White Paper

The Hows and Whys of a Smart Microgrid Feasibility Study

Identiying First Steps in a Customer's Microgrid Journey

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Introduction

The market for microgrids is clearly a global market. Yet the leading market for grid-tied microgrids for institutional, government and commercial and industrial (C&I) customers is clearly the US, where grid reliability continues to be challenged by extreme weather events, aging grid infrastructure and the transition to net zero carbon emission strategies. While utilities and military bases are also major markets in the US, these customers have unique paths to follow when implementing a microgrid. So, this white paper focuses on C&I customers – now the fastest growing microgrid market globally and in the US -- as well as institutional customers (including municipalities), which often represent critical facilities which ideally remain up and running during any power outage.

Microgrids are typically a customized solution enabling end-users to integrate diverse energy resources that can be designed and sized to meet desired outcomes. A feasibility study for a microgrid at a specific site paints a picture of what different combinations of distributed energy resources (DER) can deliver -- energy savings, air emission reductions and resiliency – and how. The process translates outcomes into specific designs and costs so the potential host can evaluate options. This white paper outlines a step-by-step process for customers trying to understand their options for developing a microgrid.

> *In the final analysis, a feasibility study lays down a solid foundation upon which a wise decision can be made on whether to proceed with a project (or not) and what the best mix of distributed energy resources (DER) to meet any projects' goals might be.*

Microgrids are a hot topic today, but sometimes pursuing such a project may not make economic sense depending upon the customer's load profile, how the host distribution utility is regulated and the top goals the customer has identified for investments in new energy and grid infrastructure. Most microgrids are upgrades, and therefore require a customized design and feasibility analysis – especially for larger and more complex projects. Customers often become daunted by the range of technology options, goals of any microgrid project – and how to fund feasibility studies when the outcome may be uncertain. In the final analysis, a feasibility study lays down a solid foundation upon which a wise decision can be made on whether to proceed with a project (or not) and what the best mix of DER to meet any projects' goals might be. Of course, these goals may or may not align, so the feasibility analysis allows the customer to understand trade-offs. It also serves as the basis for design modifications as the customer better understands what can and what cannot be achieved with any particular microgrid design – and then make informed and intelligent decisions about how to fund any project that moves forward.

The first design of any microgrid is never the final design. This is an iterative process. Customers need to understand the trade-offs between multiple project goals that typically revolve around cost, resilience and sustainability. The value proposition underpinning a microgrid feasibility study is this: invest upfront in understanding your options to make sure you spend more wisely later. In other words, the study de-risks any project development. The sizing of onsite generation and energy storage to be wrapped into a microgrid to meet customer loads is both a science and an art. A feasibility study takes into account the customer's goals *and* the practical reality grounded in specific site conditions as well as interconnection with host utility and other regulations and incentives.

Microgrid Basics: Definitions Set the Stage

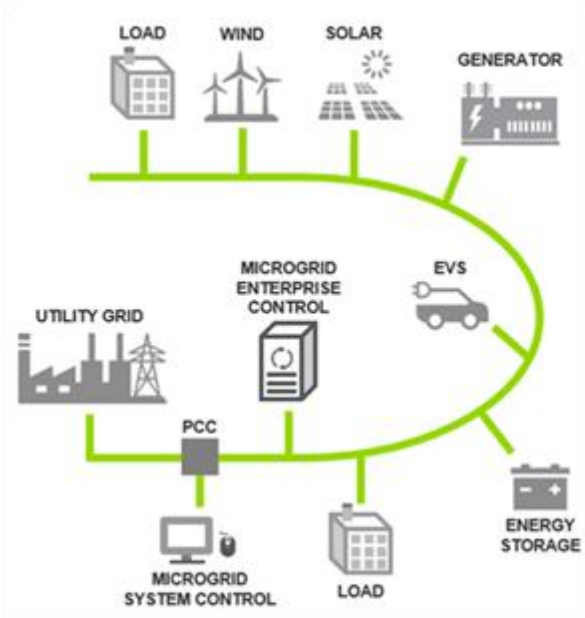
Guidehouse Insights provides the following definition of a microgrid:

> *A microgrid is a distribution network that incorporates a variety of possible DER that can be optimized and aggregated into a single system that can balance loads and generation and is capable of islanding whether connected or not connected to a traditional utility power grid.*

This definition mirrors that of the federal Department of Energy as well as other US federal agencies and global institutions. Despite congruence on fundamental definitions, there is considerable debate over whether specific projects fully meet the definition of a microgrid. For the most part, these debates center around esoteric engineering details or may be biased perspectives shaped by vendors focusing on specific microgrid-enabling technologies.

As noted in Figure 1, a microgrid is often a hybrid power system, incorporating both conventional generation sources (i.e., fossil fuel generator) and renewable energy resources, along with customer loads, which could include EVs that could also serve as a microgrid asset in the form of a mobile battery used for stationary applications or a demand response resource. The key defining feature of a grid-tied microgrid is the ability to island itself off from the larger utility grid at the Point of Common Coupling (PCC.) Adding to the complexity, generation and energy storage devices (and EVs) typically come from a variety of companies. That's why having engineers not necessarily tied to any of these DER assets that can take a more wholistic view of a microgrid system is a wise investment. Since they are technology agnostic, these engineers can make an unbiased assessment of what works best since they know the capabilities of each DER option as well as electrical and control technologies. As a result, these engineers can offer customers choices and options, including pros and cons on asset selection and system design, since they understand all aspects of the components and the system regardless of manufacturer.

