DATA CENTER Frontier Special Report

Getting to Green

Paving a Sensible Path To Sustainable Data Centers

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Introduction

Data center operators are caught in the squeeze: They need to manage rapid growth while at the same time reducing energy usage and moving to more sustainable energy sources. These goals are not mutually exclusive. There are immediate steps operators can take to switch to green energy in ways that aren't disruptive to their business while undertaking a longer-term campaign to shift to more sustainable infrastructure.

Global Data Center Market Expectations

MORE THAN **18% ANNUAL GROWTH**

TO NEARLY **$520 BILLION IN 2025**

Source: Technavio

Doing this in the current growth climate is a challenge. The global data center market is expected to grow more than 18% annually to nearly $520 billion in 2025, according to research firm Technavio. Operators are under particular scrutiny as the U.S. Department of Energy estimates the data centers consume 10 to 50 times as much energy per square foot as a typical commercial office building. Altogether, facilities account for an estimated 2% of total U.S. electricity use.

While hyperscale operators, in particular, have made great strides in reducing power use over the past decade, future progress will be more difficult. The Uptime Institute last year noted that "the energy requirements resulting from increasing IT demand are beginning to exceed the efficiency improvements made in the past decade." What's more, the widespread rollout of 5G technology—which is three times more energy-intensive than 4G—will further drive energy demand. A 2020 report by the European Union projected that 2025 data center energy use will exceed 2018 levels by 21%.

Stakeholder demands

This thirst for power comes at a time when executives and customers are more attuned than ever to the need to reduce greenhouse gas emissions. More than 90% of CEOs say sustainability is important to their companies' success and nearly half of the top 100 U.S. MBA programs offer academic programs on business sustainability, according to Stanford Social Innovation Review. Green is good for business: An overwhelming 87% of respondents to a 2017 survey of American consumers said they would prefer to buy products with social and environmental benefits and 92% are more likely to trust a company that is addressing environmental concerns.

Sustainable technology is making great strides. New data centers can be built to net-zero emissions standards and even absolute zero-emission standards. Hyperscalers have been leading the way. Microsoft has said it intends to eliminate all greenhouse gas emissions in its facilities and its supply chain by 2030. Amazon Web Services has set a goal of powering its operations with 100% renewable energy by 2025 and Google says it intends to be the first major company to operate carbon-free by 2030.

Most companies don't have the hyperscale resources, though. Operators of older data centers, in particular, must contend with diesel-powered backup generators and the need to use the electrical grid for reliable power. There is also pressure on them to contain costs and wring as much life as possible out of their existing investments.

Room to improve

Sustainability has not historically been a high priority. Uptime's annual 2021 Global Data Center Survey found that while:

- 82% of data center managers track electricity usage, and
- 70% monitor power usage effectiveness,
- Only one-third monitor their carbon impact.

Navigating a path toward a sustainable future will be challenging for the two-thirds of companies that don't monitor their emissions as something that isn't measured it hard to improve.

Data center operators have been reluctant to jump fully into using sustainable resources for good reasons. They require power that is both high-quality and predictable. Voltage fluctuations and dropouts of as little as 30 milliseconds can damage IT equipment and trigger expensive outages. A realistic approach is to move to sustainable energy sources in a staged and methodical process that minimizes disruption, extracts maximum value from existing infrastructure, and steadily reduces overall energy consumption.

This report provides an update on the status of major renewable energy sources, the likelihood that they will become viable options for data center operators, and the timeframes for getting there. It also suggests migration strategies that can begin right now.

The Five Sustainable Energy Sources

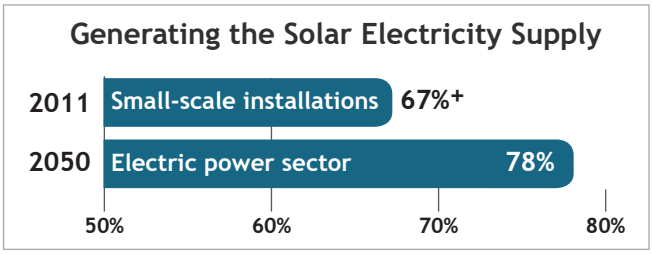
The U.S. Energy Information Association (EIA) lists five major sources of renewable energy. Let's look at each in turn as well as options for storage solutions that can reduce the need for diesel-powered generators.

