Think Microgrid

TAXONOMY BRIEF 2024

INTRODUCTION

As our energy systems transform dramatically, microgrids have a unique role to play. According to a policy vision presented by the U.S. Department of Energy, by 2035, microgrids will be the core building block of an electric grid where 30-50% of electricity generation could come from the distributed energy resource at the edge of the grid. In this vision, microgrids will nimbly and flexibly meet local energy and respond to conditions on the larger grid.

As communities and consumers seek solutions for resilience, climate and equity challenges, the combination of advanced technology and market interest provide the opportunity for the widespread commercialization of microgrids. This opportunity exists across a wide range of scales, from the largest industrial facilities to individual homes, and across a wide range of applications, from long-duration resilience to simpler clean energy and energy management goals. However, despite the promise of microgrids, policy and market barriers have limited the diversity and scale of microgrid deployment. This dynamic, in turn, is preventing private and public capital that is eager to invest in these solutions from being deployed into microgrids.

WHAT IS A "MICROGRID"?

As noted, microgrids come in a wide range of sizes and configurations. At their core, microgrids are intelligent aggregations of distributed energy resources (DERs) that can be coordinated to meet customer needs directly while also supporting the operation of the larger grid as a single flexible and controllable entity. And while some configurations operate entirely as independent "minigrids" (for example, powering islands or remote villages), Think Microgrid is focuses primarily on grid-connected microgrids.

There are three defining characteristics of a microgrid:

1. INTERCONNECTED

Microgrids represent a set of physically interconnected resources within a defined geography. Microgrids are interconnected to the larger grid at an identifiable point of common coupling that is the interface between the grid operator and the customer.

2. INTELLIGENT

Microgrids have intelligent control systems that allow them to flexibly optimize their energy demands and production. This intelligence allows the microgrid's component technologies to communicate flexibly and interactively with each other, responding to changes in internal data flows and the external grid and aligning its behavior accordingly. These capabilities distinguish microgrids from backup power systems that are only designed to operate when the larger grid fails.

3. INDEPENDENT

Microgrids can seamlessly and gracefully connect to and disconnect from the larger electric grid at its point of interconnection in response to internal and external signals. This capability allows microgrids to provide resilience during network outages, price volatility, or other "black sky" days that have grid disruptions while being able to operate as flexible distributed energy and provide grid services under "blue sky" conditions and normal operations.

When the grid fails, microgrids can seamlessly initiate island mode and supply electricity directly to critical loads or entire communities. During normal grid operations or grid-connected mode, microgrids can flexibly export power to the grid or reduce customer loads in response to real-time operational needs or grid conditions. The dual operational capability of microgrids allows them to support both local energy needs and the entire grid system.

Figure 1: Microgrid in Grid-Connected Mode

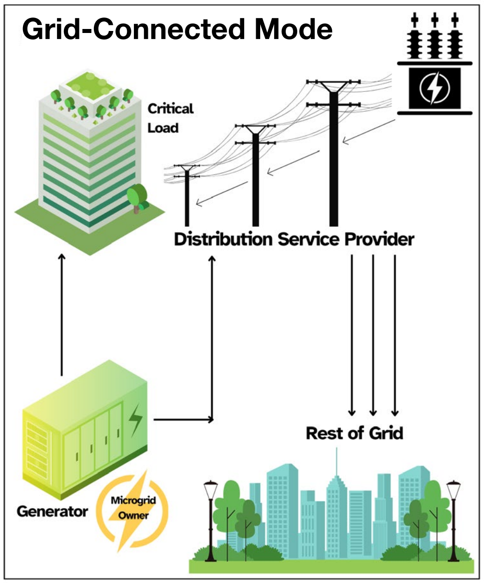
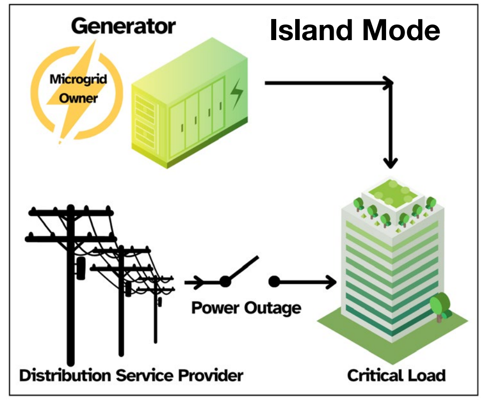


Figure 2: Island Mode



WHY A "TAXONOMY"?

