VERTIV™

TELECOM WHITE PAPER

Energy Management Tactics for Telecom Networks

Strategies for Managing 5G Energy Demand

Executive Summary

Energy use is responsible for more than 92% of telecommunications network operating costs[1], and 5G will drive unprecedented increases in consumption across the network. The urgency in urban centers and regions where 5G is a priority is palpable, but 5G is just one item on a growing list of reasons today's telcos are increasingly focused on energy and carbon responsibility. Telcos that have been caught in a seemingly endless loop of network upgrades now are turning their attention to the costs and carbon footprint associated with those advancements. There are steps operators can take to reduce the energy their networks consume, source energy wisely, and ensure more responsible operation, and there are others to monitor as associated technologies mature.

This paper will evaluate several emerging energy management and efficiency strategies for the telecom access space and look ahead to what might be next in the battle against the climate crisis.

[1] https://data.gsmaintelligence.com/research/research/research-2020/5g-energy-efficiencies-green-is-the-new-black

Introduction

It would be an overstatement — and inaccurate — to say telecom operators have been unconcerned with energy consumption and carbon emissions in the past. The industry has been deploying hybrid energy systems for decades and was an early adopter of solar energy, albeit in limited, specific applications. Operators have pursued energy efficiency technologies tirelessly, and today's most advanced rectifiers are marvels of efficiency. The industry should be commended for those efforts.

It is also true, however, that there are other motivating factors for those efforts. Hybrid energy systems, for example, are needed in remote locations where grid power is unavailable or unreliable, and their use for years was most common in those environments. Only recently have we seen on-grid hybrid energy solar systems being deployed as part of a true energy management strategy, with those examples limited mostly to Europe in response to the rising cost of energy. On-grid solar systems are virtually nonexistent in the United States, with the exception of a few trial sites on the west coast, where grid energy traditionally has been reliable and affordable. The key phrase there is "has been," because many parts of the world — California and Texas in the U.S., Denmark and Germany in Europe, and Australia being prime examples — are wrestling with the rising cost of energy and increasing demand that can exceed the capacity of existing utilities.

The severity and specifics are different in different parts of the world, but rising energy costs are clearly a global issue. Telcos are responsible for an estimated 2-3% of global energy use[2] and 1.4% of carbon emissions[3], and with 5G projected to double or even triple the industry's consumption over the next decade[4], the increased urgency operators are feeling today is to be expected.

Long a simmering issue for telcos, the climate crisis, and associated pressures to improve energy efficiency and management now carry more urgency. When you also consider the shifting political winds supporting energy management best practices, the proliferation of more stringent energy and environmental regulations, and genuine concern as global and corporate citizens, it's clear that telcos understand they must do more.

This paper will look at some near and longer-term strategies to help mitigate these challenges in the telecom access space.

[2] https://www.businesswire.com/news/home/20210209005153/en/Guidehouse-Insights-Report-Finds-Telecom-Networks-Are-Expected-to-Install-122-GW-of-New-Distributed-Generation-and-Distributed-Energy-Storage-Capacity-from-2021-2030

[3] https://www.ericsson.com/en/reports-and-papers/research-papers/the-future-carbon-footprint-of-the-ict-and-em-sectors

[4] https://www.businesswire.com/news/home/20210209005153/en/Guidehouse-Insights-Report-Finds-Telecom-Networks-Are-Expected-to-Install-122-GW-of-New-Distributed-Generation-and-Distributed-Energy-Storage-Capacity-from-2021-2030

Actions to Take Today

Let's be clear: there is no silver bullet for reducing gross energy consumption in telecom networks. There are, however, steps operators can take to reduce the power they use and shrink their electric bills.

The most obvious and already widely adopted strategy is simply transitioning to high-efficiency rectifiers in the DC power systems present at every access site. Replacing legacy DC power systems with newer, high-efficiency models can improve energy efficiency by 5-6%[5]. Every provisioning decision at every 5G site retrofit or new deployment should be made with energy efficiency at top of mind. This is happening more and more already and should be a baseline expectation of operators everywhere.

In addition, modern equipment frequently includes energy-saving modes and features that too often are ignored. Today's DC power systems, for example, are more intelligent and capable of more advanced energy management than legacy systems, but frequently operators choose to ignore those capabilities in favor of static operation.

Other efficiency-oriented strategies are less common, although in many cases, circumstances are shifting to encourage more aggressive, creative approaches.

[5] https://www.vertiv.com/en-emea/campaigns/dc-power-efficiency/

Match the Energy Strategy to the Site

It's an overstatement to say every site is unique, but when you consider geographies, climate, grid reliability, water availability, governmental regulations, and countless other considerations around the globe, it becomes clear that no single strategy is appropriate for every access site.

Energy and carbon management strategies must be linked to planning and real estate, and operators must tailor their approach to the conditions across their networks. Consider these examples:

- **Solar Power:** Solar power is the most common and scalable alternative energy option. Hybrid energy systems leveraging solar power to supplement unreliable or overtaxed grids or support remote sites are commonplace in much of Africa, South America, the Middle East, parts of Asia, and increasingly in Europe.

The price of solar, once prohibitive, has dropped considerably[6] as technologies have progressed and adoption increased. In locations with adequate sunlight, solar today is a cost-effective[7], reliable alternative power source allowing sites to go off-grid or demand less from the grid. Vertiv has deployed more than 120 megawatts (MW) of solar to access sites around the world to date, and the pace of those deployments is accelerating.

