

Is a Microgrid Right for You?



Part 1 of 3



Microgrids ARE BECOMING MORE AND MORE PREVALENT FOR GOOD REASON:

they are a modern approach to solving multiple energy challenges. But a microgrid's unique nature can trip up even the most advanced engineers and utility staff.

This handbook is designed to help determine whether a microgrid is the best solution for you and to prepare your team if you decide to pursue building one.

At a different stage in your microgrid project?

Look at these options for more tools and recommendations:

-How to Build a Microgrid (Part 2 of 3)

-The Short- and Long-term Care of your Microgrid (Part 3 of 3)

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What Problems are You Trying to Solve?

Outages cost you and your customers money.

CUSTOMER SATISFACTION — In this digital age, people expect to be connected at all times, and even short outages are increasingly unacceptable.

DESTRUCTIVE WEATHER — Weather is an unpredictable challenge, and natural disasters can cause massive damage. Technologies exist that harden the grid and improve resiliency.

GEOGRAPHICAL CHALLENGES — Topology, such as mountains or forests, can make it difficult or expensive to deliver reliable power.

New technologies and emerging social concerns are causing industry disruption.

GRID DEFECTION — Some customers, especially in the commercial/industrial sector, have opted to generate their own power to lower costs and control reliability, using the electric grid instead as backup power.

CARBON-EMISSIONS REDUCTION — There's increasing pressure to reduce harmful gases and use renewables in lieu of fossil-based generation.

DISTRIBUTION-PLANNING CHANGES — Strategies for grid modernization are moving from centralized generation to de-centralized approaches.

NEW GENERATION TECHNOLOGIES AND FUEL SOURCES — Existing 50-year power-generation plans don't account for the fact that coal and nuclear plants are rapidly being replaced with renewable energy and natural gas generation. Adjusting to new fuel mixes means strategies must change.

The existing infrastructure isn't designed for rapid change, and upgrades require significant capital.

CHANGING CUSTOMER-USAGE PATTERNS — The grid was originally designed when customers were strictly power users. It's not well structured to handle new ways customers participate in the electricity market, such as electric vehicles, time-of-day pricing, and distributed generation.

GENERATION CLOSER TO LOADS — Power generation used to be centralized and flow toward the edge of the grid, but now power flows bi-directionally from generation sources located throughout the grid.

AGING INFRASTRUCTURE — Many parts of the grid are straining at capacity and require upgrades or replacements. Utilities are looking for ways to prolong the life of these assets and defer their replacement costs.



Utility Analysis: Trends and Common Challenges

97%

of utilities believe their business model needs to change.

74%

of utilities report seeing minimum or stagnant load growth in their territory.

32%

of utilities say their single greatest challenge from their changing power mix is reliably integrating variable renewables and distributed resources.

16%

of utilities report that load defection is among their top three challenges.

37%

of utilities say renewables integration is among their top three challenges.

38%

of utilities say aging infrastructure is among their top three challenges.