1 Solar energy

Solar energy accounted for 2.3% of U.S. energy consumption in 2020, according to the EIA. The good news is that the cost of solar panels has come down dramatically, from about $11 per watt generated in 2000 to $2.25 in 2020, according to Paradise Energy Solutions. Tax credits can reduce this cost even further. Declines are unlikely to continue at that rate, however, because nearly two-thirds of the cost of solar panels is installation. A panel of specialists convened by Bloomberg forecast that the cost of solar panels will decline another 34% by 2030. The EIA expects solar energy to account for 5% of all electricity generation in 2022, rising to 20% by 2050.

Utilities have begun to make significant investments in this area. Dominion Energy, for example, plans to add 15.9 GW of solar generation capacity over the next 15 years along with 2.7 GW of energy storage. Whereas more than two-thirds of solar electricity was generated by small-scale installations in the U.S. in 2011, the electric power sector is expected to generate 78% of supply in 2050, according to the EIA.

The advantage of solar energy for data centers is that the marginal cost of operation beyond the initial capital and installation is very low. However, there are many disadvantages. It takes a lot of solar cells



to power even a small data center, and the cost of installation and real estate may not be worth the return.

A bigger problem is that solar cells only work when the sun is shining. This makes them a more attractive option for the southwest U.S. than for more temperate and snowier climes. Even then, a 24-hour operation would need to make significant investments in batteries, a technology that has developed more slowly.

Data center operators can increase their use of solar energy through the use of renewable energy credits and power purchase agreements, which are discussed below. However, as a standalone power source, solar cells are unlikely to be cost-effective until battery technology makes on-site storage practical. Hopes are high, though; data center operators surveyed by Vertiv in 2019 predicted that 13% of data center power would come from solar sources by 2025.

2 Wind

Wind generated 8.4% of electricity consumed in the U.S. in 2020 and it is on a steep growth curve thanks to its multiple advantages over other alternative energy and even carbon-based fuel sources. Its levelized costs of just over $30 per megawatt-hour for newly built projects make it cheaper than even conventional energy sources. Capacity grew at record rates in 2020 as nearly $25 billion was invested in 16.8 gigawatts of capacity. Ten states now derive more than 20% of electricity from wind.

The technology is moving ahead quickly; average capacity levels grew 40% over the last five years due largely to the use of larger turbines. At the same time, the total costs of wind projects fell about 40%. As a result, the average price of wind-powered electricity has dropped to around $20 per megawatt-hour in the interior "wind belt" of the country.

The abundance of wind, particularly in offshore settings, makes it one of the most promising alternative energy sources. A 2011 study by the National Renewable Energy Laboratory estimated that the U.S. has the potential to generate 37 petawatt-hours of electricity from wind, which is nine times the current total U.S. electricity consumption. The Global Wind Energy Council estimated that wind energy could satisfy 20% of the global demand for electricity by 2030.

> Continuing price declines could make dedicated wind power viable for larger data centers within a few years.

The negatives are similar to those of solar energy. The source is intermittent, meaning that large battery farms would be required to provide stable power to a data center. For aesthetic and safety reasons, wind turbines are also usually sited away from populated areas, meaning that large investments in transmission lines must be made. Utilities are quite bullish on the technology, however, and plan to increasingly incorporate wind power into their existing grids. Respondents to the Vertiv survey expected that 8% of their power requirements could be met by wind by 2025. Watch this space, because continuing price declines could make dedicated wind power viable for larger data centers within a few years.

3 Geothermal energy

Geothermal energy accounted for just .4% of U.S. energy consumption in 2020 but it has great promise. Derived from hot water one or two miles below the earth's surface, the technology has many advantages. It's renewable, consistent, and relatively compact. It's available nearly anywhere. It's considered the cheapest form of renewable energy and geothermal wells can even be used as heat sinks for cooling purposes.

Geothermal plants use about 11% as much land per gigawatt-hour as coal or solar and about one-third as much as wind farms. They emit one-sixth of the carbon dioxide produced by a natural gas power plant and 97% less than a coal power plant.

The supply of geothermal energy is practically unlimited and little of it has been tapped. The U.S. Department of Energy estimates that only about .7% of geothermal electricity resources have been accessed so far. It is the least-used form of renewable energy, comprising only 3.8 gigawatts of output in 2016 and growing at 2% a year. However, usage is projected to nearly triple to nearly 50,000 gigawatts in 2050.

While operating costs are low, the initial investment to build a power plant is higher than other sources and approaches that of coal-fired power plants.

There are also environmental concerns:

- The process of drilling and operating wells can consume large amounts of water and impact local water tables.
- The possibility of contaminants seeping into groundwater.
- Geothermal energy has been linked to earthquakes.

