MICROGRID KNOWLEDGE

The Rise of Clean Energy Microgrids

Why microgrids make sense for hospitals, higher education, military & government, and businesses

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Contents

Chapter 1

Why Choose a Clean Energy Microgrid?

Interest is rising in the clean energy microgrid, especially within healthcare, higher education, government and business.

What's the attraction?

All microgrids offer greater electric reliability. But the clean energy microgrid does more. It also reduces carbon emissions and helps organizations reach sustainability goals—an achievement increasingly valued by the healthcare community, business customers, government constituents, and college students, parents and donors.

How do they do this?

Clean energy microgrids produce electricity, and sometimes heat, using some combination of renewable energy, combined heat and power (CHP), and energy storage. In doing so, they are part of vibrant green trend sweeping the energy sector.

In fact, renewable energy now provides almost one-fifth of U.S. electric generation, and federal analysts forecast that it will be the fastest growing source of electricity over the next two decades. Meanwhile, energy storage is expected to grow almost seven-fold in just five years, according to research firm IHS.

Demand for CHP continues, too, as institutions and businesses seek out ways to make their energy supply increasingly efficient. This tried-and-true resource reuses a heat byproduct of electric generation that otherwise goes to waste in conventional power plants. Today, CHP represents eight percent of U.S. electric capacity, but has much more potential.

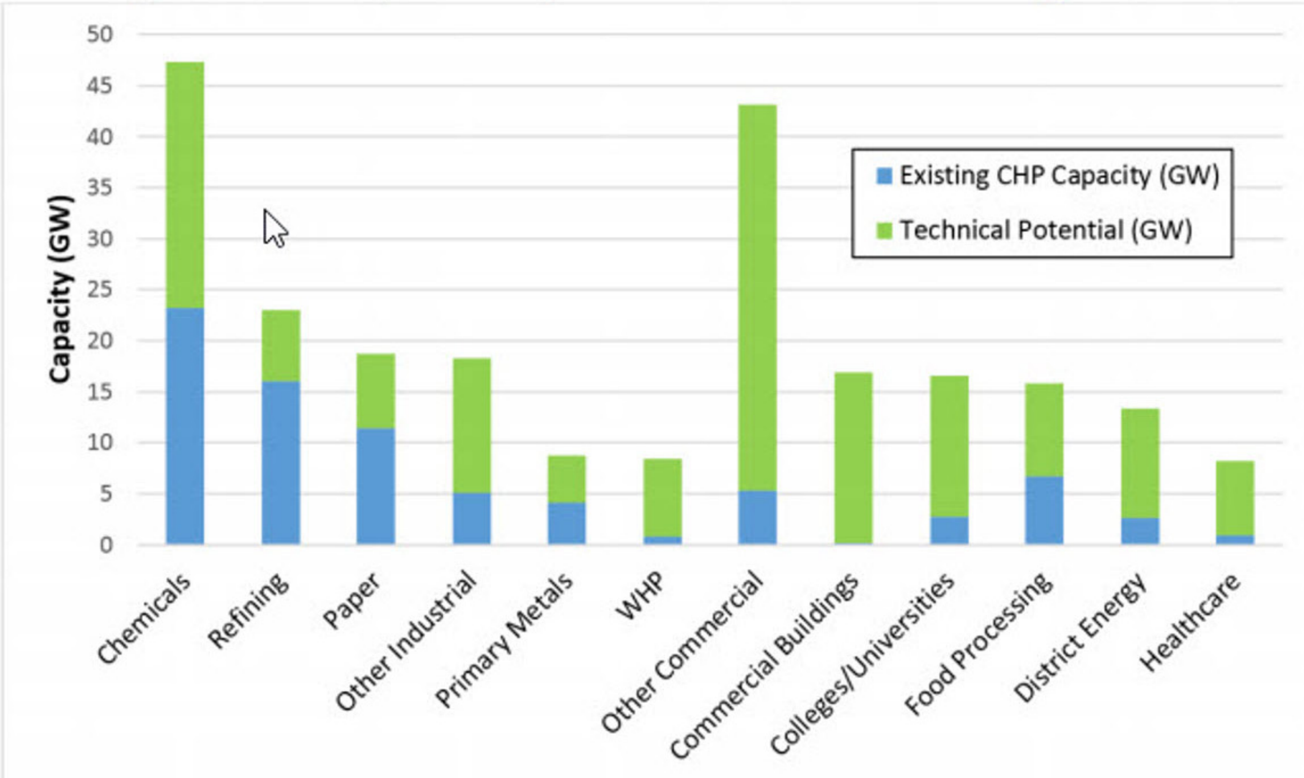
What is a microgrid?