Source: 2016 State of the Electric Utility Survey

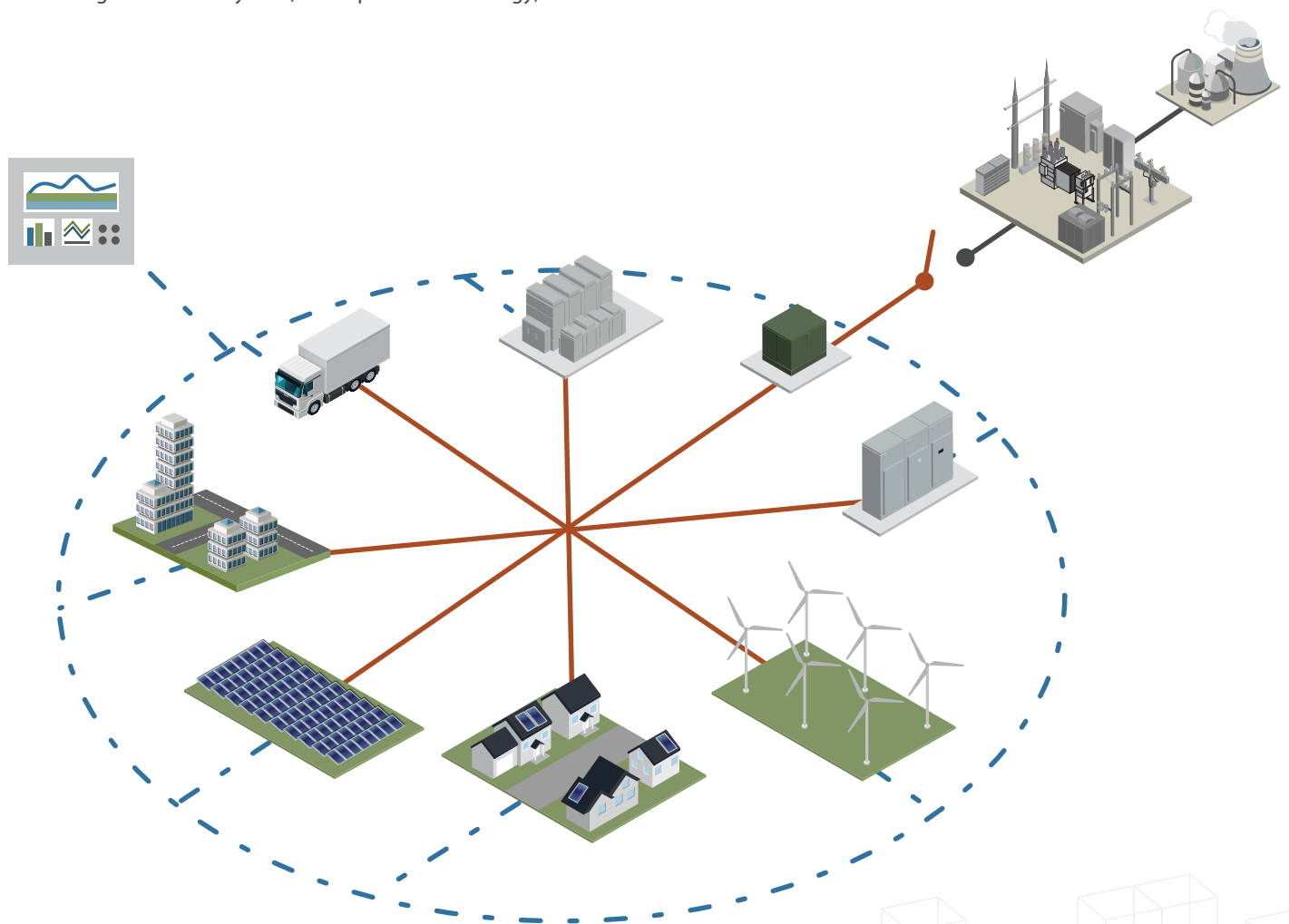
Pros and Cons of Possible Solutions

SOLUTION	PROS	CONS
Do nothing	Zero cost today	Expensive in the long run because problems grow and still cause outages
Re-engineer and re-build existing infrastructure	Get exactly what you want for exactly what you need	Extremely expensive and time-consuming; may interrupt power to local customers frequently during construction
Large capacitors and flywheels	Buffers or balances surges of load	Expensive; provides only a few seconds of back-up power
Peaker plant	Small, local option that only needs to fire up when load exceeds primary generation or when a desired net import level is reached	Expensive; can't be scaled over time to meet changing needs and contributes to carbon emissions
Microgrid	Scalable, field-proven solution that can be sized to your needs and incorporate renewable generation sources; ensures power reliability, reacts immediately and automatically when there's an issue, and can offer multiple economic advantages	Expensive; complex system may require more time to engineer and install than other solutions

What is a Microgrid?

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 a grid-connected or island mode.

— Microgrids at Berkeley Lab (U.S. Department of Energy)



The Growing Microgrid Market



26%

**of microgrid
capacity from
renewable
generation
by 2020**

2,855

**MW
operational
microgrid
capacity
by 2020**

350%

**increase in
the number
of installed
microgrids
from 2015
to 2020**

\$3.5B

**of microgrid
market value
by 2020**

These figures are based on microgrids in North America.