Geothermal energy is the wild card of renewable alternatives and bears watching. An important development was Google's announcement last year that it will begin using geothermal energy to power its Nevada data centers, the first hyperscale cloud operator to do so. For most data center operators, the best strategy is to let the hyperscalers navigate the twists and turns of the promising technology but not bake it into their plans just yet.

4 Biomass

Biomass accounted for 4.9% of U.S. energy consumption in 2020. Old is new again in this case because biomass was the largest source of U.S. energy consumption until the mid-1800s, largely through the burning of wood. It processes organic materials into an energy source, most often by burning but also through thermochemical, chemical, or biological conversion to fuel. Although considered one of the more exotic renewable energy sources, Canada has 70 biomass power plants that collectively produce over two gigawatts of power, making bioenergy the country's second most-used form of renewable energy.

Biomass can prevent some types of waste from going to landfills, but extraction of appropriate materials can be expensive, and substantial storage space is required to stockpile organic material outside of the growing season.

A principal advantage of biomass is that it can generate power continuously as long as a fuel supply is available. From a renewable energy perspective, the story is more mixed. If fuel sources such as crops and trees are continuously replaced, then burning biomass would technically not increase greenhouse gas emissions. However, doing so requires that the energy source is in physical proximity to the power plant and that resources be committed to cultivating and harvesting plant matter. Biomass can prevent some types of waste from going to landfills, but extraction of appropriate materials can be expensive, and substantial storage space is required to stockpile organic material outside of the growing season. Biomass is also considered one of the more expensive alternative energy sources.

Bottom line: This is not likely to become a major alternative energy source for data centers in the foreseeable future.

5 Hydropower

Hydropower accounted for 7.3% of total utility-scale power in the U.S. in 2020 and 37% of renewable electricity generation. However, its share of the alternative energy pie has shrunk from 30% in 1950 as other renewable sources have grown.

In some areas, though, water is king. China has made major commitments to hydropower and currently generates about 27% of the world's capacity. Washington state gets about 10% of its power from hydroelectric sources. The total power generated by the sector reached a record 4,370 terawatt-hours in 2020, most of it outside the United States. Projects totaling 21 GW and capacity were also put into operation, about two-thirds of them in China.

The advantages of hydropower are that it's cheap (about 5 cents per kilowatt-hour), clean and continuous. It can provide a reliable source of power to back up intermittent sources like wind and solar. Supply can also be scaled by releasing more water stored in reservoirs and storage tanks.

But while hydropower is renewable, it isn't necessarily environmentally friendly.

- The dams required to house turbines can significantly disrupt local ecosystems.
- Upfront construction costs are so high as to be impractical for individual data center owners.
- Power generation is also dependent upon the availability of water.
- With the west coast of the U.S. currently undergoing a historic drought, supply can no longer be taken for granted.

The large capital costs and economies of scale needed to make hydropower viable will confine its use to utilities. Companies looking to build new data centers may want to take a look at locations near existing or planned generation plants that are part of their renewable initiatives.

Batteries

Batteries are finally rounding the corner and becoming viable alternatives to diesel generators for backup power. Two major recent developments are important:

- Cata center technology company Switch has said it will use Tesla Megapacks to support more than 800-megawatt hours of storage capacity in its Nevada data center campuses.
- Google is using large batteries to replace the diesel generators at one of its data centers in Belgium.

The cost of grid-scale battery farms is coming down rapidly. The U.S. EIA estimates that project costs declined by 72% from 2015 to 2019. The agency also reported that 163 large-scale battery storage

systems encompassing 1,688 megawatt-hours were operating in the U.S. at the end of 2019, up 28% from a year earlier. Furthermore, it estimates that an additional 10,000 megawatts of large-scale battery storage will become operational by 2023.

Battery storage is now considered a viable alternative to generators on a short-term basis. Doubts exist, however, about how well the technology can perform in a long-term outage scenario. Most large-scale projects to date have been co-located with solar or wind energy farms. However, the EIA expects that future projects will increasingly be integrated with utility power plants.

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For the near term, batteries are best used to augment existing UPSs rather than to replace them. This allows operators to transition to cleaner energy while still maintaining a safety net.

Paths to Renewable Energy

Renewable energy certificates and power purchase agreements

The most immediate way data center operators can progress against their renewable energy goals is through their pocketbooks. Renewable Energy Certificates (RECs) and Power Purchase Agreements (PPAs) are the most commonly used ways to do that.