Figure 1 Schemata of a Possible Microgrid

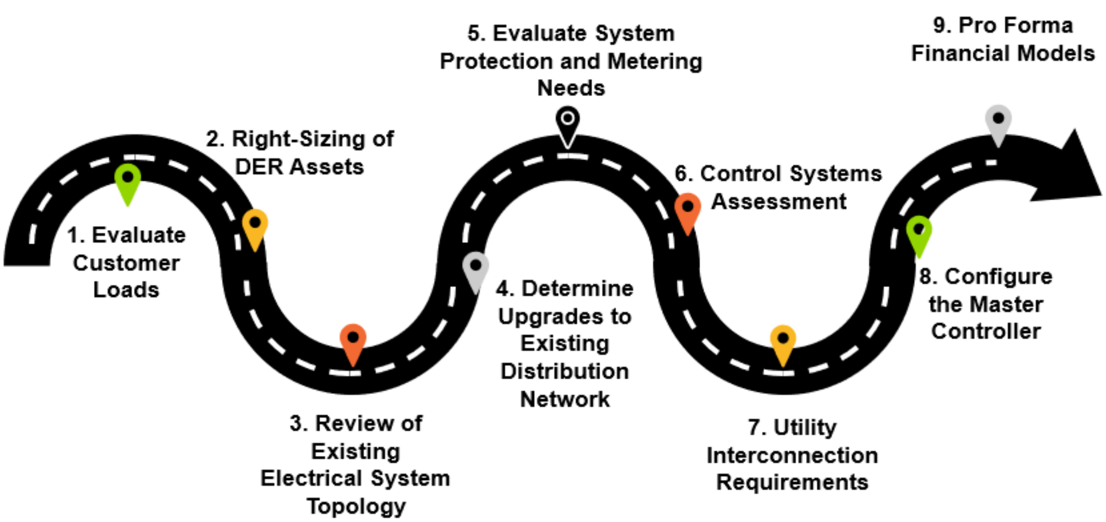


(Source: Guidehouse Insights)

Given the wide variance in scale, DER assets, applications and use cases, a feasibility study is often one of the first steps a customer should undertake when considering a microgrid project. Moving forward with a feasibility study is a worthwhile investment, even if the decision is ultimately made not to move forward with a project. Such an undertaking provides value in gaining a better understanding of what is and what is not possible with an onsite energy system. The upfront investment will pay dividends down the road. In some cases, a microgrid may not make sense immediately, but armed with the analysis, a prudent strategy can be devised on how best to optimize energy production and consumption with a microgrid platform, or perhaps related concepts such as a virtual power plant (VPP) and other creative aggregations of onsite energy resources. The feasibility study can also identify project show-stoppers. For example, if a roof is too old to support solar PV panels, the potential project host knows that if they want to get a new roof in the future, they can revisit the question of rooftop solar PV at that point in time.

Figure 2 outlines a simplified version of the necessary stops along the journey of designing a feasible and practical microgrid, steps to help transform the idea of a resilient and sustainable microgrid from the conceptual idea to a practical reality. In truth, this white paper is focused on the front end of this customer journey.

Figure 2 Customer Microgrid Journey Stops: A Step-by-Step Approach



(Source: Schneider Electric, Guidehouse Insights)

Above, a microgrid itself was defined. But what does a microgrid feasibility study really mean? Before diving into the details, always begin by understanding the big picture. What type of facility will be supported by a microgrid? Understand historical site uses but also comprehend future uses that include organizational priorities that likely include project goals such as predictable cash flows, levels of resilience or sustainability targets. Will EV charging infrastructure be added down the road? Are there any special utility relationships or contracts in place that might affect a microgrid's design? Is there a desire (or need) to reduce reliance upon natural gas by electrifying certain loads? Understanding what level of resilience – and for which critical loads – also needs to be factored into any microgrid design.

Those who are typically involved in such a feasibility study on the customer side of the transaction may include the sustainability team, energy management team, facility operations, finance, networking/IT, and more. Microgrids are a system and involve several teams coming together to make sure the optimal system is put in place and all potential risks and barriers are thought of. What are the typical specific sequential elements that comprise such a study? Below is a checklist related to the scope of any feasibility study, with concise definitions of what is entailed in each stop along the way.

Step One: Evaluate and Estimate Customer Loads

The starting point for any microgrid design is understanding the loads the microgrid will need to serve, ideally in the most cost-effective, reliable and sustainable way possible. This is where the feasibility design journey begins. These loads typically vary by season and by times of day, which shapes decisions down the road on types (and the sizing) of assets to be integrated into the microgrid.

In an ideal world, a utility would be able to provide interval data for the customer site. This is the case for the three large investor-owned utilities in California, but in many US markets, this data is not available. If the latter, the feasibility study must be based on estimates developed by the team performing the feasibility analysis. Data is required for an entire year to understand not only daily use patterns but how those demands for electricity and other energy services change throughout the course of a year.

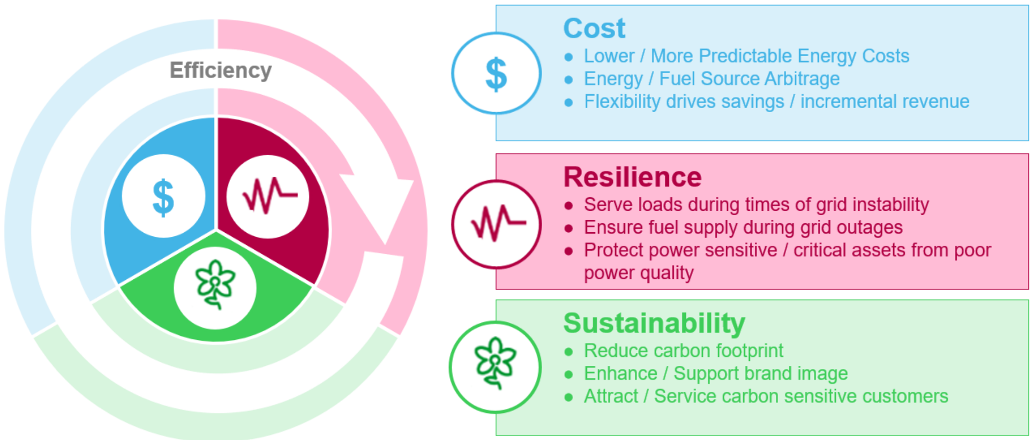
One could argue that the customer load profile is the most fundamental of all data points needed to optimally design a microgrid.

One could argue that the customer load profile is the most fundamental of all data points needed to optimally design a microgrid. The analysis flowing from this load data is not only dealing with energy. Among the most important aspects is understanding power needs, particularly during times when the microgrid is in islanding mode, separated from the larger distribution network. Most analysis of loads (and supply) focus on operations when assets are connected to the grid. For a microgrid, however, critical design decisions need to accommodate the unique constraints imposed when operating as an island. Blackstart capabilities – the ability to startup instantaneously in the event of an outage – need to be understood, as are longer-term design considerations. In an ideal world, this microgrid will operate for two decades or more. How will incorporation of EV charging or other new or increased loads shape resource needs? And can loads be categorized since they are not equal. A good way to rank the importance of loads is to rank them with terms such as critical, essential and standard loads. These rankings will impact the programming of controllers to set the proper sequencing of loads if they need to be shed during an islanding event.