Greentech Media: U.S. Microgrid Capacity Will More Than Double by 2020—and Include a Lot More Renewables

Greentech Media: North American Microgrids 2015: Advancing Beyond Local Energy Optimization

Microgrids and You

19%

of utilities are pursuing offering microgrids-as-a-service to customers.

12%

of utilities are most invested in microgrids in comparison to other technologies.

34%

of utilities believe they should invest more in microgrids.

91%

of utilities expect both distributed generation and utility-scale solar to increase in their future fuel mixes.

60%

of utilities believe partnering with third-party providers is the best way to build a business model around distributed energy resources.

These figures are based on the responses of more than 500 electric utility executives in the United States.
Source: 2016 State of the Electric Utility Survey



What are the Benefits and Use Cases of Microgrids?



Renewable Integration

Incorporates renewables and smooths variable generation



Black Start

Initiate power and sync frequency for generation sources



Islanding

Operate independently from the grid



Retail Energy Time-Shifting

Sell energy at the retail rate versus the wholesale price



Peak Shaving

Reduce the highest level of energy consumption



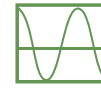
Voltage/Var Support*

Maintain consistent voltage by varying reactive power



Spinning Reserve

Provide energy to cover in case of primary generation loss



Power Quality

Protect loads from momentary events such as power interruptions and voltage sags and swells



Energy Time Shifting**

Save when cost of energy is low and use when costs are high



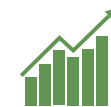
Local Capacity

Provide energy, typically in constrained areas of the grid



Power Reliability

Support loads when the grid loses power



Optimal Power Flow

Continuously match generation to the load



Frequency Regulation

Balance grid frequency by supplying either load or generation



Distribution Deferral

Postpone investments in distribution assets



Frequency Response

Balance frequency quickly after a sudden change of power consumption or generation



Economic Optimization

Perform optimal dispatch of generation sources in both grid-connected and islanded modes

*Optimized with energy storage

**Requires energy storage

Are Microgrids Worth the Investment?

What's the value of a microgrid? If only coming to a definitive answer were easy. Placing a value on microgrids is challenging because there's no simple formula that can capture every microgrid. Each location has unique problems a microgrid can help solve, and microgrids can be designed in different ways to deliver a unique set of grid services.

The intelligence and reliability of microgrids can solve multiple problems and pain points. Many of these benefits are quantifiable, but others—such as resiliency in the face of rare but catastrophic events—are particularly difficult to predict in terms of dollars and cents.

The first step to determine your microgrid's value is to be certain you're not isolating variables. Start by taking a holistic assessment of your microgrid through these three perspectives:

A COMPARISON TO YOUR ALTERNATIVES

You likely aren't building a microgrid simply because they're trending in the industry. You probably have practical problems you would like to resolve that need addressing sooner or later.

Because you're considering other solutions, the cost of a microgrid can't be compared to \$0 investment.

QUESTIONS TO CONSIDER:

- What would be the cost of repairing ongoing problems we didn't solve?
- What would we have to buy or build instead?
- How much would it cost to buy or build the alternatives?
- Would these alternatives solve our problems as effectively as a microgrid would?

THE LONG-TERM PICTURE

One reason microgrids and the equipment within them carry high price tags is that they're built to operate for several decades and adapt to future change.

The costs you're considering now are more accurately looked at as if they're spread over the lifetime of your project, which averages 20 years.

QUESTIONS TO CONSIDER:

- Are my costs of delivering reliable power likely to go up and by how much?
- How will the costs of infrastructure upgrades and maintenance change in the upcoming years?
- How will my problems get worse in a few years, and how much damage and cost would result from them?
- How will energy use within our microgrid's boundaries grow and change over time?

A SUM OF VALUE STREAMS

Because the value of a microgrid comes from multiple sources, all of these value streams must be understood, quantified, and added up for each individual project.

Some can be determined through simple calculations, but the value assessment of avoiding low-probability catastrophic events are less straightforward.