There is an oft-repeated joke that, "If you've seen one microgrid...you've seen one microgrid." This joke contains some truth: many aspects of microgrid design are customized to specific customer needs, providing "turnkey" solutions for that customer. There is no one-size-fits-all model for microgrids, and individual projects have unique characteristics and serve unique needs. Microgrid advocates are correct to highlight adaptability as one of the most impressive qualities of microgrids.

That said, reaching 8.6 GW of installed capacity in 2023, the evolving microgrid market is simultaneously diversifying and standardizing. In other words, while public policy and customer demand are driving increasingly diverse projects, many developers are responding to customer needs with standard, replicable solutions that help scale operations and reduce commissioning timelines.

Think Microgrid has developed this taxonomy as a tool for policy makers and community leaders to identify and distinguish project characteristics. Think Microgrid uses three key attributes – size, ownership and total customers – to organize projects into distinct microgrid "families". This structure helps identify the attributes that are common and variable across the wide range of individual and unique microgrids.

Applying the taxonomy to the microgrid landscape today makes clear that many microgrid families are flourishing while others face existential barriers. This is particularly true for community and multi-customer microgrids, a market segment that is currently stifled by state policies and largely unrealized. If we believe – as the Department of Energy has suggested – that the nation will benefit from the ubiquitous deployment of microgrids and distributed energy, we are going to need all kinds of microgrids and a diverse ecosystem of ratepayer, public and private investment capital. This taxonomy is designed not only to classify microgrids that have been deployed, but also to clearly highlight the technical, policy and market challenges facing microgrids today. Improved visibility and common language will promote open and informed discussions and strategies to align public policy, funding incentives and capital markets.