Step Two: Right-Sizing Onsite Generation and Energy Storage Assets

Once interval data on load patterns are understood on a daily and seasonal basis, one can make a more intelligent decision on what new supply assets may be required. Many microgrids are upgrades of existing onsite power systems. Most new microgrids are designed to be more efficient than existing electrical infrastructure. They also lean toward more sustainable energy resources, such as solar PV, fuel cells or Combined Heat & Power (CHP) systems. The greater the reliance upon variable renewables, the greater the need for some form of energy storage. But what kind of battery, or flywheel or ultra-capacitor or perhaps even a hydrogen electrolyzer makes the most sense? How best to balance the multiple goals of the customer in seeking a microgrid? (see **Figure 3**.)

Figure 3 Microgrids: Balancing Cost, Resilience and Sustainability Goals



(Source: Schneider Electric)

Along with these more higher-level issues, a feasibility study must also take into account more specific details, such as exactly where these assets will be installed. It is one thing to have a theoretical generation or energy storage asset figured out and right sized in a vacuum; it is another to find the best configuration and location for installation at a specific project site. For example, if one has determined an optimal size of a solar PV system, one still has to determine if there is enough roof space on buildings to add that level of generating capacity or would a canopy system be required? Even if there is enough roof space, is the roof structurally sound so that it can support the added weight? Will batteries be installed inside buildings or outside?

Other considerations for right-sizing microgrid assets include permitting issues linked to the existing utility distribution system which would impact the utility interconnection agreement.

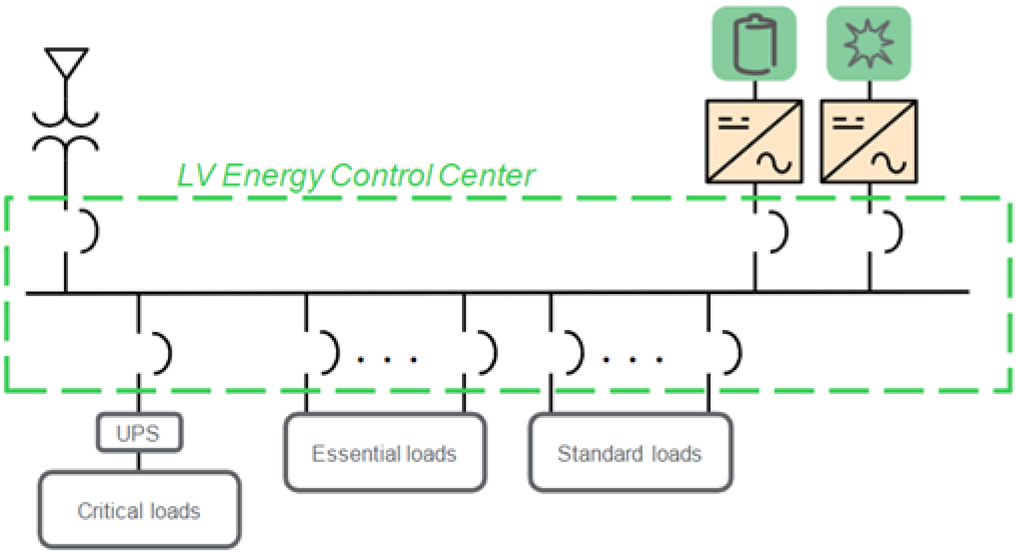
Other considerations for right-sizing microgrid assets include permitting issues linked to the existing utility distribution system which would impact the utility interconnection agreement. Availability of government incentives can also play a role. For example, in order to qualify for a federal investment tax credit, an energy storage device such as a battery must rely upon renewable energy for 75% of the electricity to charge up the battery. Other fine-tuning during this iterative design process includes whether the solar PV system should be tilted – and in which direction – or just flush-mounted.

Step Three: Review of Existing Electrical System Topology

Once the proper sizing of new DER assets is determined one has to then review the existing distribution level infrastructure to figure out how best to locate and then integrate these new assets. What can be salvaged from the existing system to reduce the overall cost of the microgrid?

Here, an existing single line diagram is the ideal scenario, though as is often the case, these may not be up to date. This is the step in the design process where an initial hypothesis on design is verified – or not. Other key considerations include whether the utility service is primary or secondary? Is the microgrid going to serve an entire campus or a select few buildings? In many cases, a microgrid may be designed only to support critical loads during an islanding event – but these loads may not be adjacent to each other. Another design consideration is how many connection points exist with the local distribution utility – and are these points too many or two few given the new assets that are being integrated into the new microgrid.

Figure 4 Line Drawing of Existing Grid Infrastructure and New Battery and Solar PV



(Source: Schneider Electric)

Step Four: Determine Upgrades Required to Existing Distribution Network

Typically, some new power management and distribution network system upgrades will be necessary to create a microgrid. This will vary greatly depending upon the age of the facility, whether the new microgrid will incorporate multiple buildings and the number and size of the new assets being installed onsite. This is often one of the least understood aspects of any microgrid – but can be thought of as the connecting tissue for the overall system. One of the primary benefits of a comprehensive feasibility study is understanding this aspect of the design process.

One pleasant surprise possible during this design phase is discovering available funds that may already be earmarked for system upgrades. Perhaps the facility already earmarked funds for general upgrades that can help underwrite the microgrid since the microgrid helps meet previously outlined facility objectives. If this is the case, these funds, already budgeted, may be able to be leveraged to reduce the cost of microgrid, perhaps expanding the originally conceived upgrades to be modified slightly to accommodate new microgrid priorities and design considerations – especially reconfiguring assets for island mode operations. The microgrid can become part of a master energy planning process. Building a microgrid should not be a siloed decision-making process. This step is particularly important for larger campus microgrids where long and expensive fiber optic installations may need to be modified to address island mode optimal configurations. Yet another factor is existing Power Purchase Agreements (PPAs) for existing onsite assets. Can the microgrid be designed to not violate existing contracts? Furthermore, can the existing or an enhanced electrical bus be augmented in a way to support resiliency?