QUESTIONS TO CONSIDER:

- What's the average frequency and duration on our system when we experience an outage?
- How much do our reliability metrics need to improve?
- What is the combined value of all value streams, cost savings, risk management, and our avoided headaches?



WHAT'S YOUR MICROGRID'S VALUE STACK?

Some microgrid value streams are easily calculated and some are more difficult to quantify. Despite the challenges in placing a defined value on a microgrid, no project can move forward without some attempt to explain what it's worth.

Start by thinking about the risks posed to your system or company. Evaluate each value stream, and place an X in the priority level column that matches how greatly these factors affect you. Your highest priorities are your value stack, which is helpful in motivating others within your company to support the idea of a microgrid and in discussing with your integrator how your microgrid should meet these priorities.

Value Stream Categories	Microgrid Value Streams	Factors to Assess This	Low Priority	Medium Priority	High Priority
FINANCIAL (direct financial savings or additional revenue streams)	INFRASTRUCTURE DEFERMENT — Instead of investing in new infrastructure to meet increasing load, such as installing lines to reach demanding areas on your grid, microgrids can localize how you solve peak load problems.	Cost of infrastructure you would have had to build instead			
	GRID SERVICES — Depending on your state's regulations, you may be able to participate in grid-service markets, such as frequency regulation, that allow you to sell power to the grid.	Estimates of additional revenue via the new value streams a microgrid opens for you			
RELIABILITY (everyday system and power quality improvements)	SAIDI/SAIFI IMPROVEMENT — Microgrids' reliability means improved metrics for you. Microgrids can be placed in areas on your system that are particularly troublesome or difficult to maintain.	Your metrics now compared to goals or regulations to improve them—and penalties avoided for not meeting them			
	POWER FACTOR CORRECTION — As loads change on the grid, so does the amount of reactive current required to keep them running. A microgrid with energy storage can provide power factor correction.	Costs saved from installing capacitor or reactor banks			
	VOLT/VAR SUPPORT — Especially at the edge of the grid, microgrids can help you manage voltage levels and reactive power.	Costs saved from investing in other solutions and reducing system losses			
	DEMAND RESPONSE — When demand on your system is high, you can use excess power from your microgrid to lower the demand in other parts of the grid.	Shortcomings of your current demand response strategy, which may be shedding load			
RESILIENCY (islanding benefits and response when the grid loses power)	CRITICAL INFRASTRUCTURE PROTECTION — Some buildings that can't afford to lose power, such as police or fire stations. Microgrid islanding can keep these places' lights on even when the grid goes down.	Mitigated damage or chaos that might ensue if critical infrastructures loses power			
	SPINNING RESERVE — The generation sources within a microgrid can provide extra power when needed to eliminate standby generation units that are only used in emergency situations.	Cost of having needed a generator always available for this overload situation			
	BLACK START — Multiple generation resources within the microgrid allow the system to start on its own without the grid.	Cost of having needed a generator available during this emergencies			
	EMERGENCY FREQUENCY RESPONSE — Using the microgrid's generation assets provide frequency support when in a time of need.	Costs saved from investing in other solutions used only a few times annually			
SAFETY (keeping crews out of harm's way)	CREW PROTECTION — Because microgrids keep power on within its parameters and help resolve power quality issues, particularly at the grid's edge, this means less time your crews are exposed to risky situations or on the road (especially long drives) in severe weather.	Better crew safety by keeping the power on, monitoring the microgrid remotely, or delaying an immediate need for crews to fix issues in severe weather			
CUSTOMER SERVICE (end-customer benefits and your brand reputation)	CUSTOMER-COST AVOIDANCE — Outages are costly and wreak havoc for your customers, especially for commercial/industrial customers for whom even a small outage can result in massive lost inventory, process disruption, damaged equipment, and opportunity costs.	Avoided cost of damage and delays, and potential grid defection from your highest paying customers			
	HIGH-PRIORITY CUSTOMERS — Some customers are more vocal or carry political weight. Microgrids can provide highly reliable power to more sensitive customers.	Managed complaints or backlash from particularly vocal or powerful customers and potential grid defection			
	BRAND/REPUTATION MANAGEMENT — Customer complaints can impact your brand and reputation, and if they have choices for power providers, may consider innovation as criterion. Microgrids position you as a cutting-edge company dedicated to delivering reliable power.	Backlash you may have endured from customers about sub-par reliability or loss of customer base who might choose alternatives			
	COMMUNITY COMMITMENT — Even for residents who aren't within the microgrid's boundaries, islanded buildings can provide a safe haven for the surrounding community in time of need.	Improved customer satisfaction based on how the microgrid can service the wider community			
SUSTAINABILITY (renewable optimization and growth)	RENEWABLES INTEGRATION — Renewables may help cut costs, but they can operate more efficiently and further lower your costs if a microgrid smooths variation in their generation.	Cost of power consumption and the smoothed production of renewable assets (contrasted to non-smoothed)			
	ENERGY EFFICIENCY — Microgrids allow you to move generation closer to loads, reducing line losses and enabling generation options, such as combined heat and power, that make for a cleaner system overall.	Facilitating company sustainability goals and improved customer satisfaction for integrating cleaner energy			



