VERTIV WHITE PAPER

Preparing for a Carbon-Free Future: Steps Colos Can Take to Reduce Reliance on Carbon-Based Energy

Executive Summary

Many of the organizations that colocation providers (colos) serve have set aggressive goals to reduce or eliminate carbon emissions. While availability, safety, and scalability remain data center essentials, those objectives must now be met in ways that advance sustainability.

Reducing and finally eliminating carbon emissions will require a transformation in how data centers are powered that has already begun.

While the efficiency of the critical power infrastructure has steadily improved over the last 30 years, sustainability goals are driving a wave of innovation that is allowing operators to make significant gains in the utilization and efficiency of critical power infrastructure. Through these innovations, today's power systems can achieve utilization rates close to 100% and efficiencies up to 99%, maximizing available capacity while minimizing the energy losses that contribute to the data center's carbon footprint.

The next step in this evolution — locally generated renewable power — will require advances in fuel cell and hydrogen generation technology. As continued progress is made on both fronts, the industry will move toward a future where locally generated renewable energy powers on-site hydrolyzers that enable fuel cells to deliver reliable and continuous power from the edge to the core.

It will take collaboration across the value chain to achieve this future. Vertiv is working closely with major data center operators, as well as fuel cell manufacturers and other stakeholders, to ensure critical power systems can operate with the highest degree of utilization and efficiency while also providing the advanced energy management capabilities required to support a carbon-free future.

The Opportunity in Sustainability

In the last year, some of the world's biggest data center operators have renewed or accelerated their commitment to carbon-free or carbon-negative operations.

Google, for example, has set the goal of employing only carbon-free energy sources by 2030. Microsoft went a step further announcing plans to be carbon negative and water positive by 2030. By 2050, the company plans to remove from the environment more carbon than it emitted since its founding. Facebook and Apple have targeted 2030 to achieve net-zero emissions for their entire value chains.

These hyperscale operators have taken a leadership role in the movement to carbon-free operations but the trend is not limited to this sector. BP, FedEx, Ford, General Motors, IKEA, Starbucks, Unilever and Walmart are just some of the companies that have announced goals to become carbon neutral within the next 30 years, and their data center operations will have to be included in these initiatives. With the movement to increase climate-related disclosure in public company filings gaining momentum, it seems likely more companies will be following suit.

This represents an opportunity for colos that can help these organizations meet their goals. Hyperscale operators will choose partners based on their ability to support their ambitious objectives, and some enterprises will find increased reliance on colocation the easiest and most cost-effective way to eliminate data center-related emissions — if colos can offer carbon-neutral environments.

There are, however, challenges that must be overcome for colos to achieve carbon-free operations without compromising performance and availability.

This paper outlines a three-step approach to achieving carbon-free operations. The first step, which many organizations have already taken, involves matching current energy use with renewable energy. The second, which is gaining traction today, focuses on increasing the utilization and efficiency of critical data center infrastructure. The final, and ultimately most transformational step, involves the shift away from utility power as the primary data center power source.

Step 1: Matching Energy Use With Renewable Energy

The amount of renewable energy available on the grid has increased in recent years; however, in almost all areas of the world, the grid is not keeping pace with data center demand for renewable energy. In the United States about 40% of electrical energy generated in 2020 was from natural gas and 19% from coal. Only 20% was from renewable sources. Even the most optimistic proponents of renewable energy suggest 2050 is the earliest the country could possibly get to 100% renewable energy.

Europe is ahead of the U.S. on this front, with renewables providing 38% of electricity output, while fossil fuels provided 37%. China has added renewable capacity at a faster rate than the U.S. and Europe but is also seeing faster growth in energy consumption than other areas, and coal is still the dominant form of energy in the country.

Hyperscalers and colos are leveraging their scale to accelerate the availability of renewable energy to power data centers and piloting projects to power data centers from locally generated renewable energy. In select cases, individual data centers are operating on 100% renewable energy, but in many areas, sufficient renewable energy capacity is not available. The vast majority of data centers continue to rely on carbon-based fuel sources for primary and backup power.

Many organizations are able to achieve the goal of matching 100% of their energy use with renewables through the purchase of renewable energy certificates and power purchase agreements. These are important strategies in the advancement of sustainability initiatives; however, the goal of achieving true carbon-free operations will ultimately require reduced reliance on utility power and increased adoption of locally generated clean power.