Step Five: Evaluate System Protection and Metering Needs

Electrical systems need to be designed with safety in mind. One also has to have visibility into which loads are consuming how much electricity – and when. This analysis builds on the previous steps and can assess what level of granularity in metering is required. In the Howard County microgrid described in more detail later in this white paper as a case study, for example, it was determined that the existing switchgear was too old and that the breakers were not sufficient to safely support the proposed microgrid. A new primary protection system had to be installed to meet the needs of the microgrid when islanding – but also utility interconnection requirements. Remember, each utility has its own utility interconnection requirements so the engineering team doing the feasibility study must understand these nuances when designing a microgrid. These issues become magnified in microgrids which rely solely on inverter-based resources such as solar PV and energy storage. In this scenario, ground fault settings need to be changed so that running on a clean energy mix of resources does not negatively impact the loads being served by the microgrid – or the surrounding utility distribution network.

In terms of metering, it may be the case that there are existing utility networks that can be used. If indeed such metering is in place, there is no need for redundant metering to be paid for by the microgrid host.

Step Six: Assess Existing Control Systems for Compatibility with New Microgrid Controllers

Many existing onsite power systems have some sort of controls, but most were not designed for the automated islanding that an advanced microgrid can provide. Yet some of these generator controls may be compatible with a new master controller – some may not. The sophistication of the controls regime is dependent upon the level of reliance upon renewable energy, the size of any energy storage system and the priorities of any specific microgrid. Is the primary goal reducing emissions or resiliency – or both? Or is the microgrid's priority cost reduction or the capture of new revenue streams through the provision of grid services supporting the larger utility grid? If the utility has already installed advanced metering infrastructure (AMI), then some level of digital intelligence is already in place. Yet even if there is AMI, there are several other considerations. Can existing building management systems or generator or other onsite device controls talk to the new master controller for the microgrid? When there are multiple inverters in a microgrid – a technology that can serve as a basic controller for small microgrids – a cluster controller is sometimes needed to align each inverter with the microgrid's mission at any point in time. Other times, dual purpose network controls can be utilized, which can optimize both energy and power. Often, building management systems to help optimize loads with generation and energy storage. Many modeling tools used for microgrid designs shortchange how the economics of the system need to be harmonized with the power needs of the system, or the project will ultimately fail.

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Step Seven: Determination of Utility Requirements for Interconnection

Most microgrids do not exist in an energy ecosystem vacuum (unless they are remote power systems installed at sites that lack traditional utility grid infrastructure). Though microgrids are capable of islanding from a surrounding utility grid, they will interconnect with the host distribution utility. Utilities will want to make sure the microgrid is safe and does not impact their ongoing operations in a negative way. The previous steps on system protection comes into play here. This is the part of the process where delays can be introduced if the feasibility study fails to adequately address standard utility interconnection protocols.

This is where the interval data so important for Step One in the microgrid feasibility process come back into play. The better the data on loads, the more confident one can be with interconnection agreements not negatively impacting either customer or incumbent utility system. For most utilities, microgrids still fall into a gray area, therefore require greater scrutiny than a standalone solar PV system or standalone battery since they are more complex systems with a wider array of capabilities for self-consumption or grid services. As microgrids become mainstreamed, this dynamic may change. For now, nonetheless, any microgrid developer must engage with the local utility. Its best to be forthcoming and to freely communicate all contingencies and to represent the customer's interests in these negotiations.

Step Eight: Configuring the Microgrid Master Controller

The key enabling technology for any microgrid is the microgrid controller. This is the gateway technology for every microgrid. The controller's power management system (PMS) takes the microgrid from grid-tied operations into island mode, orchestrating all of the DER assets to meet critical loads without any contributions from the neighboring utility distribution network. A precise sequence of operations needs to be defined when configuring the controller. In contrast, the controller's *energy management* (EMS) system features allow the microgrid to meet economic priorities when still connected to the distribution system, perhaps from the import of low-cost electricity from the larger grid or through the provision of excess capacity sales or grid services. For optimal results, the EMS needs to be configured to meet defined use cases whether to achieve cost savings or reduce emissions during grid-tied operations, for example. The controller, in short, is the key to making the microgrid project pencil out while still meeting the overall project's goals.

Given the complexity of such systems, and incorporation of products from multiple OEMs and vendors that each offering some level of controls, it is important to clearly identify which products do what when. In other words, what is the exact chain of command? It may be the case that the master controller orchestrates at a high level, but other more distributed control technologies take the lead on blackstarting or help optimize the system for economics leverages cloud-based analytics. This is where multiple use cases (see Figure 3Figure 3) come into to shape the overall design, with the sequencing of control schemes critical to the project meeting the goals that the customer outlined for the project. Ranking each use case in a matrix is helpful to understand which use case take priority if there is ever a conflict. Balancing cost, resilience and sustainability often does involved trade-offs. Yet with the right controls scheme, any apparent conflicts can be resolved in a way that minimizes disruptions, improves the economics and helps achieve resilient and reliable energy and power services. Often, the trick is what sequence of controls can keep the energy and power system stable when in islanding. Don't forget about degraded use cases, such as what happens if the battery fails?

Figure 5 EcoStruxure Microgrid Advisor: Use Case Examples and Control Priorities

Remote monitoring & forecasting	Monitoring Power / Energy and other KPI for each DER using a web access Electrical / thermal energy
Tariff Management	Control DER (consume/produce/store energy) according to variable electricity tariff rate Electrical / thermal energy
Demand Charge reduction	Control DER (consume/produce/store energy) for reducing site consumption peak
Self consumption	Control energy storage and PV system for maximizing the energy consumption from PV system
Demand Response*	Control DER for participating in DR mechanisms
Frequency Regulation*	Control local generation and BESS to support frequency regulation (local logic in DER Box)
Off grid mode preparation	Control DER for anticipating on future off grid events
Export management	Control DER for avoiding exporting energy to the grid

(Source: Schneider Electric)

Step Nine: Create Preliminary Pro Forma Financial Models

The most common question from any potential customer is always the same: How much will it cost? This is often where the go or no-go decision is made, based on rough estimates of costs. This is also where different options can be presented, and new business models such as energy as a service (EaaS) come into play. Still, without a rough order of magnitude cost estimate, customers cannot really decide what option may be best to finance the microgrid. This step can also review what government sources (see Appendix) of funding might be available, and whether those timelines and awarding of funding process from government or other sources meets the client’s time-line for having the microgrid up and running. There are tools available to estimate costs and pricing, but unexpected scenarios, such as the COVID-19 pandemic, can render some of these estimates moot due to supply-chain bottlenecks and extreme inflation. While publicly available tools from government sources such as the National Renewable Energy Laboratory (NREL) or HOMER (now part of UL) can help provide some ballpark numbers, these estimates may fall short of what is needed to make an informed decision on whether to proceed with a microgrid or not.