Who do You Need to Convince to Build a Microgrid?

CEO/STRATEGIC LEADERSHIP

- **Role:** Considers long-term strategies for the company and approves decisions in support of it
- **Motivation:** Increase shareholder and brand value, and cooperates with Public Utility Commission
- **Hesitation:** Are microgrids a risk because they're a new technology? Will they disrupt our business model? Would we be able to find a trustworthy microgrid partner?
- **Persuasion:** Your competition is building microgrids. A competitive utility is one that embraces newer technologies such as distributed generation and microgrids. Microgrid integrators with proven track records exist today.

CHIEF FINANCIAL OFFICER

- **Role:** Manages finances
- **Motivation:** Maximize revenue and minimizes expenses
- **Hesitation:** Will we be able to afford this? Is this investment too capital-intensive? Will the ROI justify the microgrid?
- **Persuasion:** Microgrids are a sum of value streams, an experienced microgrid integrator can help you determine your microgrid's value. Outside firms can help finance your microgrid, and some utilities are willing to incur a multi-year payment structure instead of investing all necessary capital up front.

FACILITIES/OPERATIONS/ PROCUREMENT MANAGERS

- **Role:** Maintain facilities and make sure they stay up and running
- **Motivation:** Maximize uptime
- **Hesitation:** Will the operation and maintenance costs be too high? Does a microgrid just mean more equipment that will break? Will our team have to learn new technology, and will they be able to understand this level of complexity?
- **Persuasion:** If you're experiencing a lot of outages, microgrids can make your life easier. Microgrids will allow you to defer distribution investments. A good microgrid partner will provide well-designed control software to make a microgrid easy to manage and will support you in the short and long term.

UTILITY DISTRIBUTION STANDARDS/ PROTECTION & CONTROLS MANAGERS

- **Role:** Engineer to protect the utility system
- **Motivation:** Keep the lights on
- **Hesitation:** Will microgrids and distributed generation interrupt power? Will microgrids break the distribution feeder and make matters worse?
- **Persuasion:** You may have standards for small-generation interconnections in place already that are likely applied differently, so you have a better idea of what to expect than you think. A good partner will be able to analyze your system, help solve problems, and reset protection schemes.