RECs are essentially investments in alternative energy. A REC is created for every megawatt-hour of renewable electricity generated by a power supplier. Energy-consuming companies can then purchase RECs and apply the carbon credits to their goals. This can move them closer to becoming a "net zero emissions" company although not an absolute zero-emissions company. Prices fluctuate and vary by the type of renewables being employed.

PPAs are a contract between an energy consumer and a renewable energy supplier. They provide for the developer to receive a fixed price for every megawatt-hour of energy it generates in exchange for the customer receiving the associated RECs. PPA contracts generally span many years. They are a vital asset for companies looking to build renewable power plants because they provide the guarantee of future business that they need to obtain financing.

RECs are somewhat controversial in that they can subject buyers to charges of greenwashing. The reality is that RECs don't produce any new green energy but rather incentivize others to do so. A more effective way to link investments to results is through "bundled RECs," which are RECs that are tied directly to the financing of a new project. Once the project is built, the operator passes along the resulting RECs to the buyer, who can then associate its investment with tangible green energy output.

PPAs are a direct investment in the creation of new renewable sources and are a better option for companies looking to assure stakeholders that they are committed to green sources.

Green business energy tariffs

Another fast and easy way to make your data center greener is to switch to a renewable business energy tariff or green power contract. Many utilities offer plans that ensure that some or all of the power the customer uses is matched with energy derived from green sources. In most cases, little or no setup is involved as the power is delivered through the existing grid. In addition to major utilities, many smaller suppliers offer attractive discounts and good customer service. The risk of working with them is that service levels may not meet utility-level standards or the company may not be as financially stable. It's important to investigate these factors and write provisions into the contract that cover exceptions.

Green power contracts can often be financially attractive, particularly if the customer is willing to make a long-term commitment. There's also no requirement that all energy must come from green sources; it may be as little as 10%. This allows data center operators to "go green" incrementally.

Primary and Backup Power Alternatives

One way data center operators can directly impact their use of efficient and sustainable fuels is by modernizing backup generators. Switching to lower-carbon fuel sources allows companies to use cleaner fuel that reduces emissions and extends equipment life.

Lower-Carbon Fuel Source Examples

- Hydrotreated vegetable oil is said to eliminate up to 90% of net CO2 from backup generators while reducing emissions of nitrogen oxide, carbon monoxide, and particulate matter. Kohler recently approved the use of EN15940-compliant hydrotreated vegetable oils (HVOs) for all its diesel engines. The fuel can be used both in its pure state or blended with conventional diesel in any liquid-cooled or air-cooled Kohler engine without modification. The renewable paraffinic fuel is produced from oils produced by the meat and fish industries and does not require agricultural resources. It can reduce carbon dioxide output by up to 90% and also reduces vehicle emissions because of its low sulfur content.
- Evolution Diesel Plus, which is made by Swedish energy company Preem, incorporates tall oil, a renewable by-product of forestry and paper production, and has been shown to provide reliable generator performance.
- Hydrogen fuel cells are also being used by several companies in emergency power scenarios, although that technology remains early stage.

Technology that allows companies to reduce the number of hours they need to test their generators by eliminating the “wet stacking” problem can sharply reduce diesel-related emissions in the short run. The solution for wet stacking has historically been to exercise the generators at 30% of rated capacity for hours each month to burn off unused fuel or prevent buildup, a wasteful procedure that emits greenhouse gases. Recent technology advances have reduced the need for this step from monthly to annually.

Recommendations

Data center operators are justified in moving cautiously to alternative energy sources. With nearly half of enterprises estimating the downtime costs more than $1 million an hour, a data center or co-location provider that can’t provide reliable availability will quickly be out of business. Even the hyperscalers who are leading the sustainability charge are setting decade-long timeframes. Smaller operators should watch the progress of these giants closely, as they will serve as proof of concept for such technologies as, wind, solar, and batteries.

For now, operators can contribute by improving the efficiency of their operations through such practices as optimizing airflows in their raised-floor facilities and using evaporative cooling to cut power and water requirements. It’s been estimated that a typical data center uses more than twice as much cooling as is necessary. Cold aisle/hot aisle containment can significantly reduce power requirements and related CO2 emissions while saving money. When upgrading UPS, look to modern generators that avoid the wet stacking problem.

RECs and PPAs are a fast and relatively inexpensive way to make an impact. So are green power contracts. These measures can be adopted incrementally and retired as on-site alternative energy options become more practical.

The path to sustainability is becoming clearer and is being paved by technology innovation across the globe. Data center operators can benefit from the goodwill that comes from committing to sustainable energy starting immediately. The costs of continuing on the journey will only continue to fall over time.