If the client elects to move forward, then a detailed financial analysis must be performed, no matter how the project will be financed. This analysis will include pricing for specific components from specific OEMs, all estimated balance of system costs -- including distribution system upgrades and microgrid controls -- as well as other site improvements necessary to create the microgrid. It will also take into account the staging of the installation step-by-step based on the conceptual sequencing outlined above, incorporating all data from the previously described steps. Most importantly, it will capture the ongoing operations and maintenance costs – the least standardized and transparent of microgrid costs. Clients need to understand the total cost of ownership of any microgrid. These are the hidden liabilities and costs that are necessary for the microgrid to continue to perform at a high level over the life of the project.

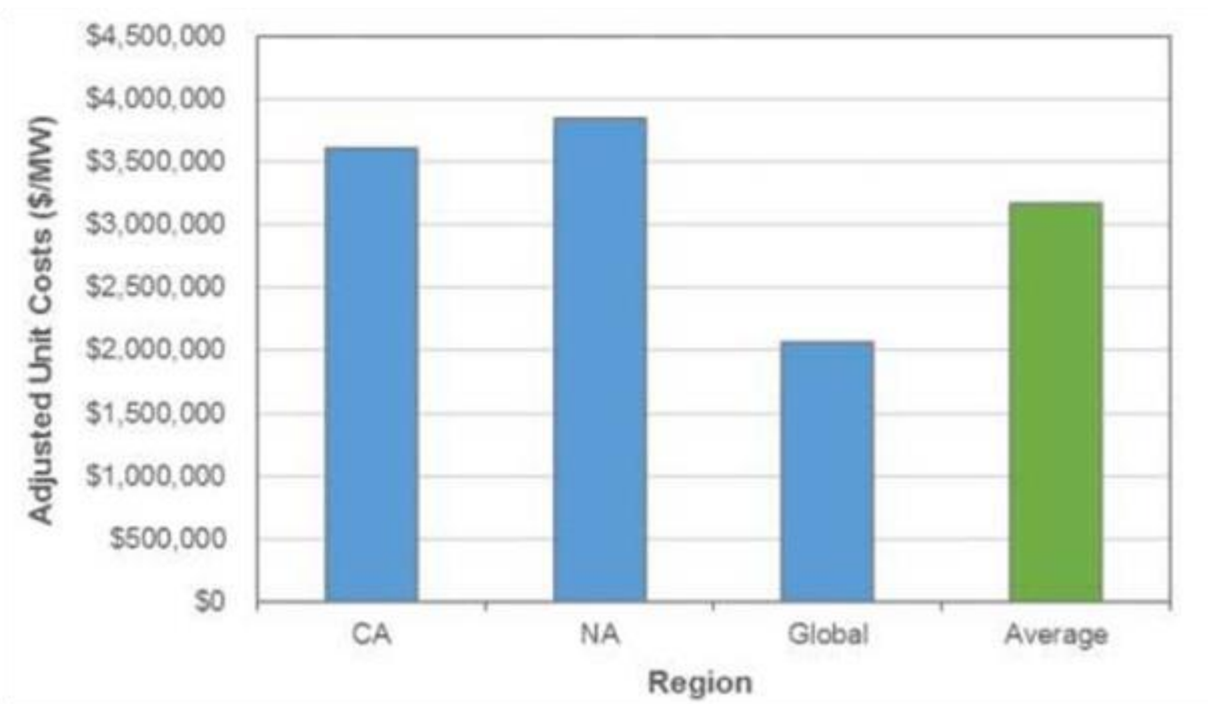
Note that the Scope of Work for a microgrid feasibility study is not a one size fits all. Based on what the customer is trying to achieve, feasibility studies can be right sized to meet the specific needs of each customer. It does not need to include all of the above referenced factors. For example, if the customer does not care about cost – albeit a rare use case – then the final financial analysis could be skipped, thereby reducing the overall cost of the feasibility study.

What Does a Microgrid Cost?

Microgrid costs vary immensely. Guidehouse has developed studies for both the California Energy Commission and the federal NREL looking at different aspects of costs. While these studies now reflect data from a few years ago, they are still illustrative. Given recent cost trends on key DER options, costs today may be lower – and may continue to decline. Nonetheless, each microgrid faces unique integration challenges. The biggest question markets still revolve around the balance of system costs, which is often what feasibility studies shed light on for any particular project.

In a 2018 study performed for the California Energy Commission focused on 29 microgrid case studies that moved forward without government grant funding, the average cost was just over $3 million per MW. Some of these projects were deployed in previous years, so these costs may reflect a premium given the growing maturity of the market. Since these projects moved forward without need for major government support – other than incentives for DER assets – one could also argue these were projects that were low-hanging fruit. The majority were C&I and institutional customers.

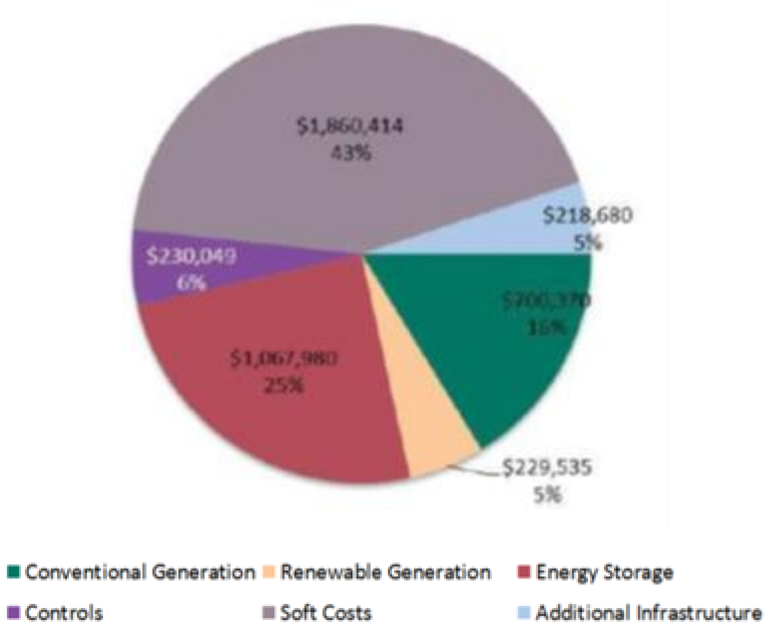
Chart 1 California, North America (NA) and Global Microgrid Costs: $/MW



