DATA CENTER Frontier Special Report

The State of the Grid: Improving Energy Solutions for Evolving Digital Infrastructure Power Needs

Microgrids are the new highly resilient, carb-neutral backup generation for today's technology ecosystems

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The State of the Grid: Improving Energy Solutions for Evolving Digital Infrastructure Power Needs

Executive Summary

The electric grid is more than just generation and transmission infrastructure. It is an ecosystem of asset owners, manufacturers, service providers, and government officials at Federal, state, and local levels, all working together to run one of the most extensive electrical grids in the world. However, reliability, efficiency, and sustainability continue to be challenging as more strains are placed on our power grid solutions. How prepared are you to ensure you have the power needed to support your data center in an emergency? How confidently can you support emerging sustainable power requirements to create a greener tomorrow?

Studies show that emergency diesel generators configurations are only 80% likely to provide power for the duration of a two-week grid outage. Furthermore, with ESG requirements growing, is diesel really the future you want to invest in?

As we explore the future of power, we see that microgrids offer a much higher resiliency level and are better for the environment. Believe it or not, they can also provide improved economics. Modern microgrids quickly become the intelligent bridge between legacy power technologies and emerging power solutions.

This special report will break through some myths and legacy concepts around microgrids and today's power requirements. Also, we'll explore how microgrids can become an alternative energy source for the future, specifically, how microgrids can help with grid stabilization as a dual-purpose energy source. Finally, we'll touch on how microgrids can get you close to carbon-neutrality and how to deliver new solutions like power-as-as-service.

Introduction

Power is an absolute requirement to support critical data center (and even edge) operations. This means supporting resiliency, reliability, and staff to support power needs in remote locations. Beyond that, it's critical to work with partners who not only deliver on power but have add-on visibility and sustainability capabilities as well.

The continued data center market growth and strains on power needs are a huge challenge. Data center and business leaders must deliver more while retaining optimal efficiency. A recent U.S. Department of Energy report indicates that U.S. data centers are projected only to increase the amount of energy they consume based on current trend estimates—a trend that's been steadily rising since 2000.

Today, data centers consume several hundred terawatt-hours (TWh) each year, more than some countries' national energy consumption.

As more organizations expand their data center environments, energy efficiency and management are more closely linked. Not only are data center administrators working hard to cut costs—they're also working to minimize management overhead and improve infrastructure efficiency.

This focus on power and growth in energy consumption has also raised another critical concern: outages.

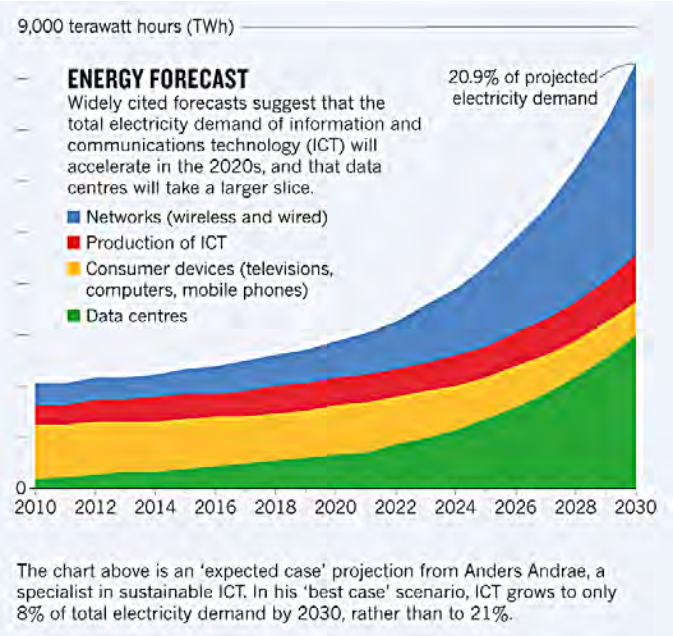
DID YOU KNOW ...

A recent NRDC report indicates that data center electricity consumption increased to roughly 140 billion kilowatt-hours annually in 2020, the equivalent annual output of 50 power plants, costing American businesses $13 billion annually in electricity bills.

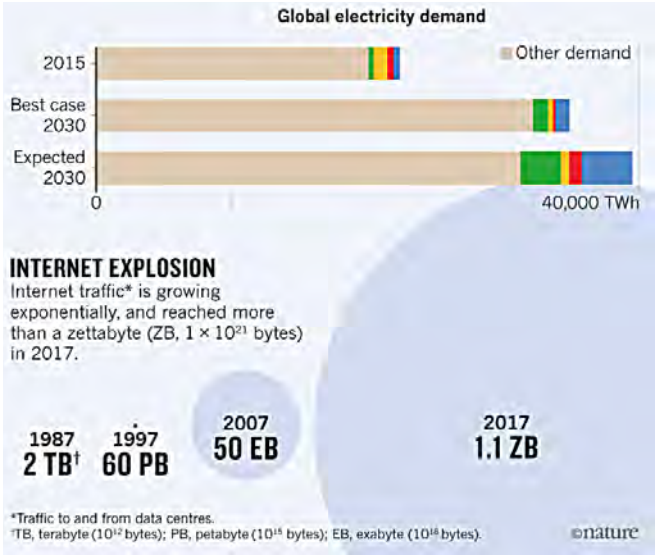
According to a 2016 Ponemon study, the average cost of a data center outage has steadily increased from $505,502 in 2010 to $740,357. Now, it averages out to about $9,000 per minute! Throughout their research of 63 data center environments, the study found that:

- The cost of downtime has increased 38% since the first study in 2010.
- Downtime costs for most data center-dependent businesses are rising faster than average.
- Maximum downtime costs have increased 32% since 2013 and 81% since 2010.

Yes, power is critical. And the delivery of that power in its various forms is also important. However, our industry is actively experiencing a shift in how we look at power delivery, sustainability, and new energy source.



The chart above is an 'expected case' projection from Anders Andrae, a specialist in sustainable ICT. In his 'best case' scenario, ICT grows to only 8% of total electricity demand by 2030, rather than to 21%.



Understanding Usage and the Power Paradigm Shift

A very recent study published in the journal Science concluded that data centers accounted for about 205 terawatt-hours of electricity usage in 2018. According to the report, the 205 terawatt-hours showed a 6% increase in total power consumption since 2010. However, over that same period, data center compute instances across the globe rose by 550%. This compute distribution represents what we see both at the core and the new *edges* of our technology ecosystems. The report noted that although the amount of power we're consuming is generally steady due to advancements in efficiency, converged infrastructure, and better power utilization, considerably more computing is still being deployed. Furthermore, the critical nature of this compute continues to increase as well, which means that the power associated with essential infrastructure becomes even more critical.

And this is where the power paradigm begins to shift. It's essential to look at power from a different perspective. Let's start with traditional generators. Sure, generators could get you up and running, but for how long? What can communities, cities, schools and universities, data centers, hyperscalers, and even edge leaders do to deploy more resilient power solutions above and beyond generators and traditional backup solutions? The other vital consideration was the intelligence and data-driven architectures behind new power delivery options.

This is where the thought process must evolve. Specifically, understanding that modern microgrids can do all of this and are now supporting a lot of different use-cases.

Microgrid Use-Cases: A quick look at modern solutions

It's important to note that microgrid solutions are entering mainstream use-cases and delivering serious benefits to resiliency, uptime, and power delivery. And the list of microgrid applications continues to grow. California wildfires have continued to cause power disruptions and PG&E has turned to microgrids to support the local power requirements. There is another use-case outside the California wildfires.

What helps power Alcatraz Island for the more than 1.5 million people that visit it annually? The answer is: one of the nation's largest microgrids, helping save more than 25,000 gallons of diesel a year while reducing the island's fuel consumption by more than 45% since 2012. How did the Texas A&M RELLIS Campus, boasting a growing list of multimillion-dollar state and national research facilities, testbeds, and proving grounds, deliver a high availability power supply for their mission? *Microgrids*.

Image Source: Enchanted Rock

Image Source: Enchanted Rock

In a traditional sense, microgrids act as a self-sufficient energy system. And they are capable of serving discrete geographic footprints, and these locations and geographies include college campuses, hospital complexes, business centers, or entire neighborhoods.