Microgrids are small, advanced electric grids with features that make them especially adept at managing energy and ensuring its reliable delivery. Self-sufficient, a microgrid serves a discrete geographic footprint, such as a college campus, hospital complex, business center, or military base.

Within microgrids are one or more kinds of distributed energy (solar panels, wind turbines, CHP, generators) that produce its power. In addition, many newer microgrids contain energy storage, typically from batteries. Governed by advanced software, microgrids are highly adept at managing resources to achieve a customer's energy goals, whether they be based on pricing, emissions, reliability, or other priorities.

Microgrids are most distinguished by their ability to island from the central grid during an outage and continue to supply electricity to customers. For more see, "What is a Microgrid?"

Existing CHP Compared to CHP Technical Potential by Sector



U.S. DOE CHP Deployment Program, 2016

The growing use of microgrids is expected to hasten development of CHP. Navigant Research sees CHP use in microgrids nearly tripling from 655 MW in 2017 to 1,906 MW in 2026.

"Modern microgrids are a global phenomenon riding parallel currents of technology, climate, and policy change—and they may represent the biggest new opportunity for CHP in decades," says Adam Forni, senior research analyst at Navigant Research. "In a growing symbiotic relationship, CHP brings mature baseload generation capability, while microgrids open new markets and improve integration with other distributed energy resources."

When incorporated into a microgrid, the benefits of CHP —as well as renewables—heighten.

Keeps the power flowing during a grid outage

First and foremost, a clean energy microgrid keeps the power flowing even when the central grid fails. Having on-site energy, alone, doesn't necessarily achieve this. Many of those with solar panels are disappointed when they discover they cannot use their solar energy as backup during a power outage. That's not the case if the solar panels are part of a microgrid. The microgrid will ensure continued supply of electricity.

This is one of the reasons installation of microgrids is growing in the U.S.—and worldwide. Again citing Navigant's work, the microgrid market is expected to grow about five-fold, from 1.4 GW in 2015 to 7.6 GW in 2024 under a conservative estimate.

Recent hurricanes and cybersecurity threats have accelerated the call for this kind of energy. But there is another big factor too: energy cost management.

The newer, cleaner generation sources used in microgrids are dropping rapidly in price, increasing their appeal, especially in parts of the U.S. where grid electricity is costly. Solar costs have fallen steadily for years and are expected to drop another 27 percent by 2022, according to GTM Research. For some uses, battery costs fell as much as 70 percent in the last year. At the same time, natural gas prices—often used in CHP—remain at historic lows.

Microgrids as energy price managers

There is another reason, too, that price-conscious customers—especially those in costly areas like the Northeast and California—are turning to microgrids. Advanced microgrid software and control technology can be programmed to leverage best prices. Without any human intervention, these microgrids choose among their internal resources, or between their resources and grid power, depending on which resource offers best pricing at any given point in time.

While the advantages of a clean energy microgrid are many, awareness of the technology remains limited. To help increase understanding about clean energy microgrids, Microgrid Knowledge and Ameresco have produced *"The Rise of Clean Energy Microgrids: Why microgrids make sense for hospitals, higher education, military & government and businesses."* We welcome you to download the report, and distribute the link widely, especially to those in the important sectors we focus on: healthcare, higher education, government and commercial and industrial operations.

U.S. Electricity Prices for the Commercial Sector 2017 (cents/kWh)

STATE	JAN 2017	STATE	JAN 2017	STATE	JAN 2017
New England	**15.02**	**South Atlantic**	**9.41**	**Mountain**	**8.96**
Connecticut	15.60	Delaware	9.78	Arizona	9.66
Maine	12.37	District of Columbia	11.76	Colorado	9.17
Massachusetts	15.29	Florida	9.48	Idaho	7.43
New Hampshire	14.32	Georgia	9.80	Montana	9.89
Rhode Island	15.58	Maryland	11.17	Nevada	7.77
Vermont	14.34	North Carolina	8.41	New Mexico	9.39
Middle Atlantic	**12.03**	South Carolina	10.14	Utah	8.07
New Jersey	11.96	Virginia	8.02	Wyoming	9.19
New York	13.87	West Virginia	9.57	**Pacific Contiguous**	**12.23**
Pennsylvania	9.00	**East South Central**	**10.44**	California	13.99
East North Central	**9.73**	Alabama	11.50	Oregon	8.72
Illinois	8.30	Kentucky	9.48	Washington	8.37
Indiana	10.10	Mississippi	10.12	**Pacific Noncontiguous**	**22.15**
Michigan	10.84	Tennessee	10.42	Alaska	18.33
Ohio	9.67	**West South Central**	**7.91**	Hawaii	26.35
Wisconsin	10.73	Arkansas	8.01		
West North Central	**8.86**	Louisiana	7.64		
Iowa	8.67	Oklahoma	7.82		
Kansas	9.74	Texas	7.96		
Minnesota	9.57				
Missouri	8.10				
Nebraska	8.40				
North Dakota	8.76				
South Dakota	8.94				
				U.S. TOTAL	**10.19**