(Source: Guidehouse-California Energy Commission)

In a study for NREL, cost data from 80 microgrids developed across the US were analyzed according to a variety of criteria. These projects also included some projects developed several years ago; some never moved forward but had performed feasibility studies identifying costs. Note that some of the largest cost category – 43% - was for soft costs. The second largest category for these C&I microgrids was energy storage (25%), followed by conventional generation (16%), controls (6%) and renewables and additional infrastructure (5% each.)

Chart 2 Cost Components for a US C&I Microgrid



(Source: NREL, Guidehouse Insights)

What about ongoing costs to keep the microgrid operating? This is another key consideration for both microgrid customers and providers.

Risks/Challenges Attached to Any Microgrid Feasibility Study

As with any investment of time and money, there are risks when moving forward with a microgrid feasibility study. One possibility is that the funds invested may lead to a no-go decision on a project. There is also inherent risk in selecting the firm to conduct the feasibility study. In an ideal world, the vendor would not be biased to any specific solution set or outcomes. They would need to be credible to assuage fears from potential investors that the analysis was sound. And they need to be realistic about what is possible, for example, when multi-purpose microgrids are being designed. In the end, the host customer needs a sound and credible analysis of what is feasible with today's component pricing and market designs, and how the microgrid can adapt to changing economic and public policy shifts over the life of a project that may have a useful life of 10 to 20 years.

Below is a SWOT chart highlighting the trade-offs between doing a feasibility study in-house, or foregoing such an exercise altogether, with a more modular and non-differentiated microgrid design. Quite a few potential microgrid hosts believe they can do the analysis themselves, but don't really understand the nuances of microgrids that are much more complex than incorporating a single DER asset, such as rooftop solar PV. Relying upon outside experts can provide third-party validation of the feasibility of any microgrid design, a precursor to identifying the best financing approach to any microgrid project.

Table 1 Microgrid Feasibility Study SWOT Analysis

Strengths	**Weaknesses**
• Understand sizing and design parameters for a microgrid upfront – before committing major investments • Tailor a microgrid to meet the specific site requirements	• An upfront cost that may seem prohibitive for smaller customers unsure about how such investments will meet internal decision-making metrics
Opportunities	**Threats**
• To fine-tune the microgrid design to meet resiliency, economic and decarbonization goals in a pragmatic manner • Uncover initial bias in design by being informed by sophisticated modeling on upfront and ongoing O&M costs	• The feasibility study leads to a no-go decision • Hype about "plug and play" systems may reduce appeal of going through the feasibility study phase of a potential microgrid project

(Source: Guidehouse Insights)

Two Microgrid Feasibility Case Studies

Perhaps the best way to understand how feasibility studies help steer both potential customers and vendors in the right direction to make informed choices is to review some specific case studies. What follows are two examples. The first involves county government facilities in Maryland. The second one is an anonymous C&I customer project profile.

Howard County, Maryland

The Howard County Office of Community Sustainability (OCS) commissioned Schneider Electric (SE) to undertake a feasibility study around microgrids as a means of sustaining 24/7 operations of critical public safety facilities in the event of a prolonged loss of electricity supply. Howard County also wanted to explore ways for a microgrid to help further its commitment to reduce greenhouse gas emissions from its government operations by 45% below 2010 levels by 2030 and to reach zero emissions by 2050.

The microgrid would be in Ellicott City, Md., at the four-building Howard County Government Campus, which houses critical facilities that include government administration offices, emergency operations, and the 911 call center, as well as police, fire, and rescue services. A nearby community center, which serves as an emergency shelter, was also under consideration for part of the microgrid. The study, which was funded through a state grant with the Maryland Energy Authority, aimed to provide detailed energy, cost, structural and site analyses to determine the feasibility of microgrid projects at the site.

The 11-month study determined that the existing switchgear and breakers could not safely support the proposed microgrid. A new primary protection system had to be installed to meet the needs of the microgrid when islanding and to satisfy utility interconnection requirements. In this scenario, ground fault settings needed to be changed so that running on a clean energy mix of resources would not negatively impact the loads being served by the microgrid, or surrounding utility distribution network. The final microgrid design included the following resources: a 1.2 MW combined cycle natural gas turbine; 1.2 MW of solar PV panels; an 800 kW backup diesel generator on the police station, as well as smaller backup diesel units on other buildings to backup IT load; and 250 kW of battery storage.

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During the feasibility study, SE discovered the buildings on campus were on different utility tariffs. By working with the utility, SE was able to get approval for the campus to be grandfathered onto the primary tariff, which produced an estimated $40,000 in cost savings. The SE engineering team also determined that using the battery as an anchor, which is a common approach for microgrids, did not work in Howard County due to high costs of battery energy storage systems in the market today. Instead, the highly efficient gas generator was recommended as the microgrid anchor resource.

The fifth building – a community center where residents could gather in the event of a widespread outage – was located uphill in a wooded area so SE recommended creating a separate low-voltage microgrid for the fifth building. While the community center could have been tied into the broader campus, doing so presented environmental issues with cutting through the forested area. The project also satisfied the local environmental groups by cutting the government buildings' carbon footprint by 50%

when the Howard County microgrid is in island mode, compared to when it is still connected to the grid under blue-sky conditions. Following the feasibility study, the proposed project moved into internal stakeholder review, which will result in one of three decisions:

1. A capital project incorporating SE's recommendations;
2. A hybrid project including capital funding and EaaS;
3. Or the decision to not move forward with the project.

Finding available funding will likely play a big role in what happens next.