Here's what's changed: Microgrid architecture has advanced from merely delivering power to doing so intelligently. Advanced microgrids are smart and leverage data-driven solutions for software and their control plane.

With all of this in mind, let's dive into the paper and the microgrid topics at hand.

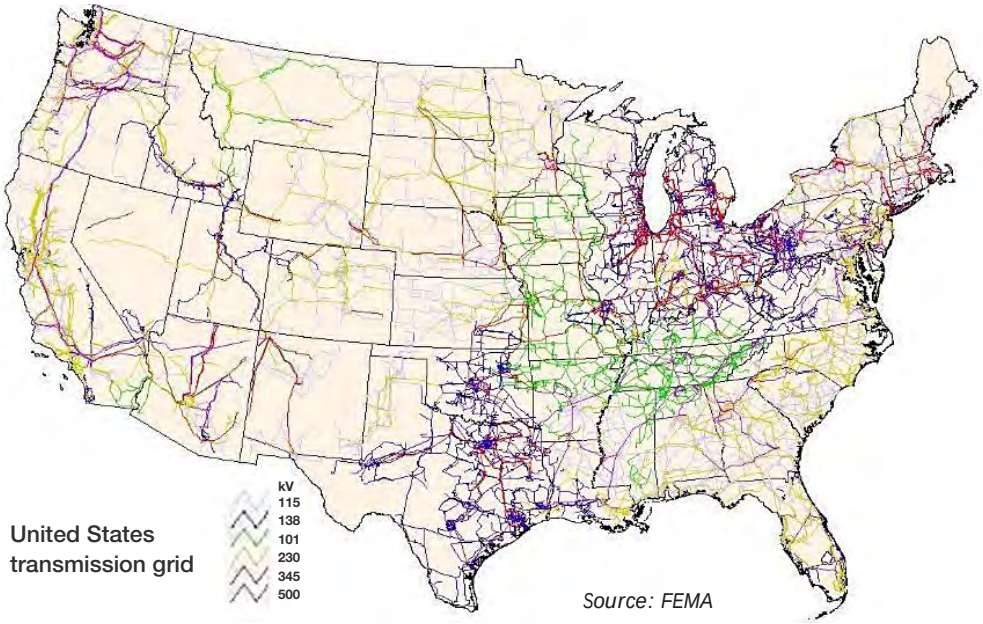
Chapter 1: The State of the Grid: Time for a Refresh

Where some believe our grid is just one giant ecosystem, that's not entirely the case. The electrical power grid that powers Northern America is not a single grid; instead, it is divided into multiple wide area synchronous grids. The Eastern Interconnection and the Western Interconnection are the largest. Three other regions include the Texas Interconnection, the Quebec Interconnection, and the Alaska Interconnection.

According to the Environmental Protection Agency (EPA), the electrical power transmission grid in the USA is made up of over 7,300 power plants. The architecture includes nearly 160,000 miles of high-voltage power lines and millions of miles of low-voltage power lines and distribution transformers, connecting 145 million customers throughout the country. It's often referred to as the most massive operating machine globally.

Source: North American Reliability Corporation

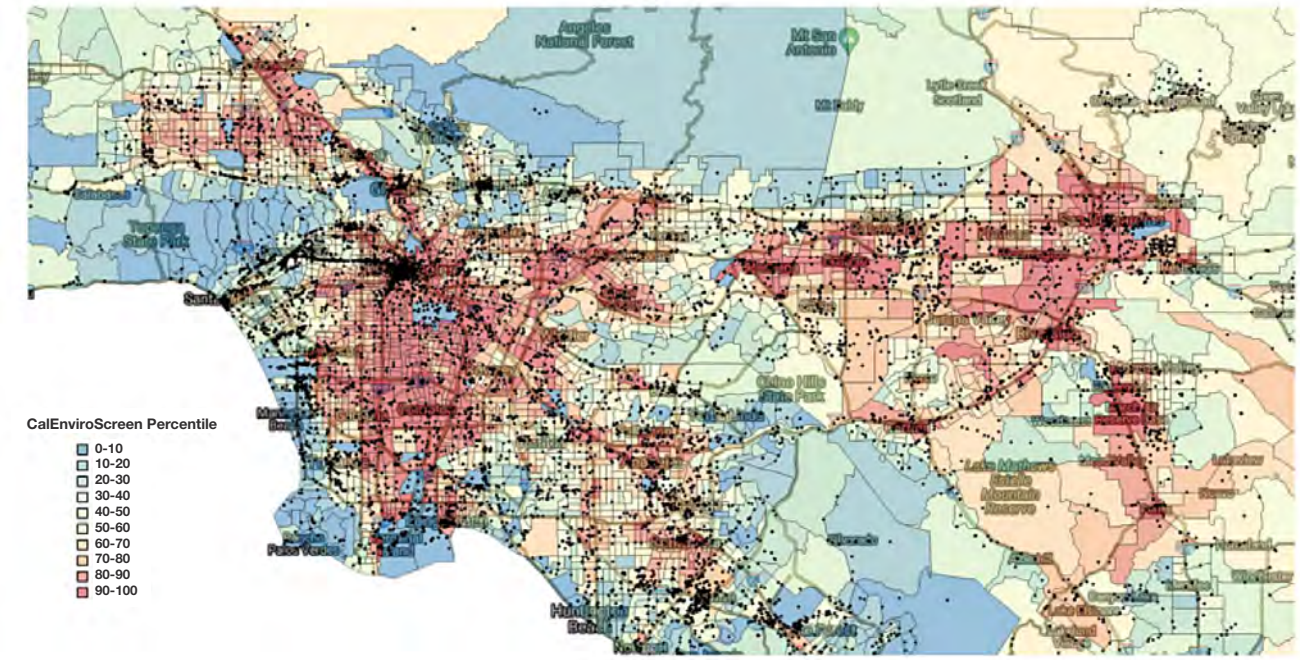
As expansive as this might be, our electric infrastructure is aging, and it is being pushed to do more than it was initially designed to do. Modernizing the grid to make it "smarter" and more resilient through the use of cutting-edge technologies, equipment, and controls, like microgrids that communicate and work together to deliver electricity more reliably and efficiently can significantly reduce the frequency and duration of power outages, reduce storm impacts, and restore service faster when outages occur.



United States transmission grid

Source: FEMA

South Coast Air Quality Management District Back-up Generators



There are almost 14,800 BUGs capable of generating 7.3 GW in South Coast. The map shows the siting of these generators in the context of CalEnviroScreen; red/orange indicates the most environmental burdened, vulnerable communities, blue/green the least.

Image Source: CaCurrent.com

Consumers can better manage their energy consumption and costs because they have easier access to their data. Utilities also benefit from a modernized grid, including improved security, reduced peak loads, increased integration of renewables, and lower operational costs.

As we mentioned earlier, the grid can certainly handle quite a bit. However, it's not perfect, and it will go down. Generally, the go-to backup method for data center leaders will be generators. Sure, generators could get you up and running, but for how long? What can communities, cities, schools and universities, data centers, hyperscalers, and even edge leaders do to deploy more resilient power solutions above and beyond generators and traditional backup solutions?

Understanding Generators and Diesel Power

Since critical infrastructure was deployed, leaders did their best to ensure that these environments stayed operational. Diesel generators were the go-to solution for hospitals, manufacturing, data centers, cities, and more for the longest time. And, for a time, they did indeed fill a specific role: ensure resiliency in times of emergencies. However, these traditional diesel generators also came with some severe challenges.

A recent study shows that in the state of California, permitted diesel backup generator systems in just two of the state's 35 air districts soared to 23,000, representing more than 12GW of power, with many more unpermitted. When fired up to keep power flowing to homes, hospitals, data centers, industrial plants and support the grid, they produce dangerous levels of toxic pollution.

California Energy Commission staff stated during a 2021 meeting that 21,000 permitted systems produce carbon dioxide emissions on par with 95,000 vehicles on the roads. This also represents about 15% of California's Grid Capacity.