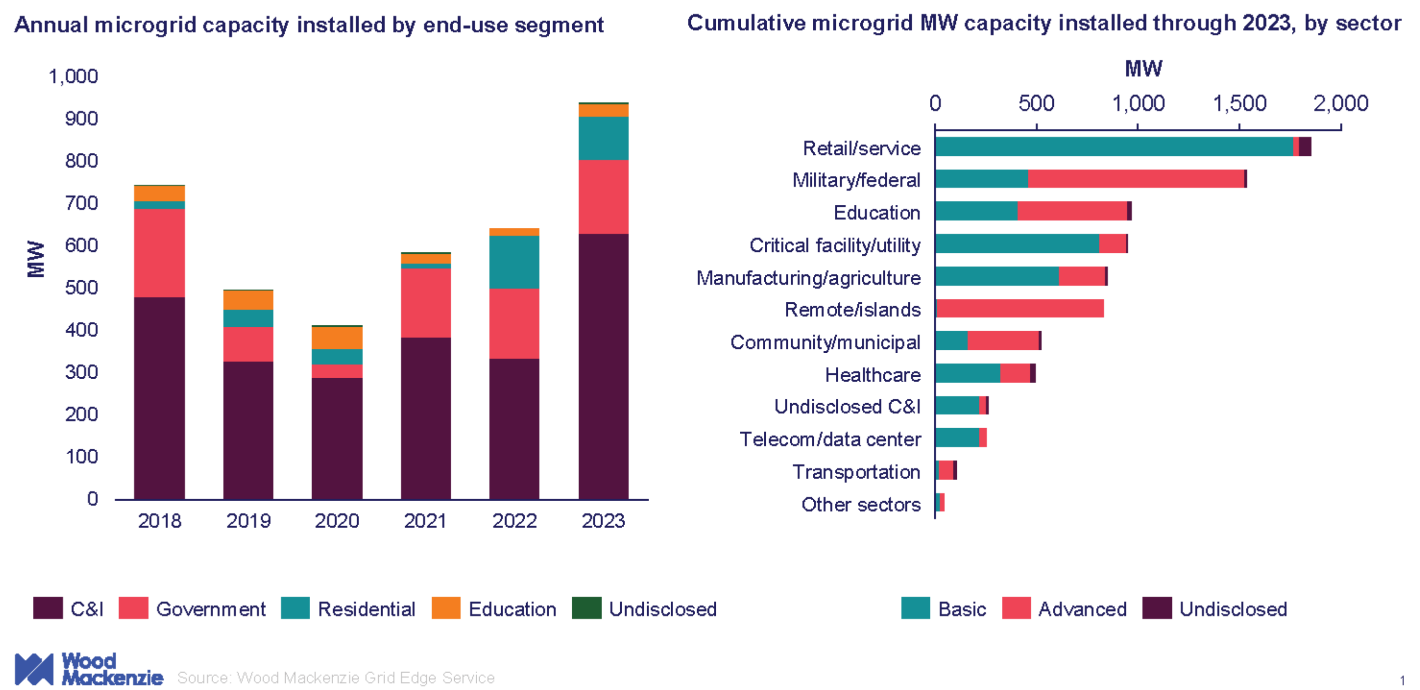
MICROGRID MARKET TODAY AND TOMORROW

Where does the microgrid market stand today and what trends can we anticipate? Think Microgrid is partnered with Wood Mackenzie, the leading research firm maintaining up-to-date market analytics and a comprehensive database of microgrids, to help answer these questions.

Microgrid deployment today is at an inflection point. Over the last several years, the vast majority of microgrids have been deployed by commercial and industrial (C&I) customers, often diesel or natural gas generators that can provide resilience in the face of long-time grid outages. In certain jurisdictions, these projects meet supportive policy environments and can participate directly in wholesale energy and services markets. However, more complex projects, such as those that integrate clean distributed energy and serve multiple customers, are often limited to utility pilot programs or specialized publicly funded projects. In these cases, policy and market barriers limit the opportunity of private and public capital investments to create more robust and large-scale markets for beneficial microgrids.

The data assembled by Wood Mackenzie about microgrids deployed today illustrates that the C&I market segment remains dominant. In parallel, microgrid deployment in the residential sector is growing and customers in the public sector (such as public school districts) are demonstrating an increasing demand for advanced microgrid configurations that include resilience and clean energy.

Figure 3: Wood Mackenzie Microgrid Market Analysis



This dataset prompts an important question: what policy and market factors have allowed for a flourishing market for basic C&I projects and a more limited market for advanced residential and community projects? Some simple explanations would be that C&I projects have demonstrated profitability as dispatchable generation in certain wholesale markets, while franchise or right-of-way laws prevent private companies to independently own and operate multi-customer microgrids in nearly all states.

MICROGRID TAXONOMY

Think Microgrid uses three fundamental characteristics to organize microgrids into identifiable families that share common attributes and, often, face similar policy and market hurdles. The defining characteristics include:

1. GRID INTERCONNECTION

Where on the transmission or distribution grid is the microgrid interconnected? This attribute deals with the voltage level of the wires to which a microgrid is interconnected. Large projects can be connected to the transmission system (generally at 70 kV or above) or high-voltage portions of the distribution system (35-69 kV sub-transmission lines that feed substations). Often, these large projects support grid operations are connected directly to heavy industrial customers. More commonly, microgrids are interconnected to the "primary" lines of the distribution system (1-35 kV) typically serving significant load-intensive applications, such as civic infrastructure, campuses or industrial facilities or "secondary" distribution lines (<1 kV), serving commercial and residential customers.

2. CUSTOMERS

Does the microgrid serve a single customer or multiple customers? While there are many types of end-users that find value from microgrids, this attribute distinguishes whether a project serves a single or multiple electric meters. Single-customer microgrids serve an independent entity active either at a one facility or across a campus interconnected to the grid at a point of common coupling. Multi-customer microgrids serve several customers crossing property rights-of-way, for example retail shops across a business district or public and private institutions across a neighborhood.