Step 2: Driving Down Power Consumption

As data center operators seek to optimize capacity and sustainability simultaneously, opportunities within the power system have been identified to increase utilization and reduce waste. For colos, these opportunities must be leveraged without compromising the ability to deliver on service level agreements (SLAs), requiring careful selection of, and close collaboration with, data center equipment providers.

Here are some of the steps infrastructure vendors such as Vertiv are working on with their customers to increase power system utilization and pave the way for a carbon-neutral future.

- **Increase delivered UPS power:** In many data centers, there is stranded power capacity between the source and the load that results from excessive derating of power system components and sizing of those components to accommodate out-of-norm conditions. Some manufacturers artificially derate UPS systems to allow for variances in the manufacturing process. This process can no longer be tolerated if UPS capacity and utilization are to be maximized. Choose equipment providers that enable all equipment to operate at 100% of rated capacity.

In addition, UPS systems are often sized based on infrequently experienced out-of-norm conditions. This practice fails to leverage the UPS system's overload rating, which is engineered to allow the UPS to safely handle short-term out-of-norm conditions. For example, the Vertiv™ Liebert® Trinergy™ Cube system enables operation at 110% rated capacity continuously, 125% for 10 minutes, and 150% for one minute.

- **Increase N+1 utilization:** Reserve architectures provided a significant step up in UPS utilization rates when they were first adopted. Where 2N architectures had maximum utilization rates of 50%, which were rarely realized, reserve architectures could achieve utilization rates up to 66% for three to make two, 75% for four to make three, and so on. Now, operators are looking to increase utilization to close to 100% without sacrificing redundancy. This is being accomplished by segmenting loads into those that require the highest level of availability and those that can tolerate lower levels of availability. When a UPS in the reserve architecture is taken offline, the remaining modules operate above their rated capacity while the operator simultaneously throttles back or sheds IT loads that can tolerate lower availability.
- **Convert to lithium-ion batteries:** Lithium-ion batteries have matured to the point where their initial costs are now comparable to valve-regulated lead-acid (VRLA) batteries, and their various benefits enable a total cost of ownership 50% lower than VRLA batteries. As a result, they are rapidly displacing VRLA batteries in colocation data centers. While this change is not being driven by sustainability, lithium-ion batteries will be more effective than VRLA batteries at supporting a future of powering data centers locally from renewable sources, as discussed in the following section.
- **Value engineer the critical power system:** Value engineering is increasingly being used to eliminate component-level redundancies in a critical power system, enabling both lower costs and increased system efficiency. Additional capacity can also be unlocked by aligning the UPS rating with the breakers being used. Overcooling the UPS can be eliminated by allowing equipment operating temperatures to rise to what the equipment can tolerate reliably.
- **Increase UPS operating efficiency:** Most UPS manufacturers have introduced some form of "ECO Mode" to reduce the losses associated with the AC-DC-AC conversion that occurs within double conversion UPS systems. ECO Mode allows the UPS to operate in bypass mode when the utility is delivering acceptable power quality and switch back to double conversion mode when power quality degrades. However, most colos are reluctant to employ ECO Mode because of the potential for voltage variations to reach protected equipment during the millisecond transfer back to normal operating mode and the negative effect the transfer can have on harmonics.

  Dynamic Online Mode delivers the benefits of ECO Mode while eliminating the risks. It keeps the output inverter active but delivering no power, enabling a near seamless transition from the high-efficiency mode to double conversion mode that minimizes output harmonics. For more information on dynamic online operations, read the Vertiv white paper High Efficiency Modes of Operation.
- **Reduce generator oversizing:** Eventually, data centers will have to move away from diesel or natural gas generators to support carbon-free operations. In the interim, more accurate generator sizing can reduce the environmental impact of this equipment. This is enabled by using frequency-based walk-in controls on the UPS to compensate for generator frequency droop when switching to or from generator power. The controls automatically adjust the walk-in to the fastest possible rate. This limits the droop that can lead to generator instability or stalling, eliminating any justification for oversizing.

The cumulative effect of taking a holistic approach to critical power system optimization that includes as many of these steps as is appropriate can be significant and help pave the way to on-site power generation. For example, increasing UPS system utilization from 66% to 95% in a 2 megawatt (MW) UPS system can unlock an additional 58 kilowatts (kW) of data center capacity. Increasing efficiency through Dynamic Online Mode can reduce energy losses in the UPS by 47%.