Aside from pollution issues, many permitted, and unpermitted diesel generators are estimated to fail 20% of the time after a two-week gird outage. Studies by IEEE and others show that emergency diesel generators tend to fail regarding resiliency. Moreover, in some cases, the average downtime of these generators can be as high as 478.0 hours per failure. Is that something you can afford? Microgrids offer a much higher level of resiliency, and they're better for the environment. Believe it or not, they can also offer better economics.

One of the most significant differences when analyzing traditional backup generators and microgrids is when it comes to continuous operations. Simple backup generators are not microgrids. Further, these generators sit idle most of the time, except for the periodic testing and occasional power disturbance. Diesel generators that sit idle for most of the year and do not provide grid services become an expensive drag on the data center operator's balance sheet and income statement. Still, they are essential to mitigating operational risk in the data center. On the other hand, microgrids operate 24/7/365, managing and supplying energy to their customers.

Another critical point is working with greener and more sustainable power solutions. Many leading organizations have actively committed to reducing emissions and running more optimally for greener and cleaner power. However, working with traditional legacy generators can pose some serious environmental efficiency challenges. Most data center operators are in a class by themselves regarding environmental performance. Their focus on improved energy efficiency inside the data center has achieved tremendous improvement in the last decade. And the decarbonizing of energy supplies is unsurpassed by any other industry. The diesel generator fleet at most data centers runs counter to these achievements. Diesel fuel is high carbon-emitting, high particulate emitting, and higher NOx emitting than natural gas equivalent.

Like those from Enchanted Rock, new solutions significantly reduced emissions of common air pollutants and about half the carbon footprint compared to diesel. With NOx emissions of less than 1% of Standard Tier 2 diesel generation and less than 4% of Standard Tier 4 final diesel generation, *Enchanted Rock generators are a much cleaner alternative than diesel.*

Let's pause here and focus on another key topic: resiliency.

Resiliency in the Digital Age

The latest Tier 4 Uptime Institute classification of onsite power generation means data centers need to be rated for prime power delivery. Because of this, many data center leaders working with the edge, primary locations, and other sites are now looking even more closely at microgrids and other onsite power generation technologies.

A significant misconception around microgrids is that you're buying a piece of equipment, and that's it. However, modern microgrid solutions go far beyond onsite physical power solutions. New offerings revolve around microgrid-as-a-service where you as the customer never have to interact with the system.

This includes system design and engineering services, construction and commissioning, and financing. Furthermore, this includes operations as well as response field services. New as-a-service features include:

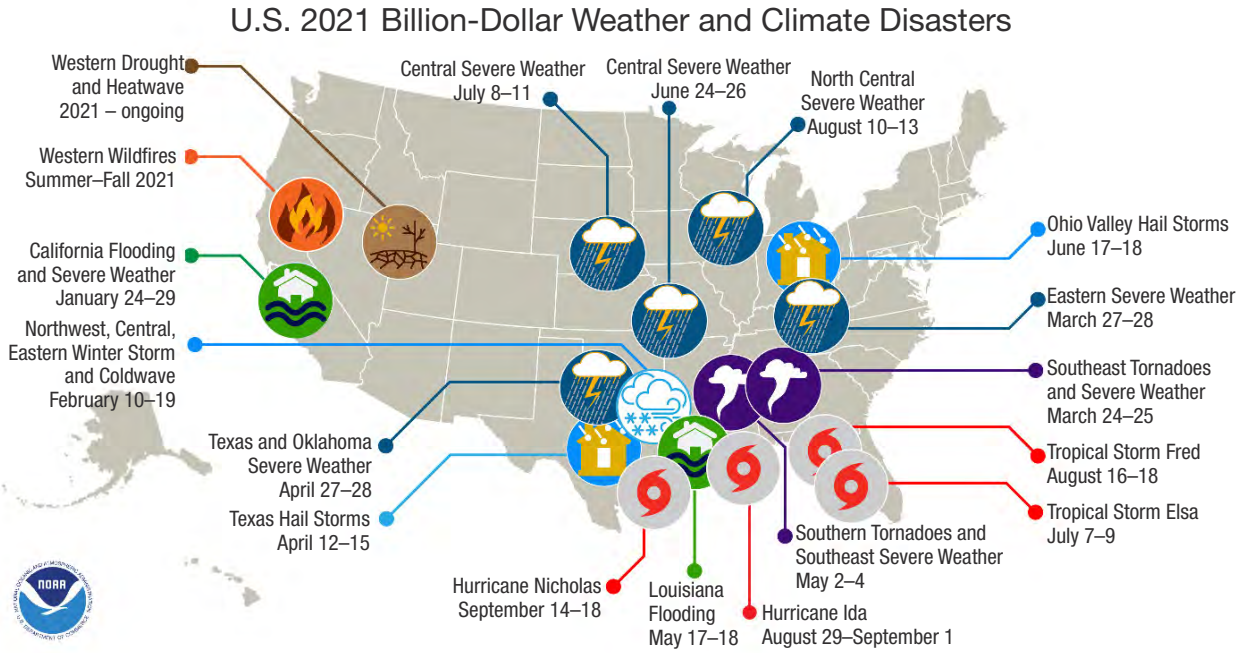
- 24/7 secure NOC
- Maintenance scheduling
- Asset management
- Market operations
- Billing and settlement
- Weekly site visits and loaded test runs
- 24/7 technician availability

Here's the other key point—all of this is driven by **data**. Modern and sophisticated microgrid solutions produce data points that A.I. and machine learning engines then analyze. This data can provide information around anomalous behavior of parts if maintenance needs to be done, fluctuation in power that wasn't expected, and even security metrics around access. Most of all, this information allows your microgrid to become predictive and prescriptive.

On the critical topic of resiliency, it's also vital to understand how new weather patterns have impacted data center operations and outages. According to NOAA, in 2021, there were 18 weather and climate disaster events with losses exceeding $1 billion each to affect the United States. These events included one drought event, two flooding events, nine severe storm events, four tropical cyclone events, one wildfire event, and one winter storm event. Overall, these events resulted in the deaths of 538 people and had significant economic effects on the areas impacted. The U.S. has sustained 308 weather and climate disasters since 1980, where overall damages and costs reached or exceeded $1 billion. **The total cost of these 308 events exceeds $2.085 trillion.**

To put this into perspective, the total cost of U.S. billion-dollar disasters over the last five years (2016-2020) exceeds $600 billion, with a 5-year annual cost average of $121.3 billion, both of which are new records.

These concerns around resiliency, costs of an outage, and the requirement to look at new power sources have driven the modernization of power solutions in the digital infrastructure space. However, microgrids are not just another source of backup power generation, and modern microgrids have become far more advanced and intelligent. Let's examine the makings of a modern microgrid.



This map denotes the approximate location for each of the 18 separate billion-dollar weather and climate disasters that impacted the United States January–September 2021.

Image Source: NOAA

Chapter 2: The Makings of a Modern Microgrid

Rob Thornton, president and CEO of the 105-year old International District Energy Association, often says that microgrids are "more than diesel generators with an extension cord." In other words, a microgrid is not just a backup generation. Still, it should be a robust, 24/7/365 asset that provides primary energy services to a market A microgrid can provide backup generation, but it offers additional, more intricate services as well. So, what can microgrids accomplish? Consider this list:

- Produce onsite generation and optimally thermal energy to be economically competitive
- Serve a distinct, interconnected load, usually with multiple buildings or meters, within a defined geographical boundary or business district
- Can act as a single, controllable entity within the central grid
- Can operate in parallel to the grid, as a grid collaborator, not a competitor
- Can connect or disconnect (island) from the central grid during interruption events with black-start capability
- May participate in demand response and buy power from the grid or sell energy, capacity, and ancillary services to the grid, depending on economics/pricing
- Provide energy 24/7, 365 days a year
- Provide Microgrid-as-a-Service capabilities

- Often incorporate advanced controls and communications and automation software for transparent and intelligent energy management and demand response
- Include distribution wires
- May use any form of fuel but are likely to run on CHP/natural gas, fuel cells or solar energy, and sometimes wind power; making them far greener solutions as opposed to only gas- or diesel-powered generators
- May include thermal and electric storage
- A microgrid is a group of interconnected loads and distributed energy resources that acts as a single controllable entity concerning the grid. It can connect and disconnect from the grid to operate in grid-connected or island mode. Microgrids can improve customer reliability and resilience to grid disturbances.