REGULATORS AT PUBLIC UTILITY COMMISSIONS

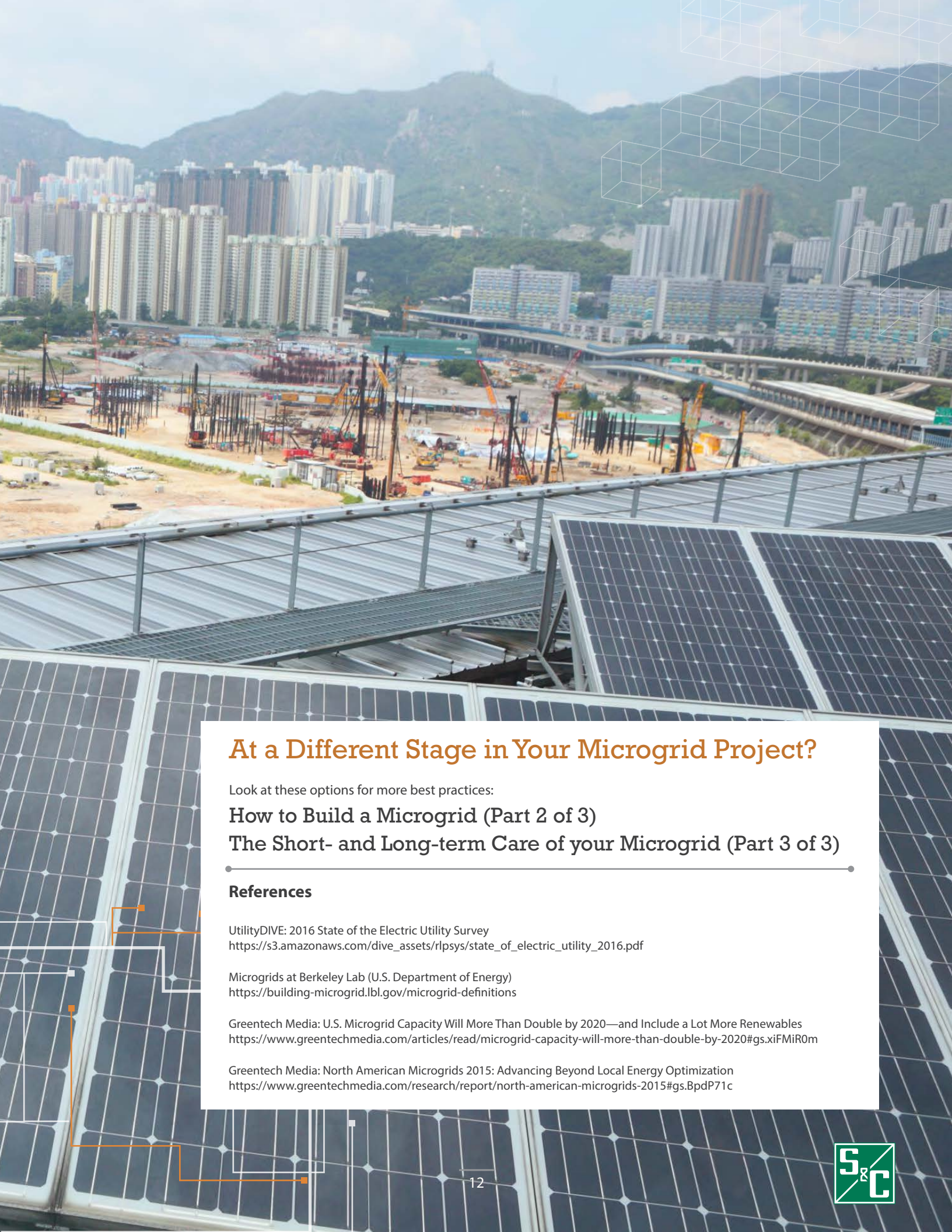
- **Role:** Supervise and control the utility and set rates
- **Motivation:** Protect the public
- **Hesitation:** What value does a microgrid bring? Is this in the public's best interest?
- **Persuasion:** Microgrids have multiple value streams and will allow capital deferral. The grid is already susceptible to outages, and distributed generation is affecting it. But microgrids allow better grid management and improve reliability for customers.

COMMUNITY STAKEHOLDERS

- **Role:** Neighbors and townspeople, the surrounding community, first responders
- **Motivation:** Look out for selves and community
- **Hesitation:** Will this disrupt power? Will it be an eyesore in the community or cause emissions? Will my utility bill go up?
- **Persuasion:** The microgrid will improve power reliability and resiliency—great for you and for attracting businesses to the community. Microgrids can be compact and often be added to existing substations or other utility sites. Depending on the microgrid's design, it can also allow more renewable generation.

Notes





At a Different Stage in Your Microgrid Project?