The microgrid price proposition is most favorable in states with high cost grid power. Credit: Energy Information Administration, Electric Power Monthly, March 24, 2017

Chapter 2

Clean Energy Microgrids for Hospitals

In most businesses, costs are a paramount concern. Hospitals are not most businesses.

At a hospital, loss of electricity can lead to loss of life. So for hospitals, reliable electricity has a very high value. That makes hospitals prime candidates for the installation of clean energy microgrids.

That was brought home in 2013 after the terrorist attack at the Boston Marathon. Area hospitals were pushed to their limits, and that changed the perspective of many administrators. One area hospital was contemplating the installation of a CHP plant as part of a new facility. Typically, the decision to move forward with such a project would be heavily weighted on the economic benefit. But after the attack, this particular hospital "saw things in a whole different light," says Michael Bakas, senior vice president at Ameresco. Economics were no longer the primary driving force. Instead, the first concern was the ability to act as a last line of defense for the city in a crisis. The hospital could not lose its power; it had to be able to "island" or operate independently from the surrounding grid should disaster strike.

Unfortunately, that is a lesson that has been driven home several times in recent years—whether it is the Boston terrorist attack, the record flooding in Houston from Hurricane Harvey, the devastation in Florida from Hurricane Irma, the destruction of Puerto Rico's grid from Hurricane Maria, or the near shut-down of New York City from Hurricane Sandy. Hospital administrators have had ample chance to gain firsthand experience of the importance of uninterrupted electrical service.

Existing safety regulations already require hospitals to have some form of backup generation, such as diesel generators. But when Sandy slammed into New York City in 2012, backup generators and other electrical systems failed at Bellevue Hospital, New York University's Langone Medical Center, and at Coney Island Hospital, resulting in the evacuation of hundreds of patients during the storm. More recently, Hurricane Maria left hospitals in Puerto Rico unable to operate on patients, and undertake other critical procedures, because generators ran out of diesel fuel.

Backup generators may fulfill regulatory requirements, but they do not always perform when they are needed. In the 2003 Northeast blackout, half of New York City's 58 hospitals suffered failures in their back-up power generators, according to the U.S. Environmental Protection Agency.

Part of the problem is that backup generators sit idle most of the time. Despite regular testing, they can fail when needed. Hospital microgrids, on the other hand, include some form of generation that operates on a regular basis, avoiding surprises when an emergency does hit.

Heat and power from one fuel

Many microgrids, for instance, incorporate CHP, which both generates electricity and provides steam and hot water for uses such as heating and sterilization. CHP plants often run all day, every day of the year. During Sandy they proved their worth. Co-op City, a massive residential and commercial development in the Bronx was able to keep the lights on and residents warm throughout Sandy by relying on its microgrid, which has a 40-MW CHP plant.

In Manhattan, New York University's microgrid kept parts of the campus up and running due to its CHP plant. And in New Jersey, Princeton University's microgrid did the same, relying on a 40-MW CHP plant kept thousands of apartments and dozens of businesses and schools running for nearly two days.

> *Hospitals that use a lot of steam, hot water, air conditioning and heat often benefit from CHP, which allows them to get two forms of energy from one clean fuel. CHP plants use the waste heat created in power generation, a byproduct typically discarded. This makes CHP a highly efficient form of energy.*

Those were among the motivations when the New York State Research and Development Authority instituted the NY Prize, a program to aid the implementation of microgrids for critical facilities in the state. More than half of the 11 communities that were finalists in the $40 million program included hospitals in their projects.

The Town of Huntington on Long Island, one of the award recipients, is building a microgrid at Huntington Hospital with a 2.8-MW fuel cell and a battery storage facility that will enable the microgrid to island from the grid. The Buffalo-Niagara Medical Campus, another NY Prize recipient, is strengthening its existing backup generators with a new CHP system, solar panels and battery storage to enable islanding.