Advanced data gathering from numerous operational microgrid deployments allows leading partners to make better decisions and proactively service units.

A fundamental feature of a microgrid is its ability to island — meaning it can disconnect from the central grid and operate independently and then reconnect and work in parallel with the grid. So, for example, whenever there is a significant storm or another natural weather event that potentially causes an outage on the power grid, the microgrid islands and activates its onsite power generators. When the power outage ends, the microgrid reconnects to the grid.

A microgrid controller gives the microgrid its islanding capability and new, data-driven capabilities. Also known as the central brain of the system, the controller can manage the generators, batteries, and nearby building energy systems with a high degree of sophistication. The controller orchestrates multiple resources to meet the energy goals established by the microgrid's customers by increasing or decreasing the use of any of the microgrid's resources — or combinations of resources. These types of solutions can also create microgrid-as-a-service capabilities.

Microgrid-as-a-service delivers a fully managed, data-driven solution to help you with your power delivery requirements. Advanced data gathering from numerous operational microgrid deployments allows leading partners to make better decisions and proactively service units. This type of managed offering will enable customers to never worry about their microgrid unit; it's all serviced, monitored, and maintained by your microgrid provider.

Let's pause there and explore one more emerging topic related to the technology above. Specifically, power-as-a-service is becoming a reality as smarter microgrids take on more power intelligence than ever before.

According to NREL, advanced microgrids enable local power generation assets — including traditional generators, renewables, and storage — to keep the local grid running even when the more extensive grid experiences interruptions or remote areas with no connection to the larger grid. In addition, advanced microgrids allow local assets to work together to save costs, extend the duration of energy supplies, and produce revenue via market participation. They usually include the following capabilities:

- Microgrid system modeling and simulation on timescales of electromagnetic transients and dynamic and steady-state behavior
- Development of power electronic converters and control algorithms for microgrid integration
- Controller hardware-in-the-loop testing, where the physical controller interacts with a model of the microgrid and associated power devices
- Power hardware-in-the-loop testing of microgrid hardware
- Programmable A.C. power supplies (grid simulators) to emulate the grid-tie as well as select electrical nodes on the microgrid
- Programmable DC power supplies to emulate photovoltaic (P.V.) arrays and battery banks
- Hybrid microgrid testing, including the distribution integration of wind turbines, P.V., dynamometers, loads, and energy storage

They also act as **dual-purpose microgrids** providing resiliency and grid stability. What does that mean? Dual-purpose microgrids are local power systems that offer sustained resiliency services to customer sites to survive long-duration power outages and provide support services to the larger grid and wholesale markets, which reduces the overall cost of each of these services.

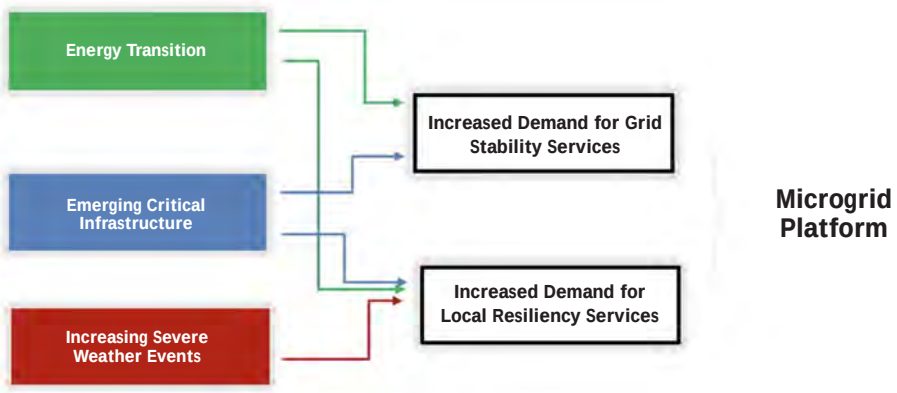


Image Source: Enchanted Rock

The image above illustrates how dual-purpose microgrids provide the essential local resiliency services of a microgrid (the ability to create an island of power when the larger grid goes down) and are ready to provide grid stability services when the grid is up and running. For example, when the wind unexpectedly dies down in a state like Texas, which leads the U.S. in installed wind power capacity at approximately one-third of all capacity, other resources must be called upon to fill the void. These supplemental resources need to respond within a brief period of time.

It's important to note that dual-purpose microgrids do not compete with grid-supplied power. Instead, they displace our historical reliance on backup diesel generators, which represent one of the most polluting of all power generation options. They also generate a new revenue stream by supporting the broader grid during times of crisis. We'll touch on that last part later.

Aside from generating a revenue stream, modern microgrids aim to become a bridge to alternate fuel sources in the future.

Microgrids and the Modernization of Power Resources

A recent report from Guidehouse Insights states that traditional microgrids such as solar plus storage, fuel cells, or combined heat and power (CHP) focus on providing 24/7 electricity, going into island mode as long as possible during a grid outage. Their purpose could be described as meeting the demand for local resiliency services at a specific site. Ideally, these microgrids could sustain electricity supply during long-duration outages. Dual-purpose microgrids also generate a cost offsetting revenue stream by supplying services to the broader grid during emergencies. These dual-purpose microgrids are critical to making a commercial reality of the energy transition to a low-carbon energy future. Why do we need these types of microgrids today? The provision and use of electricity are rapidly changing in profound ways:

- The energy transition is driving growth in variable renewable energy and retirement of baseload production, and at the same time, electrification of previously fossil-fueled energy uses is growing. According to Princeton University, the U.S. will need to quadruple wind and solar power to reach 600 GW, which would serve about half of the nation's electricity demand to get to the net-zero carbon goal by 2030 at the cost of $2.5 trillion.
- Critical infrastructure is now recognized as expanding significantly beyond hospitals and emergency services to include a much longer list of essential facilities to maintain safety, health, food, water, and communication. More businesses and organizations require continuous electricity to deliver these services to society.
- Climate change increases the number and impact of severe weather events causing large-scale power outages, including fires, ice storms, extreme cold and heat, hurricanes and flooding, and high winds. According to the U.S. Environmental Protection Agency (EPA), eight of the ten warmest years on record for the U.S. have occurred since 1998. Furthermore, nine of the ten most extreme 1-day precipitation events have occurred since 1990. The EPA also reports that single-day extreme precipitation events have increased by half of a percentage point each decade since 1910. While long-term trends show significant variability in the frequency of hurricanes, 2017 was the worst year in U.S. history, with 17 named storms causing $200 billion in damages.

New microgrid solutions take sustainability to a new level, focusing on the transition to low-carbon energy use. New microgrid solutions now offer customers renewable natural gas (RNG) as a direct fuel source. RNG results from capturing and delivering methane emissions from decomposing waste at landfills, agricultural waste, and water treatment. When injected into the existing natural gas pipeline system, it displaces the use of fossil-based gas, thus reducing the carbon equivalent emissions to zero or negative, depending on the source of the RNG.

The significant part is that RNG microgrid projects are already in the wild. Initially funded by $20 million from Congress, the San Diego, California Miramar Air Force Base microgrid is considered one of the most sophisticated under development with five distributed energy resources, including solar, energy storage, landfill gas, diesel, and natural gas plant, and E.V. charging. Given the worldwide need to manage waste — especially in light of rapid urbanization — the search is underway for ways to make productive use of gases emitted from landfills. According to World Bank, the world generates about 2.01 billion tons of municipal waste, a figure expected to grow 70% over the next 30 years.

Resources within the Miramar microgrid

- 1.3 MW solar photovoltaics
- 3.2 MW landfill gas
- 6.45 MW diesel and natural gas power plant
- 1.6 MW HVAC demand response
- 157 kW thermal energy storage
- E.V. charging station control
- 3 M.W. energy storage (microgrid system level)
- 390 kW building-level energy storage (Lithium-Ion and zinc flow batteries and vehicle-to-grid bi-directional hybrid vans)
- SCADA system upgrades
- Advanced microgrid control system
- Energy and Water Operations center (EWOC)

Completed in 2021, the Marine Corps Air Station Miramar in San Diego microgrid can electrify the base's 100 mission-critical buildings, including its entire flight line, even during a power outage. According to a recent US Marines statement, many installations may have a backup generator, but the microgrid is a more refined generation source. It establishes the capability for operators to manage the power load and everything plugged into the grid while redirecting power to parts of the base that need it most. At MCAS Miramar, a mission-critical function that would require power is flight line operations.