Financial Data Center Customer in Florida

A data center was interested in exploring options for improving electrical system resiliency at their facility, including nearby office buildings. Over the past 5 years, the customer realized significant year-over-year energy savings due to multiple site efficiency projects. It was now interested in generating its own onsite electricity as a next step. In coordination with the customer, SE determined the modifications required for creating a microgrid system to provide a more resilient electrical system for critical loads, while still meeting the customer's other energy requirements. Options under consideration included modification to existing backup generator systems along with adding solar PV and Battery Energy Storage Systems (BESS). The proposal included options for electrical system modifications required to create a microgrid system and develop a preliminary design (~30% level) for the selected option.

The feasibility study was financed through a capital expenditure from the client. The Scope of Work included the following elements:

- Facilitated conversations with local distribution utility -- which had a very good relationship with this customer -- to better understand utility application process and potential for provision of ancillary services.
- Establish detailed project requirements, including constraints, for incorporating a microgrid into the existing electrical system.
- Establish performance criteria for microgrid designs on metrics such as resiliency, sustainability and cost savings.
- Evaluate existing system protection, metering and control systems for compatibility with integration into a new microgrid controller.
- Perform short-circuit calculations, based upon grid-parallel operating mode, to evaluate adequacy of fault-interrupt ratings on existing breakers, as required.
- Review utility interconnection requirements for grid-parallel operation.
- Evaluate current site's utility tariff and corresponding implications for microgrid sizing and ongoing operations.

This project is currently ongoing. SE worked with the customer to leverage the data center's good existing utility relationship to de-risk interconnection prior to the formal interconnection application. One of the biggest costs and schedule delays for any microgrid project is the utility interconnection application process. Having support from utilities can help improve the chances for a project's success by limiting surprises. When the microgrid feasibility study is completed, the customer will gain a better understanding of both the microgrid's functional requirements and costs. Armed with this data and insights, the data center operations and executive team will be empowered to make future project decisions.

Conclusions and Key Recommendations

Microgrids are emerging as vital infrastructure throughout the US as power outage frequency goes up while simultaneously reliance upon electricity is increasing. Modern society's growing dependence upon reliable and resilient electricity requires new approaches to electricity management and supply. Microgrids, especially those that rely upon more sustainable source of electricity, are a key compelling solution for a growing list of end-users seeking to reduce costs while improving their electricity service.

The attributes that make microgrids so compelling – a customized energy solution sized to meet your specific energy needs – also makes them complex, even puzzling to many. Many potential customers either don't understand what exactly a microgrid is or have unrealistic ideas of what they cost and what they may be able to do.

Commissioning a feasibility study is the best way to know your options, weigh the pros and cons of moving forward with specific microgrid designs, and de-risk any future investments. By doing the homework upfront before investing large sums of money or entering into long-term contracts, potential microgrid customers can educate themselves and their vendor partners on how best to create a stellar sustainable and resilient microgrid.

The white paper provides a step-by-step guide to how best evaluate your microgrid options. Understanding both the electric loads served, and which are the most critical, and sizing the DER asset supply feeding the microgrid, are both vital inputs into any microgrid's design. Microgrids are typically system upgrades. They also can commonly supplement infrastructure upgrades already in the works or planned, thereby shrinking the ultimate price tag for a state-of-the-art microgrid.

Commissioning a feasibility study is the best way to know your options, weigh the pros and cons of moving forward with specific microgrid designs, and de-risk any future investments.

Though a feasibility study could lead to a decision to not move forward with a microgrid, this scenario is better than investing large sums into a poorly designed project that ends up not meeting the customer's needs – or a project whose design imposed avoidable costs and perhaps even poor project performance.

The good news is that the cost of microgrids is on a downward trajectory as solar PV and energy storage costs decline. Furthermore, microgrid controllers are becoming increasingly sophisticated and can manage an ever-expanding list of possible technologies providing value to a microgrid, including EV fast charging. There may not be one answer for how to make a site a microgrid butby going through the feasibility study exercise, one can compare different design features and resources and be assured that all possible cost savings and microgrid capabilities have been examined and dissected. In the end, the feasibility study is just a tool, just a stop along the way of a successful project implementation. Cost savings, resilience and sustainability are all possible with a microgrid – but only if the microgrid considers the full range of options and latest technological advances.

Appendix: Funding Sources for Microgrid Feasibility Case Studies

Federal programs

Bipartisan Infrastructure Deal

The **Bipartisan Infrastructure Deal** signed into law in November 2021 offers funding to microgrids to improve transmission, electrify transportation and improve rural and remote areas of the US. Microgrids could also obtain funding in resilience programs to help states and tribes adapt to climate disruption and for connection to key infrastructure corridors in Alaska, Hawaii, or US territories. The bill earmarked $50 billion for programs and technologies that improve resilience and $65 billion for grid improvements. Microgrid projects might also find opportunity from $17 billion slated for ports and $25 billion for airports, which is offered to reduce emissions and drive electrification and low-carbon technologies.

Federal Emergency Management Agency Building Resilient Infrastructure and Communities Pre-Disaster Mitigation Grants

The Federal Emergency Management Agency (FEMA) offers the **Building Resilient Infrastructure and Communities** Pre-Disaster Mitigation Grant Program, which offers grants to state and local governments with mitigation planning and projects to reduce their reliance on federal money in any future disaster. The grants are awarded annually with most of the funding going toward the national competitive selection process. FEMA announced the availability of $500 million under the program for FY 2020.

FEMA Hazard Mitigation Grant Program

FEMA also offers a **Hazard Mitigation Grant Program** to fund projects in areas under a Presidential Major Disaster Declaration that are determined by the state's governor. The program provides funding for disaster areas depending on the amount of disaster assistance required for the designated area. State governments apply for the funding and then award funding to sub-applicants. Qualifying uses of this funding include infrastructure retrofits that mitigate risk to existing utility systems. Microgrid projects that can prove they fit this category may be able to be awarded funding for development.

Housing and Urban Development Community Development Block Grant

The US Department of **Housing and Urban Development** (HUD) offers grants to redevelop infrastructure damaged by natural disasters. Eligible projects include green infrastructure projects or activities that allow for microgrid funding. HUD currently has $83.9 billion allocated for this program, of which $55.1 billion is in active grants. Funding can be used to supplement other federal funds for disaster relief.