Environmental and monetary benefits of hospital microgrids

While resilience and reliability may be compelling reasons, they are not the only motivation behind hospitals' adoption of clean energy microgrids. According to a 2013 survey conducted by Johnson & Johnson, nearly 90 percent of hospitals reported that they were incorporating sustainability into their planning process. Because of their software intelligence, microgrids are able to manage a hospital's energy resources, so that the cleanest generation is used first.

Being a good citizen is part of the rationale, but the falling prices for solar panels and battery storage makes choosing a microgrid a wise economic decision, as well.

That is particularly true as hospitals face growing budgetary concerns. Hospitals are heavy energy users, making them particularly vulnerable to rising energy costs. Even though hospitals account for less than 1 percent of all U.S. commercial buildings, they account for 5.5 percent of commercial building energy usage.

In addition to providing resiliency and reliability, an intelligent hospital microgrid can monitor grid electricity prices throughout the day and switch to its own lower cost energy when grid prices spike. By shaving the top off those energy peaks, a hospital can also lower its demand charges because those charges are based on peak usage.

Taking the first step in installing a microgrid could impose a hefty financial burden on a cash strapped hospital, but the rising popularity of microgrids has spurred financial innovations that can ease that burden.

By signing a power purchase agreement with a microgrid developer, for instance, a hospital pays only for the energy it uses from the microgrid and shares any savings while the developer handles installation and operation and maintenance.

Hospitals are just one of society's pillar organizations turning to clean energy microgrids. Higher education is another. We explain why in the next chapter.

Chapter 3

Clean Energy Microgrids for Colleges and Universities

Colleges and universities were among the first institutions to embrace microgrids—and that's not surprising considering how well the technology is suited to campuses.

There are now university microgrids across the country, from Wesleyan University in Connecticut to the University of California at San Diego (UCSD).

> *Instead of burning fuel to make steam, a university can burn a single fuel to make both electricity and steam, raising the efficiency of the system and saving money in the process.*

Princeton University's microgrid kept the lights on when Hurricane Sandy slammed into the East Coast in 2012 even as much of New Jersey remained in the dark.

UCSD's microgrid supplies the university with about 92 percent of its electricity, but it is also set up to pull energy from the grid and can, if needed, separate from the grid and operate autonomously, what is known as "islanding."

One of the biggest microgrids in the country is at the University of Texas at Austin. It includes a 135-MW CHP plant that produces electricity and steam, as well as a chilled water plant, a 36,000 ton-hour thermal energy storage tank, and six miles of pipes to distribute hot water and steam. It can provide all of the university's power, heating and cooling needs.

There are many reasons why universities were among the early adopters of microgrids. The most obvious is that a university has a large and well-defined load on the grid and many campuses have historically had a physical plant to supply steam for heating. That makes them an easy candidate for upgrading to a CHP microgrid. Instead of burning fuel to make steam, a university can burn a single fuel to make both electricity and steam, raising the efficiency of the system and saving money in the process.

Squeezing efficiencies out of its CHP plant has allowed UT Austin to expand the size of its campus by millions of square feet without using more fuel, or emitting more carbon dioxide than it did in 1976.

Clean energy microgrids boost sustainability, protect research

Sustainability is also an important aspect of a university microgrid. Universities want to be good corporate citizens, and their students expect them to be. With growth slowing in college enrollment, it's important for a university to remain attractive to environmentally conscious students. By replacing an old diesel or coal-burning boiler with a CHP microgrid, a university can cut its emissions. If the university uses a fuel cell or adds solar panels to its clean energy microgrid, it can lower emissions even further.

Research in medicine and the life sciences can involve specimens that need to be kept cold indefinitely. Losing power is not just an inconvenience, it could mean losing years of work.

UCSD's microgrid incorporates a fuel cell powered by biogas, solar panels and electric vehicle (EV) charging stations. By enabling EV charging during periods of peak demand, the university's microgrid can further contribute to the greening of the grid as a whole by absorbing excess solar generation from the system of its host utility, San Diego Gas & Electric.

Another part of the equation, especially for research universities, is reliability. In particular, research in medicine and the life sciences can involve specimens that need to be kept cold indefinitely. For them, losing power is not just an inconvenience, it could mean losing years of work.

At UT Austin, 80 percent of the campus is dedicated to research that is valued at $500 million. "If a professor loses a transgenic mouse with 20 years of research built into it, that's a nightmare," Juan Ontiveros, the university's executive director of utilities and energy management, told Microgrid Knowledge. That adds to the value of the UT Austin's microgrid, which has delivered 99.9998% reliability over the last 40 years.