Here's another remarkable fact: modern microgrids not only produce minimal emissions, but they're also very quiet. New microgrid solutions operate at less than 68 dBa, which is suitable for urban use and offers no disruption to business operations. Just for reference, everyday conversational speech usually measures at around 60dBa.

Even with these advancements, there are still reservations about deploying modern microgrids. It's essential to break down some of those historical perspectives to understand the future of power delivery, sustainability, and resiliency.

Chapter 3: Breaking Historical Power Norms: Energy and Resiliency as a Service

This section is arguably one of the most important to grasp. Here, we will explore how new solutions around power and microgrids break legacy paradigms. It'll be essential for you to take an introspective approach when looking at modern microgrid solutions and understand just how far these technologies have come.

With that in mind, leaders in the power and data center space still have misconceptions about power delivery, decarbonization, efficiency, and resiliency. A significant focus in working with power solutions today revolves around sustainable designs and ensuring more significant levels of resiliency.

While evaluating your energy transition toward decarbonization, every facility must make an informed decision based on organizational goals and requirements. Unfortunately, there is conflicting information and confusion in today's market, so let's look at some of those statements to separate fact from fiction.

First, let's look at renewable natural gas.

Renewable Natural Gas (RNG), Separating Fact from Fiction

What is RNG?

Renewable natural gas, or RNG, is pipeline-quality gas that is interchangeable with conventional natural gas. RNG is the product of the decomposition of organic matter (biogas) that is processed to purity standards.

Is RNG a fossil fuel?

No, RNG is an ultra-clean and ultra-low-carbon natural gas alternative that is a mixture of carbon dioxide and hydrocarbons, primarily methane gas. It is captured when organic waste decomposes and releases biogas, which is collected and purified. Sources include landfills, livestock operations, wastewater treatment, and organic waste from industrial, institutional, and commercial entities.

How is RNG carbon negative?

RNG can be carbon negative depending on the source and its intended use. Instead of methane gas being released into the air, it is captured, processed, and then combusted in an engine where the byproduct is carbon dioxide and electricity. Because the carbon intensity of methane gas is 25 times greater than the carbon intensity of carbon dioxide, displacing methane results in significantly lower greenhouse gas emissions.

> RNG is an ultra-clean and ultra-low-carbon natural gas alternative that is a mixture of carbon dioxide and hydrocarbons, primarily methane gas. It is captured when organic waste decomposes and releases biogas, which is collected and purified.

With the definition in place, RNG provides a new avenue for data center and digital infrastructure leaders to design sustainable solutions and carbon-negative ones. Let's examine some critical facts about RNG and how it impacts power delivery.

FACT: Diesel produces higher emissions than other fuel alternatives

The EPA regulates emissions from new diesel engine generators for NOx, VOCs, Particulate Matter (PM), and CO. Compared to these regulated emissions levels, solutions like those from Enchanted Rock's generators are significantly cleaner.

For example, Enchanted Rock's natural gas microgrids offer cleaner local emissions than diesel by orders of magnitude with practically no run limitations—allowing facilities to support both resiliency and sustainable strategies. These systems use natural gas, propane, and biogas to reduce or eliminate the carbon footprint.

On the topic of renewable natural gas, in a recent report from The Brattle Group, "Decarbonized Resilience: Assessing Alternatives to Diesel Backup Power," four scenarios are evaluated as alternatives to diesel. The report finds that "relative to diesel, these alternatives can virtually eliminate the emission of pollutants such as NOx, particulate matter, and volatile organic compounds, which contribute to local air quality problems."

Figure 1. Generator Emission Factor Comparison

Compound	ERock Rich-Burn		Tier 2 Diesel		Tier 4f Diesel		CARB DG-CERT Engine Emission Factor
	Engine Zero-Hour Emission Factor (lb/MWe-hr)	Emission Factor Source	Engine Zero-Hour Emission Factor (lb/MWe-hr)	Emission Factor Source	Engine Zero-Hour Emission Factor (lb/MWe-hr)	Emission Factor Source	
VOC	0.001	ERO Test Data	14.11	NSPS IIII	0.42	NSPS IIII	0.02
NOx	0.0035	ERO Test Data			1.48	NSPS IIII	0.07
CO	1.09	ERO Test Data	7.72	NSPS IIII	7.72	NSPS IIII	0.1
PM/PM10/PM2.5	0.003	ERO Test Data	0.44	NSPS IIII	0.066	NSPS IIII	-
SO2	0.007	AP-42 Table 3.2-3	0.016	AP-42 Table 3.4-1	0.016	AP-42 Table 3.4-1	-
CO2	1,395	ERO Test Data	1,555	AP-42 Table 3.4-1	1,555	AP-42 Table 3.4-1	-

Diesel Engine Emissions Compared to ERock

Compound	Tier 2	Tier 4f
VOC	3136x	419x
NOx		422x
CO	7.1x	7.1x
PM/PM10/PM2.5	147x	22x
SO2	2.3x	2x
CO2	1.1x	1x

ERock Emissions as a Percentage of other Engines and Regulations

Compound	Tier 2	Tier 4f	CARB DG-CERT
VOC	0%	0%	5%
NOx		0%	5%
CO	14%	14%	1090%
PM/PM10/PM2.5	1%	5%	-
SO2	43%	43%	-
CO2	90%	90%	-

Notes:

1. *Enchanted Rock ISO 8178 D1 weighted test cycle emissions results from a single engine. Actual field test results may vary due to site conditions, installation, fuel specifications, test procedures, and engine to engine variability.*
2. *VOC emissions found to be below the minimum detection level of the equipment.*
3. *NOx and CO emissions data are near-zero hour non-deteriorated emission rates which are not guaranteed emissions for purposes of air permitting. These rates are typical for lower run hours which will increase with catalyst age.*
4. *PM emissions not expected to change with catalyst age, although differences in fuel quality could impact actual emissions.*
5. *NSPS IIII emission limit for electric generator rated greater than 560kW.*
6. *California Code of Regulations Title 17, Division 3, Chapter 1, Subchapter 8, Article 3 - Distributed Generation Certification Program*
7. *NSPS JJJJ emission limits for stationary non-emergency natural gas engine greater than 500 hp, with an efficiency of 92%*
8. *AP-42 calculation assumes engine has a heat rate of approximately 12 MMbtu/MW.*

The numbers speak for themselves. As you can see in *Figure 1,* the Enchanted Rock emissions are far less than that of a Tier 4 diesel engine output across the board.

FACT: Natural Gas is More Resilient and Reliable than Diesel as a Fuel Source

A recent study by the National Renewable Energy Laboratory (NREL), "A Comparison of Fuel Choice for Backup Generators," analyzes the relative reliability of using natural gas compared to diesel as a backup fuel source. Their conclusion is: "We find that natural gas provides the largest additional reliability compared to diesel for regions that have high risks of long outages."

Fuel availability and transportation also need to be considered. Natural gas is delivered through an incredibly robust underground infrastructure. Natural gas is readily available during crises when diesel refueling is not always possible due to terminal supply shortages or over-the-road hazards. Solutions like those from Enchanted Rock systems can run independently in island mode for days to weeks without requiring refueling logistics.

The reality is that constant conditioning and testing of engines leads to a higher level of reliability. Enchanted Rock natural gas-fueled microgrids run loaded while providing grid stability services, unlike diesel engines which are significantly limited in run hours.

MYTH: Diesel Backup is Always Less Expensive than Natural Gas Backup

We'll discuss microgrids in general in the next section. However, it's essential to focus on diesel backup first. While diesel generators can be less expensive on a standalone basis, *that is not the case for a dual-purpose microgrid.* By combining backup power with grid stability services, the net cost of natural gas services is lower than diesel. The NREL study concludes, "grid-connected generators can create positive economic value and have significantly lower failure rates than backup-only generators."

