MICROGRID KNOWLEDGE SPECIAL REPORT

5 Steps to Develop Microgrids Easier, Faster and at Less Cost

The Definitive Guide for Microgrid Developers

Princeton Microgrid Project

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Executive Summary

Microgrids continue to gain traction at health care facilities, universities and corporate campus settings, but that's just the tip of the iceberg for developers. An increasingly diverse mix of commercial and industrial customers with retail, office, entertainment, production and many other types of facilities are seeing the value of microgrids for their operations. Industry trends are expected to enhance the benefits of commercial microgrids and create a booming market in the years to come.

Microgrid developers require a playbook, a checklist of sorts, to navigate the process from serving the customer to vendor management and procurement to integration.

But as the market grows and diversifies, microgrid developers are suffering growing pains. Customer needs are shifting. Projects are becoming more diverse, with some requiring greater complexity while others need to fit a cheaper, more replicable template. New technologies are changing microgrid possibilities almost daily. An already patchwork mix of rules and regulations is shifting at different speeds and directions from market to market.

It's a landscape where even experienced developers can run into potholes, hurdles and brick walls in the form of unwelcome scope gaps discovered during the development process, cost overruns and project delays. The results are often unmet customer needs.

Microgrid developers require a playbook, a checklist of sorts, to navigate the process from serving the customer to vendor management and procurement to integration. This special report, prepared by Microgrid Knowledge in partnership with Siemens, offers a guide to avoid the pain points that can wreck the financial and operational assumptions for a project and turn a win-win into a lose-lose for developers and their customers.

Delivering on the promise of microgrids is a challenge

The market for commercial microgrids is forecast to grow rapidly in the coming years, creating a major business opportunity for both new and experienced microgrid developers. Commercial and industrial microgrids, once the smallest segment of microgrid development, has already grown to become the second largest market segment with 26% of global market share.[1]

[1] Lisa Cohn, "Industry Bullish on Future of Microgrid Market Over Next 10 Years," Microgrid Knowledge, November 18, 2020, https://microgridknowledge.com/industry-leaders-bullish-on-future-of-microgrid-market-over-next-10-years/

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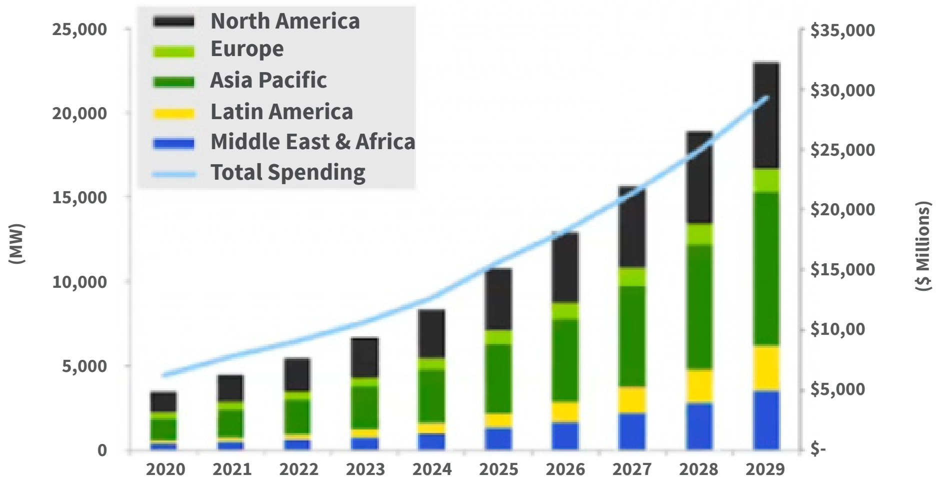
What does the future hold globally?

Microgrid DER Capacity and Revenue by Region, World Markets: 2020-2029



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As commercial and industrial customers increasingly consider microgrids for their operations, they do so with three primary goals: cost savings, resiliency and sustainability.