Microgrids are also attractive to universities as platforms for other types of research. UT Austin uses its microgrid for research projects for the Navy and on isolated power systems. The university's microgrid also serves as a platform for showcasing new distributed energy technologies. Other higher education microgrids double as educational tools for students in the engineering and environmental sciences.

Microgrids and campuses are a natural fit

There is another reason why colleges and universities are apt to embrace microgrids. Campuses, by their nature, are naturally suited to the technology. Microgrids offer local generation that can be distributed efficiently among several buildings located within a discrete geographic footprint. Further, because the college or university owns the land, the microgrid escapes certain regulatory burdens. For example, utilities prohibit privately owned electric distribution wires from crossing their rights of way without their permission. As bounded entities, colleges and universities are spared this problem when a microgrid serves multiple buildings on the campus.

Not to be forgotten, microgrids offer a road to good management of an institution's energy budget. Governed by highly intelligent energy software, microgrids can be programmed to provide the most efficient, least cost energy first. In addition, they offer potential revenue opportunities. Microgrids, for example, may sell services to the electric grid, such as capacity or grid balancing.

Clearly, clean energy microgrids can serve many purposes in higher education. They can ensure electric service, contribute to sustainability goals, and create a cost-effective energy supply.

Developing microgrids for colleges and universities: First step

How to get started?

The first step is to evaluate the campus' existing energy infrastructure, model its energy usage patterns and analyze the financial implications of micro-gridding all or part of the campus. Some colleges and universities begin by applying the microgrid to only its critical infrastructure, and then expanding the system as time and capital allow. If the campus has existing on-site generators, such as solar panels, CHP or diesel generators, it may be able to incorporate them into the microgrid—which can decrease capital expenses significantly.

A knowledgeable and experienced microgrid developer will guide the institution through this important early modeling.

The U.S. military has been another early adopter of clean energy microgrids, as we'll describe in Chapter 4.

Chapter 4

Clean Energy Microgrids for the Military

Mission critical is a phrase almost synonymous with military operations, and in an increasingly electrified world, critical missions cannot be accomplished without electricity. Today's military needs electricity for everything from logistics and communications to vehicle repair and field hospitals.

The U.S. Department of Defense (DOD) recognized its vulnerability to the flow of fossil fuels years ago and instituted programs to reduce its reliance on those fuels, often replacing them with cleaner and more sustainable sources of energy.

Across all branches of the military, the DOD has a goal of meeting at least 20 percent of its demand with renewable resources by fiscal year 2020. By that same date, the DOD is also looking to reduce facility energy intensity by 37.5 percent and decrease non-combat greenhouse gas emissions by 34 percent.

Microgrids are resilient because they can "island," that is, separate from the grid and operate autonomously during a natural disaster—think of Hurricane Harvey or Irma—or other emergencies, enabling the uninterrupted flow of power.

Concerns about energy security are not new among the top military brass. The military has long used backup generators and small, isolated, self-contained grids in remote locations to ensure operational integrity. But the advent of the modern microgrid has changed the way the military and the federal government approach reliability and sustainability.

"The desire to meet renewable energy goals turns a light on in people's' heads. They say, 'While we are doing this, can't we use this to power our facility in case of an outage?'" says Anthony Colonnese, vice president of energy security solutions at Ameresco.

Weaving in reliability with military microgrids

For instance, a military base could plan to install solar panels for some portion of its load and to help meet its renewable goals and realize that solar power could also make the base more resilient and self-sufficient.

"The trick is to take something like solar power, which is a variable generation source, and to make an application to weave that into reliability," Colonnese says.

The Navy was one of the first branches of the military to embrace microgrids. Not only did the Navy build a microgrid in San Diego, it linked three microgrids together, one at the hospital at Naval Base San Diego, another at a data center at Naval Base Coronado, and the third at Naval Base Point Loma.

The Navy identifies three main benefits it derives from microgrids: energy resilience, energy security, and cost savings.

Microgrids are resilient because they can "island," that is, separate from the grid and operate autonomously during a natural disaster—think of Hurricane Harvey or Irma—or other emergencies, enabling the uninterrupted flow of power.

Much of the U.S. power grid relies on technology that dates back to the 1960s and 1970s, making it vulnerable to both physical and cyber attacks. Microgrids can be built from the ground up using the most up-to-date cyber security protocols.