Solutions like those from Enchanted Rock offer Managed Power Resiliency allowing customers to focus on their core business. At the same time, the partner provides local resiliency, managed assets, and is responsible for maintenance and operations. Partners like Enchanted Rock aggregate the generator capacity and sell it back to the grid to earn revenue when customers do not require backup power. These periodic runs allow the partner to subsidize the cost to customers substantially.

Some microgrid design costs are in the thousands of dollars, while more complex systems may cost more than a few million dollars.

A dual-purpose microgrid offers significant economic advantages for customers, including lowering the initial cost to implement and ongoing maintenance and fuel costs. While diesel averages typically $400-500/kw plus a lifetime of maintenance, natural gas microgrids run $150-300/kw with no added cost for maintenance — a significant difference!

FACT: There Are Real, Measurable Environmental Benefits of Using RNG in Microgrids

- It puts organic waste to good use while reducing greenhouse gas (GHG) emissions.
- Lowers emissions when methane (CH4) is captured and repurposed as RNG, rather than being released directly into the atmosphere or flared.
- It offers a carbon equivalent (CO2e) neutral energy source because it reduces methane emissions into the atmosphere. Methane is a much more potent GHG than carbon dioxide.
- Because it is produced from actual waste (as opposed to crops grown specifically for fuel or diverted biomass that has other more beneficial uses), its production and use results in a net reduction in methane emissions.

Backing up a little, it's vital to look at microgrids in general and understand the difference between legacy microgrid solutions and more modern implementations. During the latest AFCOM Data Center World Conference, a critical session dove into the differences between older and new microgrid solutions. In researching microgrids and learning about their capabilities, many will quickly run into three myths still in this industry. These were the discussion points from the AFCOM event.

Modern Microgrids: Fact vs. Fiction

Microgrids are too expensive.

Yes, there is an upfront cost of building a microgrid. However, it entirely depends on your use-case and the scale of the project. Some design costs are in the thousands of dollars, while more complex systems may cost more than a few million dollars. However, look at it from a healthcare data center perspective for a second. "The extreme case would be for your medical device to stop working," says Dave Carter, the managing research engineer at the Schatz Energy Research Center and the lead technical engineer on microgrid projects. "The value of the power that the microgrid can provide when the rest of the county [in California] is de-energized is high."

Another critical point comes from the previous section. As a dual-purpose microgrid solution, organizations participating in grid services or programs can actually allow the customer to deploy and operate a microgrid for the same or less cost than a traditional diesel backup system. These can become revenue-generating power services.

Microgrids are way too complicated and challenging to manage.

This used to be a sticking point for many. However, a lot has changed. Modern microgrids are a lot smarter, automated, and data-driven than ever before. Plus, the whole design around microgrid-as-a-service enables enterprises, healthcare providers, cities, and even data center operators to focus on what they're good at and their business requirements. Today, the microgrid is easier to manage, has more integration points with power solutions, and significantly improves resiliency.

Microgrids are basically the same as a generator.

Microgrids are certainly not the same as traditional generators. First of all, if you have a diesel generator, there is a chance that you might be limited in how much you can test it due to environmental regulations. Secondly, microgrids can be wholly independent and not rely on diesel fuel. Remember, they can source power from multiple locations. Finally, you can absolutely use a generator alongside a microgrid.

As an important additional point, natural gas-powered resiliency microgrids provide a path towards decarbonization, addressing local resiliency and grid stability needs. New solutions that focus on managed power resiliency help critical infrastructure reinvent how they approach electricity resiliency. Your microgrid partner can provide fully managed, clean natural gas-powered resiliency microgrids, support services, and flexible pricing options designed for fast, simple, and worry-free protection from extended grid outages.

Once people believe some of these false narratives around microgrids, they almost immediately turn to traditional generators for the answer. However, as soon as you see past a legacy mindset, you'll quickly understand how emerging power solutions are reshaping managed power services, microgrids, and even becoming carbon negative.

When it comes to providing reliability and resiliency, many utilities, regulators, communities, and large energy users are re-evaluating their use of diesel and considering cleaner options such as RNG. This is just one of the new aspects of working with modern microgrids. Not only do you have the capability to turn power generation into revenue services, but you also impact your ESG goals and work to become carbon negative. Let's dive into some of the latest and newest designs in the power and microgrid space.

Chapter 4: What's New? Data-Driven, Efficient, Resilient, and Sustainable

The modern microgrid is far more advanced than even those systems from a few years ago. Modern microgrids are smart — they have sophisticated software and controls. Among other things, this intelligence allows them to 'island' from the primary grid. That means when they see the domino effect beginning to occur, microgrids can separate and protect themselves from the trouble appearing on the primary grid. They stop relying on the grid's power plants and rely only on their own. They can also work intelligently in unison.

> If energy prices are inexpensive at any point, your microgrid may choose to buy power from the central grid to serve its customers rather than use energy from, for example, its solar panels.

When everything is working right, the grid and the microgrid operate in tandem and serve one another. If a microgrid power plant fails, it can turn to the primary grid for supply. Or if the main grid runs low on power supply — as it sometimes does on hot summer afternoons when we all are running our air conditioning — it can turn to the microgrid for some help. The microgrid gets paid for providing services to the grid **(known as capacity, demand response, and ancillary services)**, so the grid can generate revenue for the microgrid.

Furthermore, modern microgrids are data and software-driven. These advanced microgrid controllers leverage machine learning and data-driven solutions to track real-time changes in the power prices on the central grid and the overall functionality of the power system.

This intelligence can also prove to be highly cost-effective. If energy prices are inexpensive at any point, your microgrid may choose to buy power from the central grid to serve its customers rather than use energy from, for example, its solar panels. The microgrid's solar panels will instead charge its battery systems. Later in the day, when grid power becomes expensive, the microgrid may discharge its batteries rather than using grid power.

Leveraging data-driven designs, microgrids operate via complex algorithms to ensure the best possible utilization of resources and constantly work to improve data center power economics. This level of orchestration and automation is all done instantaneously and autonomously. When leveraging solutions like Managing Microgrid Services, all of this data is fed to your provider, and they can take predictive action around a variety of patterns. From a customer perspective, there is no need for human intervention.

Another critical update revolves around the capability for microgrids to work as true resiliency-capable solutions. There's good news on that front.

Resiliency and microgrid-as-a-service

A significant misconception around microgrids is that you're buying a piece of equipment, and that's it. However, modern microgrid solutions go far beyond onsite physical power solutions. New offerings revolve around microgrid-as-a-service where you as the customer never have to interact with the system.

This includes system design and engineering services, constriction and commissioning, and even financing. Furthermore, this includes operations as well as response field services. New as-a-service features include:

- 24/7 secure NOC
- Maintenance scheduling
- Asset management
- Market operations
- Billing and settlement
- Weekly site visits and loaded test runs
- 24/7 technician availability

Here's the other key point—all of this is driven by data. Modern and sophisticated microgrid solutions produce data points that A.I. and machine learning engines then analyze. This data can provide information around anomalous behavior of parts if maintenance needs to be done, fluctuation in power that wasn't expected, and even security metrics around access. Most of all, this information allows your microgrid to become predictive and prescriptive.

Furthermore, leaders in the space don't just operate one or two microgrid solutions. Instead, they'll have hundreds of sites that are all aggregating management data. Microgrid innovators can then use this information to improve your site's efficiencies. All of this enhances reliability, helps you avoid product loss, reduces non-compliance, and ensures that you have constant capacity when it comes to power.

For the microgrid industry, this is revolutionary. The leading microgrid providers leverage data to make better decisions and improve overall operation. All of this brings further benefits to the customer without increasing complexity. Modern microgrids act as connected systems with numerous data points as a pivotal point to reduce complications around power deployment. Managing these deployments and data sets could become a challenge without a solid management ecosystem. This is where microgrid network operations centers (mNOC) come into the conversation.

The Connected Microgrid: mNOC Services

Ensuring power resiliency for customers requires continuous monitoring of microgrid sites across the United States. Acting as the nerve center for every active microgrid installation 24/7/365 in every market, solutions like those from the Enchanted Rock Microgrid Network Operations Center (mNOC) deploys proprietary software and integrated processes and technologies that together ensure worry-free, long-duration, reliable power to customers by helping mNOC operators identify and address issues before they become problems.