Look at these options for more best practices:

How to Build a Microgrid (Part 2 of 3)

The Short- and Long-term Care of your Microgrid (Part 3 of 3)

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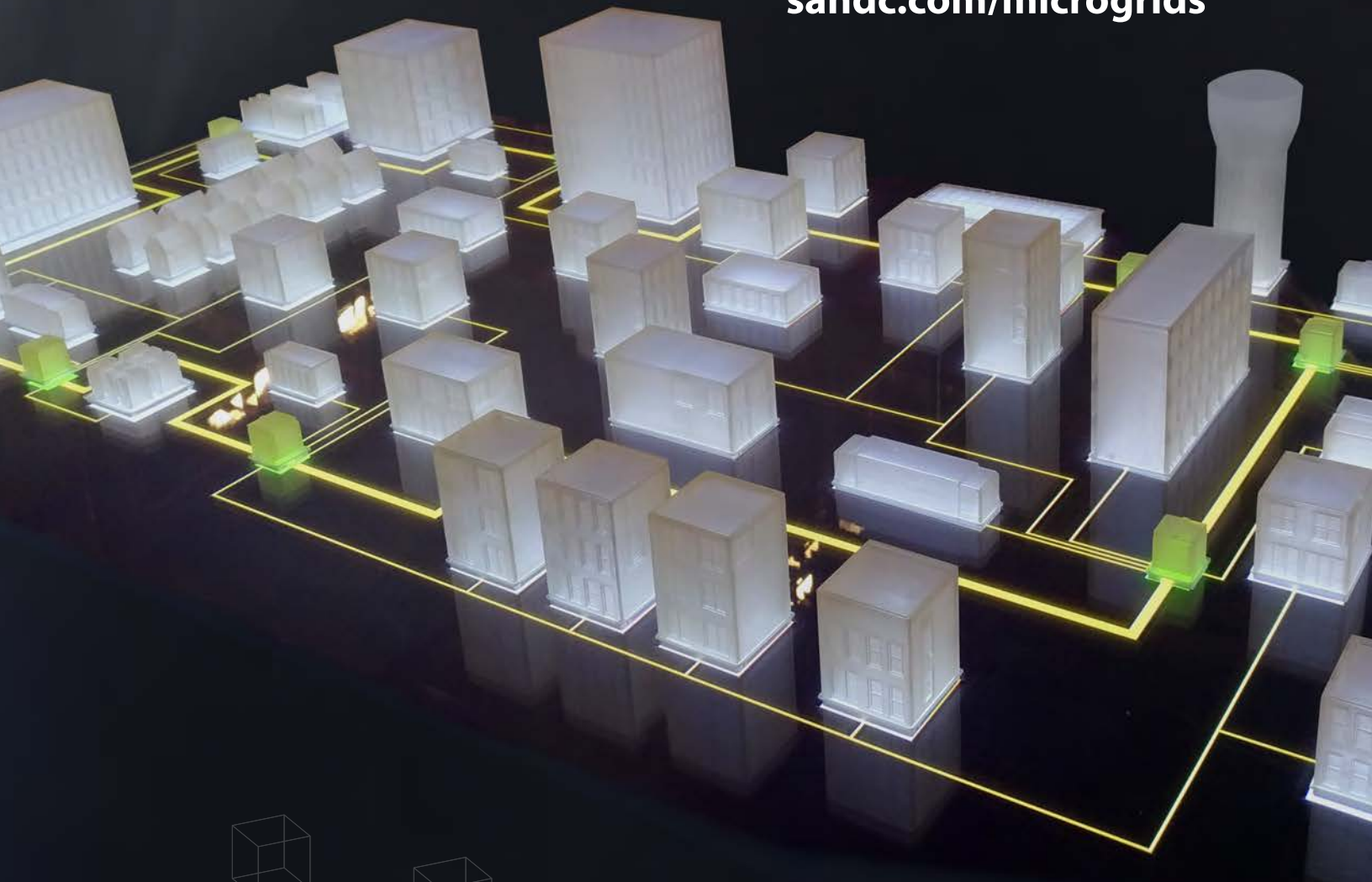
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Want Help Mastering Your Microgrid?

Connect with us at
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