However, not all microgrid developers are prepared to deliver on those customer goals. They sound simple, but the list of challenges to achieve them can be long and complex. As a developer, you must be ready to:

- Set appropriate customer expectations for what their microgrid can deliver.
- Determine if financial assumptions are accurate.
- Explore ownership and operating models that are desirable for the project, such as an energy-as-a-service contract.
- Navigate jurisdictional regulations, permitting and requirements, including the relationship with the local utility.
- Manage vendors.
- Integrate systems and hardware into a smoothly operating microgrid that delivers everything promised to the customer.
- Plan for future changes to meet customers' changing needs.
- Fill gaps in expertise on the developer team as new technologies emerge.
- Find trusted partners to plan and execute increasingly complex projects.

If not properly managed, all of these challenges can cause costly planning and execution delays as well as unwelcome surprises in the form of scope gaps. These result in projects delivered late and over budget.

What is a scope gap?

A scope gap occurs when there is disconnect between two parties that leads to a different project outcome than the intended or desired outcome. Between the developer and vendors, these often emerge as gaps in understanding project expectations. Between the customer and developer, the gap often lies between what is promised and what is delivered. In all cases, scope gaps result from a lack of clarity around project goals and deliverables.

There are five steps every microgrid developer should take to avoid these headaches and develop a reputation for delivering on the promise of microgrids for customers.

Five steps to develop microgrids

1. **Understand project and operational requirements**
2. **Conduct studies that provide real, project-specific answers**
3. **Make the right procurement decisions**
4. **Manage balance-of-plant considerations**
5. **Smoothly integrate the system without scope gaps**

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Step 1: Understand project and operational requirements

Every new microgrid project starts with what the customer needs. Before a customer commits to a specific project scope, it's helpful to assess what's ahead with potential partners. However, this isn't always possible if a customer has already committed to a project design.

Depending on the stage of planning, there are two paths to leverage the power of partners to understand project and operational requirements based on what the customer needs. If the customer has not yet committed to a rough system design, developers should talk to a system provider to plan an optimal system for fewer surprises and issues down the road. If the scope of the project is already defined with the customer, developers should engage with system and equipment providers to identify key unknowns. It's not too late at this stage to close the planning gap and avoid surprises and costs later.

Potential unknowns

A microgrid that delivers everything a customer needs can sound simple on the surface when not all of the relevant considerations and obstacles are on the table. However, there are always important unknowns that, if not identified at this stage, can throw a project off track.

- **Time-of-use pricing:** If a customer's top priority is to reduce energy costs, it's critical to know if time-of-use pricing is available from or imposed by the local utility. This would create a need for an advanced microgrid controller that can respond to market pricing signals and optimize use of local generation sources versus grid power.
- **Energy supply rules:** A customer might assume the net energy metering policy or wholesale energy market participation rules in its state or territory will turn distributed energy resources (DERs) within its microgrid into revenue generators, but there could be restrictions on power exports to the grid that wreck those assumptions.
- **Tariff changes:** Comparing a customer's pre-microgrid energy bill to a hypothetical energy bill in which its operations are supported by a microgrid is far from an apples-to-apples exercise. Deploying a microgrid can result in significant tariff changes from the local utility that need to be understood during early planning.
- **Regulatory and policy changes and deadlines:** No one has a perfect crystal ball, but some regulatory changes are signaled earlier and more clearly than others. Sunsetting incentives might make it imperative to speed up development, while a new policy or regulation taking effect in the near future might be cause for a pause.

If the customer has not yet committed to a rough system design, developers should talk to a system provider to plan an optimal system for fewer surprises and issues down the road.

Commercial and industrial customers typically share the same three goals — cost savings, increased reliability and more sustainable operations. However, developers need to know how the customer prioritizes each. Customers should answer several questions so that the developer can work with vendors to better design a microgrid based on their priorities, including:

1. Does the customer want to make the most money possible and ensure the system pays for itself as quickly as possible?
2. Is the customer willing to tolerate a potential power outage if grid power fails or must the lights stay on through all circumstances and conditions?
3. How does the customer want to operate the microgrid control system — with someone on-site, someone remote or via automated switching?

Identifying unknowns and customer priorities are key ways to determine project and operational requirements that will impact the decisions developers make in each of the following steps regarding studies, procurement, balance of plant and system integration.

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Step 2: Conduct studies that provide real, project-specific answers

A power supply study for a microgrid project is an important part of the process. A penny of planning prevents a pound of cure. Such studies add to upfront costs but can prevent costly errors and additional development steps later on. However, not all studies are created equal, nor are study providers.