3. OWNERSHIP

Who owns and operates the microgrid? Recognizing that microgrid projects may involve nuanced partnerships with various actors involved in financing, development, and operation, we distinguish between three broad classes of microgrid owners. The first is utility ownership, wherein a distribution utility (investor-owned, municipal, or cooperative) utilizes some combination of ratepayer, shareholder, or public funding (e.g., grants and incentives) to capitalize the development of a microgrid. These projects may involve utility partnerships with private developers or public entities (e.g., counties, municipalities) to manage aspects of the project. The second class includes ownership by public agencies or authorities, such as counties, municipalities, tribes, government agencies and military. The third class includes the private projects owned by private developers, independent customers, households and private campuses, such as universities and corporations.

INTERCONNECTION

Where on the electric system is the microgrid interconnected?

CUSTOMERS

Does the microgrid serve one or multiple customers?

OWNERSHIP

Is the microgrid owned by a utility, public agency or private entity?

These three categories are the foundation of the taxonomy below, which is designed to be inclusive and mutually exclusive of any project across the landscape. The 18 combinations of these characteristics, reflected in the 'ownership' column, reflect microgrid "families" further illustrated in the "Representative Projects" table.

Figure 4: Microgrid Taxonomy

INTERCONNECTION (VOLTAGE)	CUSTOMERS SERVED	OWNERSHIP
High Voltage	Single Customer	Utility
		Public
		Private
	Multi-Customer	Utility
		Public
		Private
Primary	Single Customer	Utility
		Public
		Private
	Multi-Customer	Utility
		Public
		Private
Secondary	Single Customer	Utility
		Public
		Private
	Multi-Customer	Utility
		Public
		Private

MICROGRID APPLICATIONS

Regardless of size and configuration, microgrids can provide a wide range of benefits and services. In this regard, the taxonomic "family" describes the "what" of the microgrid while how that microgrid is used describes the "how" and the "why". These characteristics can be articulated as project goals, configuration, and use case.

In general, there are three fundamental goals that drive microgrid deployment, although often for a given project one is more prominent and identifiable. Most microgrids today incorporate some element of each value. Project goals are especially relevant when microgrids are supported by public policy, which often deploys grants, loans, or other incentives conditionally based on a project's ability to realize the outcomes to the right.

The three main drivers include:

1. ECONOMIC

Microgrids provide direct energy production and flexibility, which can be used to harness low-cost energy (such as solar), manage utility rate programs (such as demand charge reduction) or provide long-term price stability. In many cases, microgrids can provide power where utility service is unavailable or inadequate (such as electric vehicle charging facilities). In the same way that many prefer to own rather than rent critical assets, microgrids allow customer to take agency of their energy needs by investing in high-quality energy systems that are suited to their unique needs.

2. RESILIENCE

Microgrids can provide resilience that centralized resources cannot. If the grid system fails, only directly connected microgrids can provide backup power. Microgrids provide sophisticated solutions that allow critical loads to continue operation in the face of grid failures and instabilities. This can include both short-term resilience (for example, several hours of battery capacity) or long-term resilience (such as on-site generation). In this respect, resilience solutions can be designed for the specific needs of individual customers, businesses or critical facilities that serve broader public purposes (such as emergency facilities).

3. CLEAN ENERGY

Microgrids are often designed to optimize local energy resources or harness clean energy from solar, wind and other renewable energy sources. These clean energy resources help support corporate sustainability objectives or community environmental goals. When connected with other resources, such as electric vehicles, these microgrids can also be an important component of broader public policy programs.

While there remains a broad range of specific applications or market segments, most microgrid projects can be organized into several broad use case categories, each of which has a diverse range of subsegments within them.

Think Microgrid identifies six core use cases:

INFRASTRUCTURE. Load-intensive civic infrastructure including wastewater treatment plants, irrigation facilities, waste facilities, ports and transportation centers, military bases.