Cost of power outages to the military

The DOD reported 114 utility power outages that affected military installations and lasted eight hours in fiscal year 2014. Those outages cost the DOD $246,000 per day. Military microgrids can provide cost savings by helping to avoid losses due to outages. Microgrids can also help reduce electricity bills, if they are programmed to switch to lower cost local generation sources when grid power prices spike.

In 2011, the DOD joined with the Department of Energy and the Department of Homeland Security to launch the Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) project. The aim was to demonstrate a secure microgrid architecture able to maintain operational integrity at military installations. The program resulted in three microgrids that function as permanent energy systems at Joint Base Pearl Harbor-Hickam in Hawaii, at Fort Carson in Colorado, and at Camp Smith in Hawaii.

According to a Navy report the SPIDERS program met all of its operational objectives. The microgrids withstood a simulated "red team" attack, improved reliability and efficiency—resulting in a 30 percent reduction in fossil fuel usage, and enabled the successful integration of renewable energy resources while providing a platform for future cost reductions.

The solar panels of the Alcatraz microgrid have cut fuel consumption at the facility by 45 percent since they were installed in 2012. The facility is naturally islanded, and high fuel costs were one of the main reasons why the prison closed in 1963.

Other microgrid applications for government

The military isn't the only branch of the government pursuing microgrids. Alcatraz, the former prison in San Francisco Bay now run by the National Park Service, is home to one of the largest microgrids in the country. The solar panels of the Alcatraz microgrid have cut fuel consumption at the facility by 45 percent since they were installed in 2012. The facility is naturally islanded, and high fuel costs were one of the main reasons why the prison closed in 1963.

Overall, federal buildings consume $6.5 billion in utilities every year, including $400 million spent directly by the General Services Administration. Like the military, the GSA is trying to improve efficiency, lower emissions and reduce costs at the buildings it manages. Between 2003 and 2014, the GSA reported a 23.54 percent reduction in energy consumption.

Microgrids are one of the tools the GSA is using to meet those goals. In Washington, D.C. the GSA is looking at using a microgrid as part of an upgrade of a large block of buildings it operates.

Among the GSA's goals are increasing the comfort of occupants, ensuring reliability, improving the ability to engage in sophisticated demand-side management measures, and even winning LEED Gold certification. The U.S. Treasury building, built in 1836, won a LEED Gold certificate and reduced its annual operating costs by $3.5 million.

"One of the first things to do when looking at installing a microgrid is to find ways to reduce load. If you can get your load down, your overall costs are going to be different."

– Anthony Colonnese, Vice President of Energy Security Solutions, Ameresco

Despite the many benefits of microgrids, even within the government and the military with its high priority on mission critical performance, the biggest barrier to implementation is still costs.

How to pay for energy security

"Everyone is interested in having energy security, but it can be difficult to budget the money," says Colonnese. One way to approach the problem, he says, is to combine conservation and energy efficiency with resiliency in order to enable the combined package to pay for itself out of savings. One of the first things to do when looking at installing a microgrid, he says, is to reduce load. "If you can get your load down, your overall costs are going to be different."

Goals should also be looked at in perspective, says Colonnese, by "clarifying what you are looking to back up or protect."

No one wants to be without power—and some operations cannot withstand even a momentary loss of power—but for some uses, it could be acceptable to be without power for five minutes. "There is a huge cost to having power be seamless," says Colonnese.

There is not a single answer when it comes to designing a reliable, secure and cost effective microgrid, he says. "It is a process." And it's one the military and federal government have been undertaking in earnest, acting as early leaders not only in demonstrating microgrid technology, but also in readying for use by the commercial and industrial sector, as described in the next chapter.

Chapter 5

Clean Energy Microgrids for the Commercial and Industrial Sector

A growing number of corporations are going green. According to the Rocky Mountain Institute, nearly two-thirds of Fortune 100 companies and nearly half of Fortune 500 companies have set ambitious renewable energy targets.

They use a variety of ways to meet those goals, but increasingly corporations are looking for additionality in their sustainable portfolio. That means they are no longer content to buy renewable energy credits (RECs) and claim success. They want their efforts to have more impact. They are looking to invest directly in renewable energy projects that will displace plants fired by fossil fuels.

Corporations from Google to 3M are buying power directly from newly developed power projects and are even taking part in developing wind and solar projects themselves. In many cases, one of the most cost-effective ways a corporation can invest in a renewable energy project is by investing in a microgrid.

Microgrids have the ability to aggregate and control a variety of renewable resources. By including both wind and solar sources, for instance, a microgrid can overlap the intermittency of those generation streams, and by using baseload power from a CHP plant or a fuel cell, a microgrid can combine enhanced reliability with a lower emissions profile.