The right study

Before a study begins, great care should be taken to define the study scope, which should clearly identify output requirements and the associated conditions. This upfront work will ensure a study results in the right outputs that define a project's needs and requirements for design and interconnection.

The right study partner

Some projects involve highly technical considerations and requirements. Others are fairly straightforward. Developers need a study partner who understands what information a study should provide based on the complexity of the project as well as relevant regulations and local utility requirements.

Long Beach marina and shipping port

The consequences of a study that doesn't produce the right outputs can be fatal to a project. The Port of Long Beach in California sought a microgrid to help it reach its goal of zero-carbon emissions by 2030. The zero-carbon requirement led to a microgrid incorporating energy storage. However, planning studies for the project did not identify Southern California Edison's (SoCalEd) Rule 18, which prohibits the utility's customers from reselling electricity it provides from the grid. Because the microgrid's energy storage units were partially charged with SoCalEd electricity and sold to a private business at the port, the project was nearly killed and the city of Long Beach is now engaged in a lengthy regulatory battle.[2]

> **If a study's outputs don't clearly define key information, vendors might provide solutions that don't fulfill project needs, resulting in plan updates, change orders and potential delays at the cost of the developer.**

Here's what a developer should be looking for in a power supply study and a study partner:

1. The study should provide information the developer and vendors can translate into a clear set of deliverables, directly addressing the project's needs, business case and interconnection assessment required by the relevant jurisdiction or utility.
2. The study should follow best practices to enable effective communication and planning between developer and vendors.
3. The study should be right-sized for the project with the necessary level of detail.
4. The study provider should be using a set of microgrid study tools that match what vendors need to deliver the right solutions in areas like controls development.

Studies that don't deliver on those measures result in costly scope gaps down the line. If a study's outputs don't clearly define key information, vendors might provide solutions that don't fulfill project needs, resulting in plan updates, change orders and potential delays at the cost of the developer. A study for a microgrid with Level 3 EV chargers that does not specify the voltage requirements for fast charging can result in vendors supplying hardware that is insufficient. Or, in another example, a study that does not adequately define switchgear requirements, such as busbar sizing, can result in a developer making late specification changes for equipment that vendors have already procured.

The key for developers to receive studies that deliver specific best practices for a project is simple: Don't seek studies; seek outputs from studies that provide the right, useable information. These outputs need to be well-defined and tailored for each project.

[2] Elisa Wood, "Long Beach Says California Decision Fails to Remove Key Barrier to Microgrids. Calls for Rehearing," Microgrid Knowledge, Feb. 23, 2021, https://microgridknowledge.com/long-beach-microgrid-barriers/

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Step 3: Make the right procurement decisions

A developer must bring together providers for controls, electricity, generation and much more. As microgrid technologies advance and options proliferate, it can be difficult to keep pace with the latest options and make the right procurement decisions.

> By ensuring that equipment from various vendors integrates seamlessly and making a careful decision around the most critical piece of equipment – the microgrid system control – procurement decisions become a perfect patchwork quilt rather than a minefield.

The pitfalls of making the wrong decisions regarding major equipment from vendors, such as DERs or the microgrid system control, include development challenges that remain hidden until they are at their most difficult to solve.

For example, choices that lead to negotiating contracts with multiple vendors often result in costly time delays. Or a battery system provider might want to sell controls for its system, unaware that other DERs in the system and customer needs require a different type of microgrid control.

The local utility will have interconnection rules and fees and may require grid connection upgrades. It could impose other requirements, even capping the size of the system permitted. A generation provider unfamiliar with those limits might be happy to provide more generation than the microgrid is allowed to install.

However, by ensuring that equipment from various vendors integrates seamlessly and making a careful decision around the most critical piece of equipment — the microgrid system control — procurement decisions become a perfect patchwork quilt rather than a minefield.

There is no Apple for microgrids (yet)

Many vendors offer solutions that are not truly technology agnostic. This can limit a developer’s ability to ensure the microgrid is built to evolve with new technologies and changing customer needs. In the world of personal computing, a company such as Apple can provide solutions for all of a customer’s needs. But in the case of microgrids, hardware and software innovations are emerging rapidly from new and established vendors. There is no Apple that can seamlessly do it all. The most seamless option is the use of hardware and systems that can interconnect and function together regardless of the component manufacturer.