INDUSTRIAL. Load-intensive industrial facilities including manufacturing facilities, data and telecommunications centers, agriculture, and energy production.

UTILITY. Utility facilities including substations, control centers, remote loads (non-wires alternatives).

CIVIC SERVICES. Buildings and/or campuses providing civic or critical services, such as police and fire stations, community centers, libraries, prisons, and emergency response centers.

COMMERCIAL. Commercial buildings and/or campuses including retail stores, shopping centers, offices, religious centers, hospitals, airports, and schools and universities.

RESIDENTIAL. Residential neighborhoods and residential infrastructure, such as parks and transportation hubs.

As noted earlier, there are also independent microgrids (or "minigrids") that serve remote customers that are not connected to a larger distribution grid (such as isolated villages or islands). Additionally, there are also mobile microgrids that can be deployed in temporary and emergency settings. Both of these uses cases are beyond the scope of this taxonomy and the focus of Think Microgrid.

We hope that this taxonomy provides a common framework and terminology that supports a core objective of Think Microgrid – allowing industry leaders to engage in productive conversations about how to create opportunities that align public policy, market dynamics and advanced technology in order to find resilience, climate and equity solutions enabled by microgrids.

REPRESENTATIVE PROJECTS

PROJECT	STATE	LOCATION	COMMISSIONING	FAMILY	USE CASE	RESOURCES	INCENTIVES
Cuyahoga Green Energy	OH	Cuyahoga County	Development	High-Multiple-Public	Multiple - Community	Solar, storage	$1.9M DOE grant
Atlantic City Microgrid	NJ	Atlantic City	2022	High-Multiple-Public	Multiple - Community	Gas	$1.1M NJ BPU TCDER grant
SDG&E Remote Operable	CA	San Diego	2024	High-Multiple-Utility	Multiple - Community	Solar, storage	
BHE Business District	WV	Ravenwood	Development	High-Single-Private	Industrial	Solar, storage	
Asheville Substation	NC	Shiloh	2020	High-Single-Utility	Substation	Storage	
Bronzeville Community Microgrid	IL	Chicago	2022	Primary-Multiple-Utility	Multiple - Community	Gas, solar, storage	$5M DOE grants
Redwood Gate Ranch	CA	Jenner	2022	Primary-Multiple-Public	Infrastructure	Solar, storage, EV charging load flexibility	$5M CEC EPIC grant, $6M USDA loan
Babcock Ranch	FL	Babcock Ranch	2020	Primary-Multiple-Private	Residential	Solar, storage	
Marine Corps Air Station Yuma	CA	Yuma	2016	Primary-Single-Utility	Infrastructure	Gas	
Soboba Casino & Resort	CA	Riverside County	Development	Primary-Single-Public	Commercial	Solar, storage	CA PUC SGIP grant, federal Direct Pay ITC
Boston One Campus	MA	Andover	2017	Primary-Single-Private	Commercial	Gas, solar	
Town of Fairfield	CT	Fairfield	2013	Primary-Multiple-Public	Multiple - Community	Gas, solar	$1.1M DEEP grant
Heron's Nest	NC	Shallotte	2018	Secondary-Multiple-Private	Residential	Solar, storage	$6.65M DOE grant
Mt. Sterling	NC	Mt. Sterling	2019	Secondary-Single-Utility	Utility	Solar, storage	
Northside Aztlan Community Center	CO	Fort Collins	2023	Secondary-Single-Public	Civic Services	Solar, storage	$200,000 DOLA grant
Shalom Mennonite Fellowship	AZ	Tucson	2023	Secondary-Single-Private	Commercial	Solar, storage	
Isle au Haut	ME	Isle au Haut	2021	Remote-Multiple-Public	Multiple - Community	Solar, storage	$211,000 USDA grant, $1M USDA loan
Delta Health Center	MS	Rolling Fork	2023	Mobile-Single-Private	Civic Services	Solar, storage	