Unlike power supplied from a central station grid or a single renewable energy plant, “a microgrid has the flexibility to use a wide range of energy sources increasing renewable energy supply options while improving resiliency,” says Michael Bakas, senior vice president at Ameresco.

How commercial and industrial microgrids achieve a favorable payback

But even at the greenest corporation there is still a keen focus on the bottom line. Corporations have to cut costs to compete, and microgrids can help meet both goals. For a lot of corporations looking at investing in a microgrid, their top concern is payback.

There are many ways a microgrid can cut costs and contribute to the bottom line, but the first thing a business should do when looking to invest in a microgrid, says Bakas, is look at energy efficiency and demand reduction measures. A 5-MW CHP plant is far more expensive to construct and operate than a 3-MW plant, he says. “If you can reduce your energy load (possibly through a self-funded approach like energy performance contracting) thereby directly lowering your construction, operational and fuel costs of the facility, along with any additional incremental volumes of energy purchased from the grid beyond the supply of the CHP facility, why wouldn’t you?”

One of the most direct ways a commercial and industrial microgrid can be used to cut costs is as a means to hedge power prices. The system controls of a microgrid can be programmed to optimize for price. For example, a microgrid could use utility power until prices rise and then switch to its own, lower cost power. A microgrid’s ability to use a variety of generation sources—from natural gas to solar or wind power—gives it more pricing flexibility. And, because a microgrid’s generation is local, there are no line losses.

In locations where there are transmission constraints, a microgrid coupled with some distributed generation can save a company money by avoiding congestion charges. For instance, in some parts of PJM where Ameresco has energy assets, congestion pricing would have had an adverse materially effect on our client’s total energy cost but not for our projects that are helping alleviate such, says Bakas.

Future proofing with a business microgrid

“A microgrid can also give some control of its future back to a business,” says Bakas.

“Building small local generators can be accomplished much more efficiently and in a shorter time frame than waiting for a power company to build a central power station or put in a new substation, he says. “And that gives a business much more flexibility to expand their plant on their own time line.”

But one of the biggest values a microgrid can provide can be harder to quantify. Microgrids can enable a business to weather a storm or continue to run when the utility grid loses power. When disaster strikes, the value of resiliency and reliability rises astronomically.

“Placing a value on resiliency can make or break a business case,” says Bakas. One of Ameresco’s clients, BMW Manufacturing Corporation of North America, maintains their largest manufacturing plant in the world in South Carolina. In 2016 BMW manufactured 400,904 cars at its Spartanburg facility. Assuming an average sale price of $55,000 per car, losing power for one day could cost more than $60 million. "They cannot afford, nor will they tolerate, disruption of service; their product is their life line," says Bakas.

The same is true for a supermarket chain, as some learned during Hurricane Sandy. Losing power for four hours could mean throwing away as much as $400,000 of food per store.

Dairy manufacturer HP Hood installed a 15 MW microgrid at its facility in Winchester, Virginia, to ensure it could continue to operate if the surrounding grid went down. Even a short loss of power requires the plant to shut down for up to 12 hours to re-sterilize its equipment. The prospect of lost income was a compelling reason to set up the microgrid, but Hood was also driven by the prospect of cutting costs and even being able to generate income by selling ancillary services into the PJM Interconnection's wholesale power market.

A good example of how a commercial and industrial microgrid design can come together is the project being built at the Philadelphia Navy Yard. The 35-MW microgrid includes a peaking plant plant that will enable it to island from the grid, generate revenue by selling voltage, frequency, and power quality management services to PJM, and the project is expected to reap over 61,000 MWh in energy savings over the course of the microgrid's life.

Given all of the benefits microgrids offer businesses, it's little surprise that they are embracing the concept. In fact, the commercial and industrial sector is poised to install microgrids faster than any other, surpassing even early adopters like the military, according to market data collected by Navigant Research. Data centers, manufacturers, hotels, mining, resorts, airports and railways are among those choosing a technology that offers sustainability, reliability, resiliency, efficiency and favorable economics.

Chapter 6

Parris Island Microgrid Case Study

Marines must be superbly trained, well equipped, bravely led and tough enough to accomplish the mission regardless of obstacles. Their energy supply must do the same; it must be resilient.

What is performance-based contracting?