System control is mission critical

The microgrid system control is perhaps the most important procurement decision to ensure the microgrid can deliver customer expectations — when it comes online and in the future. Developers need to be aware of how controls for various systems compare. There are hardware, software and cloud-based software control options available, and controls expertise is needed to best choose the one that will serve project needs better than others.

Considerations for the developer

Key system control considerations include:

1. What are the use cases for grid-connected and islanded modes of operation, such as reducing demand from the grid during peak use periods, energy arbitrage and resiliency?
2. What are the switchgear load shed capabilities and critical load priorities? Are there any controllable loads?
3. How will the microgrid respond to large step changes in load or generation, as determined by the transient stability study?
4. Does the site have existing DERs and how will the microgrid monitor and control these assets? Is supply from any of the existing DERs contracted under a power purchase agreement?
5. What is the preferred black start sequence of operation and how will the microgrid connect back to the utility grid when power is restored (i.e., open or closed transition)?
6. Are there clean air restrictions limiting the operation of fossil fuel generation?
7. What are the utility interconnection rules and restrictions that limit microgrid operation or define the minimum power quality requirements?
8. What protection scheme and relay protection settings are adequate for operating in island mode?

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Step 4: Manage balance-of-plant considerations

Even after decisions on DERs and the microgrid controller are made, there remain numerous hardware decisions on items such as switchgear, busbars, breakers, inverters and panel boards.

Making the wrong "balance-of-plant" hardware choices leads to a number of additional development challenges. These can include increased costs on replacement orders or additional hardware to cover shortcomings, project delays stemming from implementing solutions to new problems and unfulfilled goals for customers if a system begins operating with suboptimal hardware.

One real life example of a balance-of-plant hardware choice gone wrong happened in California when a rental truck company sought to develop its own microgrid to manage an electric truck pilot project. The company purchased a battery and vehicle chargers from one vendor and chose a separate electrical contractor to install a switchboard. Unfortunately, the contractor did not set up a means to monitor and report the system's energy use, meaning the company could not produce the time-of-use and self-generation reports needed to earn the rebates and incentives available in California that made the project economic. After the initial project was complete, the rental truck company had to find another vendor and pay additional costs to have new hardware installed to fix the issue.

Hardware choices become harder to get right if they are preceded by gaps in understanding project requirements, studies that don't produce the necessary outputs or procurement of a control system that doesn't fit project needs.

However, by following the previous three steps, there are several key considerations to take into account when making critical hardware decisions at this stage. (See checklist at right.)

The list of balance-of-plant considerations is intimidating to be sure, which is why it's so common for something simple like lack of equipment space in an older building to escape notice until the problem reveals itself and time and costs are already sunk. This makes it critical for developers to not only take the considerations above into account, but also seek guidance from trusted partners, before making balance-of-plant choices.

For example, when a large multifamily residential building owner in Manhattan sought to install a microgrid with a battery storage system, the developer discovered that lithium batteries were not allowed inside the building and there was nowhere in the highly dense urban area outside the building to locate the system. Siemens helped develop an alternative approach to use a lead-acid battery array that could be located under the building's parking lot.

Many of these unwelcome surprises emerge because it's impossible for a developer to solve a problem it doesn't know exists. However, they are avoidable. Ask the right questions and work with experienced partners who have "been there and done that" to get answers and avoid big surprises that can result from what seem like small balance-of-plant choices.

Balance-of-plant considerations

Some of the most important considerations include:

1. A vendor's ability to provide the necessary support for hardware throughout the life of the system should play an important role in the hardware selected.
2. The system's sequence of operation should be determined upfront and drive inverter selection. There are many inverter manufacturers in the market, offering a wide array of features and options. Selecting based on system sequence of operation will help determine the features and specifications required (grid-forming, ramp-up time, regulation performance, controls and communication).
3. The need to retrofit or add new power distribution equipment to integrate new DER assets or controllable loads.
4. The availability of floor space indoors or outdoors for new equipment, which will dictate selection of switchboards or switchgear. Limited space may require an external power control center solution.
5. Switchgear construction should meet the application requirements (arc resistant, metal clad, UL1558 or UL891).
6. Serviceability should determine what type of breakers are suitable (fixed-mounted versus draw-out breakers).
7. The need to add motor operation to legacy breakers, which allows the microgrid controller to shed load.
8. The available fault current for microgrid operation in grid-tied and islanded mode, which may require protection relays and power breakers that support dual-protection settings.
9. The impact of the ground fault protection scheme for the power distribution network and bonding of new DER assets on the design of the new power distribution system.
10. The communications capabilities of legacy power distribution control devices, such as protection relays, power breakers and power meters, which a microgrid controller needs to be able to communicate with to provide a real-time picture of controllable assets and load.
11. The role of the microgrid controller to serve as the primary controller to facilitate high-speed switching between the microgrid's grid-tied and island modes in the event of a utility voltage or frequency issue.