Image Source: Enchanted Rock

The mNOC system runs on proprietary microgrid aggregation and control software in a secure Tier 4 data center, allowing experienced operators to monitor asset conditions and energy markets and manage all status, security, maintenance, scheduling, and dispatch in real-time. The mNOC also interfaces in real-time with retail and wholesale markets, and energy trading experts manage the process of providing grid capacity and ancillary services based on the unique requirements of each electricity market program and revenue opportunity.

A variety of sophisticated, quick-response microgrid support activities take place under the supervision of energy engineers and trading experts, including:

- Monitoring weather and stability of the electric power grid
- Autonomous activation of microgrids during a loss of utility voltage
- Monitoring and diagnosis of all comms and equipment installations in the field

- Maintenance management and resource optimization
- Upgrade of program management
- Monitoring and forecasting of electricity market conditions
- Optimized dispatch for excess energy sales

Before we go too much further, it's vital to touch on one more important point: cybersecurity.

Cybersecurity and the microgrid

Believe it or not, it's not just about power delivery. There's a big concern about security within the grid. Microgrids can disconnect from the grid if there is an issue. Intelligent microgrids can do this proactively, leveraging data analytics, anomalous behavior/power monitoring, and even user access protocols.

Enchanted Rock has a 24/7 secure network operations center (NOC) that proactively monitors the activities of more than 600 deployed and active microgrid deployments.

Basically, in cases of an attack, you can completely disconnect from the grid and ensure that you still have reliable power sources. This is a specific, proactive measure to mitigate the risk of the grid being impacted by a cybersecurity threat. And this is something that Enchanted Rock offers and works with very closely. As part of their turnkey solution, they have a 24/7 secure network operations center (NOC) that proactively monitors the activities of more than 600 deployed and active microgrid deployments. This data intelligence and aggregation level allow Enchanted Rock to respond to power and even security issues faster than anyone else.

Finally, let's focus on an acronym that's seemingly on everyone's mind: ESG.

Microgrids and ESG

To start, it's essential to understand what ESG is and how it impacts organizations briefly. Environmental, Social, and Corporate Governance (ESG) evaluate a firm's collective conscientiousness for social and environmental factors. It is typically a score compiled from data collected surrounding specific metrics related to intangible assets within the enterprise. Why is this important, and how does it connect to microgrids and RNG? **RNG is being used as a direct power source for microgrid solutions for the first time.** This is a massive ESG game-changer for data center leaders aiming to become carbon neutral and *even carbon negative.*

According to the Environmental Defense Fund, methane has more than 80 times the warming power of carbon dioxide over the first 20 years after it reaches the atmosphere. This reinforces RNG's effectiveness for a company's **ESG initiatives** and underlying mitigation for downstream global warming. Further, the United States recently released its new U.S. Methane Emissions Reduction Action Plan. The U.S., along with more than 100 countries, recently signed the Global Methane Pledge at the COP26 summit, committing the countries to reduce their emissions by 30% by 2030.

This is important because, for the first time, new microgrid solutions like those from Enchanted Rock are directly integrating RNG into their power delivery solution. RNG results from capturing and delivering methane emissions from decomposing waste at landfills, agricultural waste, and water treatment. When injected into the existing natural gas pipeline system, it displaces the use of fossil-based gas, thus reducing the carbon equivalent emissions to zero or negative, depending on the source of the RNG.

> "RNG is an essential component of a strategy to decarbonize America's energy portfolio, and a no-regrets solution to addressing methane from society's organic waste streams. Enchanged rock has forged a sterling reputation for developing and deploying clean and reliable back-up power solutions, and today's announcement is a strong proof point of their success."
>
> – JOHANNES D. ESCUDERO, FOUNDER & CEO OF THE COALITION FOR RENEWABLE NATURAL GAS

For partners like Enchanted Rock, this advancement represents a history of clean energy innovation dating back to 2012 when the company pioneered cleaner generators beginning with EPA Tier 4 diesel and further evolution to ultra-clean natural gas. Enchanted Rock has already reduced the local pollutants of backup power solutions by over 99% and carbon intensity by 10%. With this announcement, Enchanted Rock will now reduce the carbon intensity of backup power by 100%.

"We've heard repeatedly from our customers that they're seeking to both reduce local pollution from diesel backup and to meet their robust ESG goals," said Allan Schurr, Chief Commercial Officer of Enchanted Rock.

Quick Recap—Microgrids have changed. A lot.

Let's pause here and take this all in. We've discussed how microgrids have changed, specifically, how they are much more intelligent and data-driven than ever before. And how they can be used as grid-stability solutions to ensure optimal efficiency and resiliency.

We've also discussed how start times for these new solutions (less than 10 seconds for the entire load) will rival and even out-perform many other backup generation designs.

Finally, we've discussed ESG and how emerging RNG solutions are entirely changing the power delivery game. This last part is one of the most critical to take in. Microgrids aim to decarbonize data center designs and allow for carbon-neutral (and even carbon negative) data center architectures in conjunction with RNG designs. As a bridge to the most optimal ESG scores, microgrids are reshaping how we examine sustainable and resilient power solutions. However, few partners lead the power discussion as much as Enchanted Rock when deploying microgrids. Let's look at how working with leading partners can shift your power designs.

Chapter 5: Microgrid Partners and Real-World Use-Cases

The way we deliver power solutions has fundamentally changed. A shifting paradigm now focuses on new power solutions aimed at greater levels of resiliency and sustainability. With more significant threats from climate, geopolitics, and unknown business factors, the need for continuous operations becomes even more critical. Furthermore, new economic and sustainability initiatives have made power a front and center issue related to removing carbon and the use of fossil fuels.

And so, this next point is critical.

Microgrids have become the official bridge between legacy and next-generation power delivery. They're capable of working entirely on their own as an island of power, or they can integrate legacy fuel sources with next-generation energy like RNG, solar, geothermal, wind, and more. For example, Alcatraz. Today, Alcatraz Island is equipped with a solar-diesel hybrid power system. The solar panels connect to a battery bank and power inverters that help power the island instead of relying solely on diesel generators. How have microgrids changed the economics of a location that gets more than 1.5 million visitors a year? This $7.1 million project, funded initially through the American Recovery and Reinvestment Act, has reduced the island's fuel consumption by

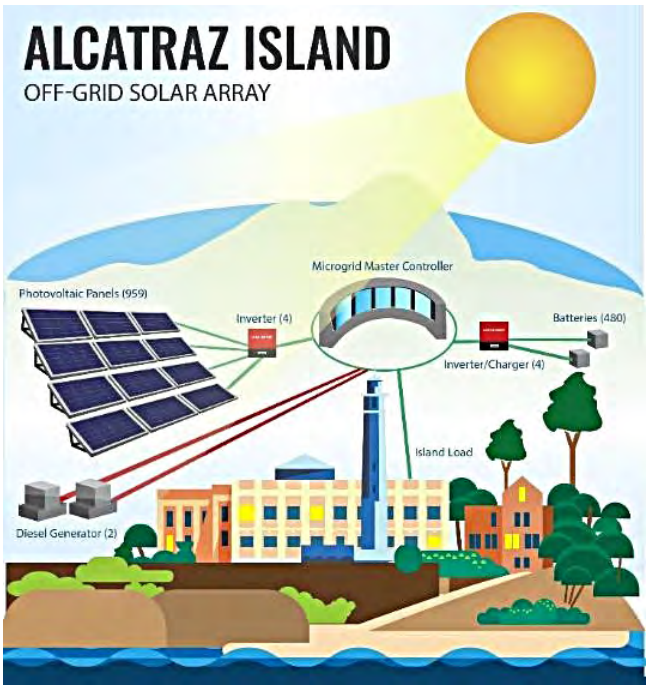


Image Source: U.S. Department of Energy

45% since its 2012 installation. It also saves more than 25,000 gallons of diesel fuel a year in the process—proving historic preservation and renewable integration is possible.