A microgrid may reduce costs over time, but for many customers the upfront investment can be daunting. However, financial mechanisms exist that spare the customer any capital costs. Energy savings performance contracting is one of the more popular of these approaches and has been used for years to finance other kinds of energy projects. Working with an experienced partner, the customer identifies ways to reduce energy use and costs—such as through certain energy efficiency practices and upgrades. The cost savings can then be used to finance the microgrid.

So when their Parris Island training facility needed a new electrical system, the Marines selected Ameresco for the job.

After a competitive solicitation, Ameresco was given the task in January 2017 to replace an outmoded legacy plant at the South Carolina base, an 8,095-acre compound where as many as 20,000 recruits train annually.

The new facility—a 10 MW military microgrid complex—is being developed under a $91.1 million energy savings performance contract through the Naval Facilities Engineering and Expeditionary Warfare Center.

The Parris Island microgrid promises to not only ensure reliable and secure energy, but also reduce lifecycle operating costs and mitigate electric commodity price volatility. Its resources will include:

- 3.5 MW natural gas-fired combined heat and power (CHP) plant
- 6.7 MW-DC of solar photovoltaic (PV) panels
- 8 MWh of battery energy storage
- 3.5 MW backup diesel generators
- Two 30,000 lb/hour dual fuel backup boilers

The microgrid's primary mission is to provide continuous on-site energy in the event of a central grid failure. If utility power goes down, the microgrid's intelligent controller automatically disconnects or "islands" from the central grid and turns on its onsite generators to power the base.

With the new CHP plant, the base will be able to eliminate use of an aging, inefficient and highly polluting fuel oil #6 central steam plant. The PV arrays and lithium-ion battery energy storage system will add a layer of resilience to the microgrid. The batteries will capture and store over 1.1 million kWh of excess from the PV generation for later use. This will allow the base to reduce power and energy purchases from the utility.

The new facility also will serve the full steam needs of the base during normal, or "grid-connected" operations. This too will allow the base to offset utility energy purchases.

However, the microgrid's primary mission—which sets it apart from standard power production—is to provide continuous on-site energy in the event of a central grid failure. If utility power goes down, the microgrid's intelligent controller automatically disconnects or "islands" from the central grid and turns on its onsite generators to power the base.

To ensure optimal orchestration of the generation assets, the microgrid controller will monitor and coordinate the dispatch. When load shedding is necessary, the controller will determine where to reduce or shut off power, based on the base's priorities, as well as power and energy conditions at the time. The software also is responsible for re-connecting the microgrid after islanding and checking the health of the utility connections.

Energy and water efficiency upgrades to 121 Parris Island buildings round out the project. Ameresco is installing more than 29,000 high-efficiency LED-based fixtures and retrofits to replace existing lighting systems. The energy efficiency lighting will reduce annual maintenance costs.

Other improvements include upgrades to the energy monitoring and controls system (EMCS), heating ventilation and air conditioning, chillers, cooling towers, lighting controls, water fixtures and steam traps.

These EMCS upgrades will improve overall energy efficiency and system performance and optimize building operations and maintenance. This in turn will extend the operating lifespan of mechanical and electrical equipment, leading to lower utility costs, and a better quality of life for people in the buildings.

Overall, the project will revitalize Parris Island's existing infrastructure and enhance the reliability and functionality of site buildings and facilities. With the new microgrid and system upgrades Ameresco calculates that the base will annually:

- generate 10 MW of electricity on-site
- reduce its utility energy demand by 79 percent (about 384,962 million BTUs)
- reduce water use by 27 percent (74.6 million gallons)
- reduce CO2 production by 37,165 metric tons

The microgrid, authorized under a task order with the Naval Facilities Engineering and Expeditionary Warfare Center, is slated to be complete in the summer of 2019.

The Marine Corps Recruit Depot has been on Parris Island continuously for 100 years and the Navy presence dates back to the 1860s. All male recruits east of the Mississippi River and all female recruits nationwide are trained for 13 weeks at this facility.

About Ameresco

Founded in 2000, Ameresco, Inc. (NYSE: AMRC) is a leading independent provider of comprehensive services, energy efficiency, infrastructure upgrades, asset sustainability and renewable energy solutions for businesses and organizations throughout North America and Europe. Ameresco's sustainability services include upgrades to a facility's energy infrastructure and the development, construction and operation of renewable energy plants. Ameresco has successfully completed energy saving, environmentally responsible projects with federal, state and local governments, healthcare and educational institutions, housing authorities, and commercial and industrial customers. With its corporate headquarters in Framingham, Mass., Ameresco has more than 1,000 employees providing local expertise in the United States, Canada, and the United Kingdom. For more information, visit www.ameresco.com.