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Step 5: Smoothly integrate the project without costly scope gaps

Throughout the commercial microgrid development process, limiting project complexity through operational bundling and effective communication with the customer, vendors and other stakeholders are keys to successful project development. Unfortunately, it's easy to plant the seeds for scope gaps that will emerge at inopportune times, but following the steps in this report will help developers avoid the most common types of scope gaps.

To prevent communication scope gaps, developers should ensure a clear understanding of customer needs, attain the right outputs from studies that provide information vendors need, and simplify and streamline vendor management. To prevent technology integration scope gaps, they should choose vendors whose systems and products are technology agnostic and don't rely on proprietary solutions.

Developers can make a series of choices throughout the steps of development to ensure smooth integration and a microgrid that delivers on a customer's priorities.

- Select a partner early in the process with a broad scope of knowledge to eliminate key unknowns and identify potential problem areas in the conceptual design phase before they become costly.
- Partner with an adviser that can fill developer team knowledge gaps on near-term projects and help grow the developer team's knowledge and capabilities for more self-sufficiency on future projects.
- Minimize the number of vendors supplying the project for more effective communication and to avoid integration issues.
- Create a microgrid system that is vendor agnostic and that doesn't rely on proprietary communication protocols so that it will work with whatever technology and capability emerges in the future.
- Ensure that all software, systems and devices can "talk to each other" for a smooth integration.
- Future-ready the system so that it can be updated on an ongoing basis to meet new customer needs. A customer that uses a small natural gas generator on-site today might have a new sustainability standard tomorrow that prevents its ongoing use of gas-fired generation.

Siemens can leverage its comprehensive microgrid experience to help developers tackle challenges throughout the entire system and deliver efficient, resilient and sustainable commercial microgrids. Benefits Siemens brings to developers throughout the key steps of the process include:

- Serving as a trusted adviser across key decisions to ensure it enables customer priorities.
- Reducing the number of vendors and contracts needed to execute a project.
- Defining the optimal microgrid design through simulation-based supply system analysis.
- Ensuring that technical and economic requirements are met.
- Assessing the scope and design of the microgrid to determine the appropriate system control.
- Providing operational analysis so developers can continue to improve the performance of the microgrid on behalf of customers throughout the life of the system.

Siemens Princeton Microgrid
A case in point for smooth integration

The Siemens Princeton Microgrid was developed as a "living laboratory" to test the future of microgrid capabilities and best practices. The microgrid is one of the first to combine renewable DERs and energy storage with both building management and energy management solutions that include building automation and cloud platforms.

It's true that developers won't often encounter the favorable set of conditions that led to the Siemens Princeton Microgrid — collaboration was a top priority for all stakeholders and the project involved Siemens developers working with Siemens clients. However, several best practices and important insights emerged from this "lab-controlled" project to help developers ensure smooth integration without scope gaps.

The development team and clients at the Siemens research and development (R&D) facility in Princeton, New Jersey, forged an energy strategy from the start, mapping out goals, objectives and needs. The teams analyzed existing systems at the R&D facility and deployed simulation tools and data analysis.

The teams collaborated and communicated early and often with internal stakeholders, such as the Siemens real estate department, and external partners, such as the US Department of Energy. Relationship building was key to simplifying complexity and avoiding additional expenses. Rather than view the project's many stakeholders as obstacles, the project team found benefits from open communication, such as leveraging the knowledge of the Siemens real estate team to accurately size and configure the electrical systems being installed in what was an older building.

Contact Siemens at microgrids@siemens.com to take a holistic, custom-engineered systems approach to commercial microgrid development and act in a technology- and vendor-agnostic fashion to meet customer goals.

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