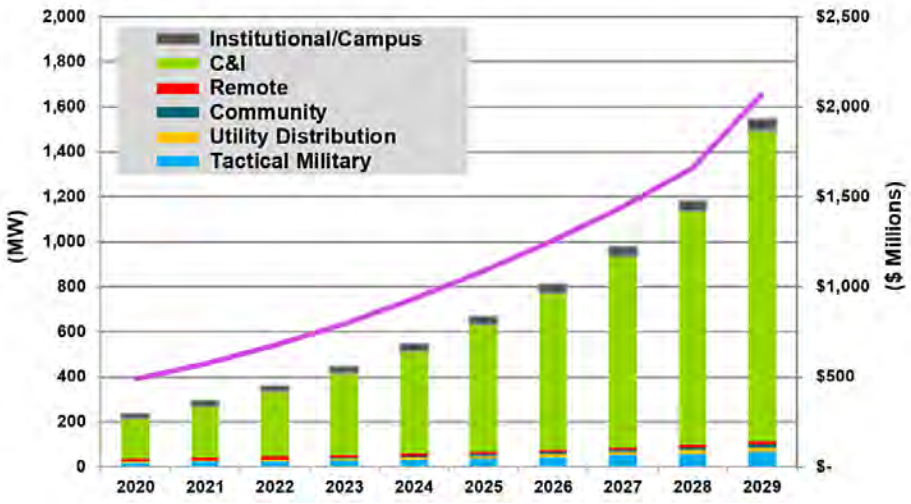
Microgrids as a Real Option for Data Center Power Delivery

Microgrids have come into direct focus over the past couple of years as more organizations, technology leaders, and government municipalities deploy them.

Navigant Research forecasts a $30.9 billion microgrid market by 2030. Looking at the market in general, you'll see that the pace of microgrid installation has picked up and is expected to grow dramatically as distributed energy prices drop and worries heighten about electric reliability due to severe storms, cyberattacks, and other threats.

Navigant expects global microgrid capacity to reach 7.6 GW by 2024, up from 1.4 GW in 2015. The research firm sees North America and Asia as the centers of growth.

Annual Modular Microgrid Capacity and Implementation Spending, North America: 2020-2029



Source: Navigant Research

Outside of the obvious economic impacts behind outages and downtime, there's another key reason why there will be even more growth in the microgrid sector.

Microgrid costs have been falling in recent years, and this is mainly due to a decline in the cost of the kind of supply assets used by many contemporary microgrids. Falling prices for renewable energy and battery storage heavily influenced a 30% decline in microgrid costs from 2014 to 2018, according to Peter Asmus, research director for Guidehouse.

Another misconception is that you might need to pay for everything upfront. In some cases, this is true. However, with energy and even microgrid-as-a-service offerings, contracts require little or no upfront capital paid by microgrid customers; they just continue to pay for their energy in a budgeted manner, much as they do if they buy it from a utility — except they have the added benefit of power from the microgrid when a grid outage occurs. A partner owns the project and takes the risk. On that note, it's essential to discuss the partners leading the microgrid market.

How Enchanted Rock is Shaping the Microgrid Market

Getting started means working with the right people. Before you even begin the journey towards the microgrid power architecture, it's critical to understand your business, how it'll change your power requirements, and where there will be positive impacts.

Partners like Enchanted Rock were founded on the principles of creating a cleaner, quieter, and far more reliable and sustainable solution than traditional diesel generators. Enchanted Rock's unique Managed Power Resiliency solution brings patented technology, advanced microgrid designs, and integrated services together in a tightly orchestrated delivery model, fully managed by energy experts in a turnkey model.

Modern microgrids — leveraging a complete turnkey solution

A significant innovation in microgrid solutions has been both the intelligence the data can provide, coupled with some of the best *microgrid-as-a-service* options in the market. Working with Enchanted Rock not only ensures you're working with people who have a lot of experience in the field but can also completely manage your microgrid architecture. This includes:

- **System Design and Engineering** Site evaluation, electrical, mechanical, and civil engineering, architectures around grid synchronous as well as island mode are all a part of the offering.
- **Construction and Commissioning:** End-to-end EPC, complete project management, and full commissioning of the microgrid ecosystem.
- **Finance:** Ready access to capital, 10-20-year horizon, and — this one is important — Enchanted Rock bears all market risk.

Furthermore, complete microgrid operations managed service includes:

- 24/7 secure mNOC
- Maintenance scheduling
- Asset management
- Market operations
- Billing and settlements

Finally, a fully-managed microgrid platform will also focus on advanced operations services. This includes:

- O&M of more than 600 generators
- Always-in-stock critical spares
- Weekly site visits, loaded test runs
- Technicians on call 24/7

Working with *microgrid-as-a-service* solutions is an entirely new way of leveraging resilient, clean, and dependable power. In the past, microgrids were more complex and a challenge to manage. Today, leaders in the energy and microgrid space are changing how this power is being delivered and leveraged. Enchanted Rock allows you to focus on your business and what you're best at doing. That means never working about resilient power and always knowing that someone is helping ensure your systems stay up.

Operating more than 350 MW of distributed generation assets, Enchanted Rock has a proven operating history with availability now exceeding 99.999% uptime. This means minimal disruptions, all operating on an intelligent system.

And it's the intelligence in the microgrid infrastructure that makes this platform so unique and revolutionary. Gathering metrics from more than 600 operating microgrids, Enchanted Rock has some of the deepest functional visibility because of its data gathering, machine learning, and analytics platform. They can see fluctuations in the environment, improve security posturing, and even help you make decisions ahead of any changes in your business or even the grid.

Today, there are new options in designing sustainable and resilient power solutions.

When working with Enchanted Rock, you'll quickly see that there are new options available comprised of natural gas generators that perform like diesel but are clean enough to operate as grid support resources to earn revenue when not in use for resiliency. This translates to:

- Fast ramp time and transient performance to match diesel
- Compact footprint and low noise levels, scalable from 5 M.W. to 100+ MW
- Less than 4% of Tier 4F diesel NOx and zero SOx and PM 2.5

Today, Enchanted Rock operates more than 350 MW of distributed generation assets with 7x24x365 management centers and more than *600 microgrids constantly feeding information.* That last part is essential. Enchanted Rock's microgrid platforms are the definition of intelligent power delivery. That is, they leverage data, machine learning, and data analytics to know exactly what power needs to be delivered, power sources, and when to service the unit if required. This is the kind of design that allows customers to have little-to-no interaction with the grid itself. This solution is positioned to be a market-leading, fully managed microgrid ecosystem. Further, this fully managed system helps increase uptime and resiliency while reducing complexity and management challenges.

Final Thoughts and Getting Started

The focus on sustainable and resilient power will not be going away any time soon. Data center leaders are actively looking for ways to become greener and more resilient with their power designs in the digital infrastructure space. Consider this, data centers are located in every state, but the largest hyperscale data centers are sited where power is the least expensive. However, low-cost power does not ensure highly reliable power. The standard data center design includes backup power systems that can carry the facility computing and infrastructure loads without interruption during a power outage. It also does not guarantee that this power will be from renewable sources.

Microgrid designs aim to change all of this. Microgrid architectures are redefining how we deploy dual-purpose grid technologies to improve power solutions and generate new revenue streams by bridging legacy and next-generation power sources. Remember, in a constantly connected world, it's not just data centers that benefit from improved power designs. Others, including cities, healthcare services, and critical infrastructures like data centers and the edge, are already using microgrids to become greener and more resilient. Companies and service providers can now deploy physical infrastructure in locations they never thought possible.

To some, working with microgrids will be a new endeavor. However, it doesn't need to be a daunting task. Asking reflective questions of your business and current power designs can really help you understand what you need today and in the near future in terms of power needs, green infrastructure, and resiliency. Partners like Enchanted Rock work to make the power decision-making process easier with highly resilient microgrid solutions, much more economical, and operate as turnkey designs. Further, as part of your ESG planning and goals, microgrids allow you to leverage new renewable energy sources like RNG to become carbon neutral and even carbon negative. These types of impacts on both the business and the environment will make a real difference in our connected world. And microgrids aim to be the bridge into that future.

In a constantly connected world, it's not just data centers that benefit from improved power designs. Others, including cities, healthcare services, and critical infrastructures like data centers and the edge, are already using microgrids to become greener and more resilient.