquire a more complete understanding of barriers to microgrid adoption and (2) highlight successful approaches to problem-solving that can be considered for replication or modification in other jurisdictions. The MSWG will continue to develop additional resources to support these efforts and enable State Energy Offices and Public Utility Commissions to more effectively speed the deployment of microgrids throughout the states, including through sharing challenges faced and lessons learned as states pursue various strategies to address barriers to development.