Step 3: Changing How Data Centers Are Powered

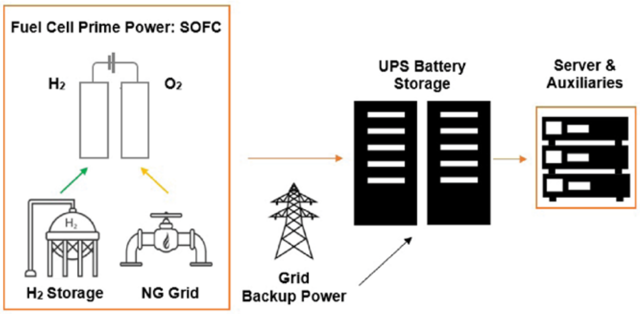
For data centers to become carbon free, the current method of relying on the utility for primary power with the UPS and generators providing emergency backup power, will need to evolve. Not only is the utility limited in its ability to deliver renewable energy, diesel and natural gas generators represent a source of carbon emissions that needs to be phased out.

The continued advancement of fuel cell technology will make this possible. In the short-term, fuel cells create the opportunity to replace carbon-fueled generators as a source of backup power. Proton-exchange membrane (PEM) fuel cells have excellent power density and can start quickly even in low temperatures, making them ideal for mobile and backup power applications. The key obstacles restraining the use of PEM fuel cells as a backup power source today are the cost of hydrogen, which will come down as adoption of fuel cells increases across various industries, and the challenge of storing the quantities of hydrogen required to ensure 24 or 48 hours of backup power.

Ultimately, this second obstacle will be addressed by implementing on-site hydrolyzation that, when powered by renewable sources, creates enough green hydrogen to enable fuel cells to serve not only as the backup power source, but as the primary source of data center power.

Wind or solar energy generated on site will power hydrolyzers and charge lithium-ion batteries. The lithium-ion batteries store energy for short-term backup power, while hydrogen generated by the hydrolyzers is used by fuel cells that provide primary power to the data center. When the batteries approach the limit of their runtime, the UPS switches the data center to the grid to maintain continuous operations.

Based on the current state of the technology, solid oxide fuel cells (SOFCs) show more promise for base load applications than PEM fuel cells, since they have a longer lifespan and their



slower start speeds are not an issue in continuous power applications. Most SOFCs in use today are natural gas based with embedded reformers, but they have proven capable of running on green hydrogen.

In this scenario, the UPS provides key energy management capabilities in addition to its power conditioning and backup power functions. For example, operators that make the investments in renewable energy and fuel cells may want the ability to save excess energy for later use or use it within their campus to offset existing base loads. The UPS can orchestrate this. Future generations of UPS platforms will need to include smart energy management capabilities.

This transformation represents one of the most significant changes in data center operations that has occurred this century. That may convince some it can never happen. There are certainly challenges that must be addressed; however, this approach is being actively pursued by large operators today and ultimately represents the fastest and most viable path to truly carbon-free operations, which is key to the continued growth and success of the industry. It only becomes more viable as continued advances in renewable energy, fuel cells, and hydrolyzers improve the performance and lower the cost of these technologies.

Beyond Sustainability

While the changes occurring in data center power systems are largely being driven by sustainability, they offer additional benefits to colos that should factor into the decision-making process:

- **Expanded capacity:** Operators that can increase utilization of their critical power systems expand the available power capacity at those sites, offsetting demand for new capacity.
- **Lower costs:** Actions can be taken today to lower operating costs of existing deployments through power system optimization. As the cost of locally generated energy comes down, operators will be able to optimize based on energy cost in addition to space, efficiency and footprint.
- **Increased location flexibility:** Some cities and utilities are already limiting the power that will be supplied to data centers, and this trend could increase in the future and limit the ability of providers to locate where there is demand. By becoming energy-independent, colos will have the flexibility to locate in key primary and secondary markets with limited dependence on the local utility.

Conclusion

Reducing dependence on carbon-based fuels represents a competitive advantage in the short term and a necessity in the long term. Working with a forward-thinking and innovative infrastructure partner like Vertiv puts you in the position to move forward with proven technologies that allow you to take steps today toward a carbon-free tomorrow. Vertiv stands ready to work in partnership with colos seeking to reduce or eliminate their reliance on carbon energy sources.

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