State Programs

California

California established the **Electric Program Investment Charge** (EPIC) program in 2012 to provide public interest investments in applied R&D, technology demonstration and deployment, market support, and market facilitation of clean energy technologies and approaches. Through 2020, the CEC has granted 385 projects about $846 million, including $207 million for grid decarbonization and decentralization. Businesses raised $3.5 billion in private investment after receiving CEC funding.

Colorado

HB22-1013, **Microgrids For Community Resilience Grant Program**, which is pending before the Colorado General Assembly, would offer grants to cooperative electric associations and municipally owned utilities to finance the purchase of microgrid resources in eligible rural communities within the utility's service territory that are at significant risk of severe weather or natural disaster events and in which there are one or more community anchor institutions.

Connecticut

The Connecticut Green Bank's (CGB) **Microgrid Financing Program** complements microgrid funding from the Connecticut Department of Energy and Environmental Protection (DEEP). CGB offers loans of up to $2 million for microgrid projects that also received **funding from the DEEP**. Private capital could also supplement the loans if the loan amount does not fully cover the microgrid costs. In 2016, the program made its first loan of $500,000 to the City of Bridgeport to help fund its proposed microgrid.

Hawaii

Regulators in May 2021 became the second state in the US to approve a **microgrid services tariff**, which will facilitate microgrid development in the state, primarily through the state's primary utility Hawaii Electric. Hawaii is now evaluating how microgrids can provide services in nonemergency situations, as well as how customers providing power to the grid would be compensated.

Maryland

In 2022, the Maryland Energy Administration (MEA) launched its **Resilient Maryland Capital Development Pilot Program** to help offset the costs of analyzing, planning and designing clean and resilient DER. For 2022, the MEA is seeking projects that pursue creative solutions, incorporate innovation, explore potentially replicable and scalable project models, and enhance energy equity to communities. Maryland expects to distribute $300,000.

Massachusetts

Massachusetts microgrid legislation focuses on increasing renewable energy, mitigating climate change impacts, and making microgrids more accessible to local towns and municipalities. In 2018, the state **distributed grants** of $75,000 each to 14 microgrid projects for microgrid feasibility studies to encourage microgrids that lower customer energy costs, reduce GHG emissions, and increase energy resiliency.

Michigan

Michigan's **MI Power Grid**, which was launched in 2019, is a multi-year stakeholder initiative supported by the state's Public Service Commission (PSC) to maximize the benefits of the transition to clean, DER for residents and businesses, including the integration of new energy technologies such as microgrids. Regulatory efforts have been hampered by the COVID-19 crisis, however the PSC hosted multiple working groups related to grid modernization during 2021.

New Jersey

Most New Jersey microgrid legislation has focused on evaluating microgrids as a possible solution to long-duration outages. The state allocated more than $2 million to 13 microgrid projects for feasibility studies under its **Town Center DER Microgrid Program**. In 2021, the state approved an additional $4 million to push those projects forward with detailed designs, including more than $1 million for a 20 MW project in Atlantic City.

New Mexico

HB 245, which was signed into law in April 2021, clarifies that grid modernization projects may include distribution system hardening projects for circuits and substations designed to reduce service outages or service restoration times. The projects can include microgrids that support circuit-level grid stability, power quality, reliability or resiliency or provide temporary backup energy supply.

New York

Legislation has focused on microgrids that support critical facilities and disadvantaged communities. In 2015, New York launched its **New York Prize** competition to offer funding to independent, community-based electric distribution systems. Stage 1, which focused on funding feasibility studies, drew 83 microgrid proposals funded at $100,000 each. Stage 2 approved up to $1 million for 10 designs.

Rhode Island

Following multi-day power outages due to severe weather events in recent years, the Rhode Island Office of Energy Resources is seeking consultant support for design of a program – **Resilient Microgrids for Critical Services** – intended to enhance the energy assurance of critical infrastructure through deployment of DER and other means. A **report** published in 2017 describes technologies, procurement strategies, and polices that can contribute to microgrid development.

Tennessee

SB 795, signed into law in April 2021, authorizes local governments to establish commercial property assessed clean energy and storm resiliency programs to ensure that owners of agricultural, commercial, industrial, and multifamily residential properties can obtain low-cost, long-term financing for qualifying improvements, including microgrids.

Texas

State legislative activity focusing on grid resilience picked up considerably following the major winter weather events of February 2021. Regulators opened several dockets to consider grid resilience and wholesale market design, while utilities filed proposals to deploy AMI.

Washington

The state's **Clean Energy Fund** (CEF), established in 2013 to provide funding to utilities for grid modernization projects, has awarded grants totaling more than $38 million in the past four years. In August 2021, the CEF announced $3.9 million in grants to design and build 18 grid modernization projects, including nine that include microgrids.

Wisconsin

The **Critical Infrastructure Microgrid and Community Resilience Centers Pilot Grant Program**, implemented in June 2021, offers grants for innovative pre-disaster mitigation through critical infrastructure microgrids and other resilient building strategies by studying the feasibility of the deployment of DER and appropriately sized storage. **Sixteen applications were submitted** totaling $962,695. Individual grant requests ranged from $17,865 to $100,000.

Acronym and Abbreviation List

Battery Energy Storage System .... BESS

Combined Heat & Power .... CHP

Commercial and Industrial .... C&I

Distributed Energy Resources .... DER

Electric Vehicle .... EV

Megawatt .... MW

National Renewable Energy Laboratory .... NREL

Office of Community Sustainability .... OCS

Photovoltaic .... PV

Point of Common Coupling .... EV

Power Management System .... PPA

Power Purchase Agreement .... PPA

Schneider Electric .... SE

Virtual Power Plant .... VPP

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Scope of Study

Guidehouse Insights has prepared this white paper, commissioned by Schneider Electric, to provide a step-by-step guide for prospective microgrid customers to understand the process and the value of engaging in a feasibility study. The white paper describes in a detailed manner each step along the customer journey of evaluating whether a microgrid can meet the customer's needs – and what cost. Along with data on microgrids costs and key component categories, the white paper includes case studies as well as recommendations. An Appendix is also included listing federal and state programs that may offer funding for microgrid feasibility studies.

Sources and Methodology

Guidehouse Insights' industry analysts use a variety of research sources in preparing research reports and white papers. The key component of Guidehouse Insights' analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Guidehouse Insights' analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Guidehouse Insights' reports. Great care is taken in making sure that all analysis is well-supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

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