Hybrid/solar adoption has lagged in the U.S., where most of the country enjoys affordable, reliable grid service, but the calculus is changing in parts of the country. California has struggled to maintain energy capacity as the state's population and demand for energy increase, and energy costs have gone up in an attempt to balance market conditions. Texas has experienced its own issues related to its grid and challenges meeting unexpected demand. These challenges are familiar to many parts of the world.

There are opportunities — and an increasingly compelling economic case — in countries with plentiful sunshine to introduce solar power as a supplement to the grid. That case may be more difficult to make in Louisiana where electricity is 9 cents per kilowatt-hour (kWh) or in countries primarily powered by coal like South Africa; but solar power is critical to places like Denmark and Germany, where prices routinely exceed 30 cents per kWh. And, of course, those prices can and will continue to fluctuate.

The takeaway is this: When increasing the solar component of a site's energy mix, operators must consider a variety of factors in addition to climate, including cost of electricity from the utility compared to the cost of solar; reliability, energy security and resiliency of the grid; as well as availability of sunlight and whether the site footprint can accommodate solar panels. Solar technologies have reached a point — and a price point — that demands consideration, but that does not mean it is the right choice for all sites.

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[6] https://www.nrel.gov/news/program/2021/documenting-a-decade-of-cost-declines-for-pv-systems.html

[7] https://www.vertiv.com/4a48af/globalassets/products/critical-power/dc-power-systems/white-paper---when-can-we-afford-to-deploy-solar-.pdf

- **Lithium-ion Batteries:** Li-ion batteries have a greater energy density than traditional valve-regulated lead-acid (VRLA) batteries, which can be leveraged either to pack more storage in the same space or to reduce the space used by batteries. They can operate at higher temperatures reducing the energy required for cooling and last longer than VRLA. With the mandatory battery management system, remote monitoring and management is available. All of this contributes to less frequent replacements and reduced truck rolls and costs, plus reduced carbon dioxide (CO2) emissions associated with those activities. These features offer real, tangible environmental benefits.

  The questions around Li-ion batteries have long been aimed at the costs and recyclability of the batteries, with skeptics believing all Li-ion batteries end up in landfills or as unsalvageable scrap byproducts from inefficient recycling processes. Today, a growing number of companies are using recycling processes that recover more of the valuable elements in the battery while minimizing or eliminating waste byproducts.

  Government pressure and the migration to electric vehicles are helping ensure Li-ion reuse and recycling programs emerge. The Canadian company Li-Cycle and U.S.-based Redwood Materials are two companies investing aggressively in recycling programs in North America[8]. In Europe, NorthVolt and Polarium have partnered to recycle telecom lithium batteries[9].

Thinking more holistically, Li-ion batteries with intelligent battery management systems enable peak shaving and similar energy management strategies (discussed below). These capabilities remain largely unused to date at on-grid sites, although we anticipate operators will more aggressively leverage these options as the batteries are more widely deployed. Li-ion batteries age, discharge, and recharge gracefully, reducing the risk of shifting load to the batteries. All of this makes Li-ion a good fit for peak shifting and shaving at on-grid sites, or to reduce the use of diesel fuel at poor grid and off-grid sites.

[8] https://www.vertiv.com/4a8498/globalassets/documents/white-papers/vertiv-lithium-ion-battery-recycling-wp-en-na-sl-70850-web_339930_0.pdf

[9] https://polarium.com/insights/why-lithium-batteries-need-to-be-recycled/

- **Thermal Management:** Historically telcos haven't had to worry too much about thermal management efficiency at the access site. The telecom equipment at these sites is not as heat sensitive as the IT gear in data centers. 5G is changing everything, however. IT systems are ubiquitous across 5G networks, and those heat-generating systems are out of place outside their data centers and similar climate-controlled environments.

  Today, there are smaller, modern enclosures for telco access sites designed to protect sensitive equipment from the elements and minimize the need for dedicated cooling. These enclosures can be equipped with cooling technologies tailored to specific site needs. For example, Vertiv has developed an innovative climate control functionality that automatically adjusts fan speed based on internal humidity levels to optimize the energy used for cooling.

- **DC/AC Load Management:** The introduction of IT equipment in the telecom access space presents challenges beyond cooling. As more computing is introduced into traditional DC-powered environments, the need to reliably and efficiently manage both AC and DC loads increases. Power inverters with integrated AC and DC distribution panels can ensure zero transfer time between AC mains and DC battery sources, delivering the most reliable backup possible for critical AC and DC loads.

  The best of these inverter units can deliver peak efficiency of 96.3%, while eliminating equipment and reducing maintenance costs. By providing clear visibility into both AC and DC loads, they enable more accurate capacity planning and management and maximum availability.

Vertiv™ NetSure™ M Series

Vertiv™ NetSure™ Inverter System

Vertiv™ NetSure™ Inverter Cassette

Use Intelligent Controls to Manage the Load

As electricity providers around the world increasingly struggle to balance supply and demand, many have adopted pricing policies to help manage the strain on their grids. These policies are used as levers to reward customers for balancing their grid by persuading them to defer (or shift) their use of electricity — concepts telecom operators must know and understand. The first policy is Time of Use. This is when the cost of electricity is predictable by day and time, allowing consumers to plan when to use electricity from the grid; and, just as importantly, when to defer use of grid electricity in favor of on-site power.

Demand Pricing is not predictable, and surge pricing is intentionally painful in an effort to suppress demand. Utilities with Demand Pricing require consumers to react when prices escalate. Utilities everywhere, such as Reliant Energy in Texas and EnergiNet in Denmark, are adopting Demand Pricing.

There are two adaptive strategies telecom operators can use to address these utility policies. These are widely available today and increasingly common — although still underutilized. When employed, they also move loads off the grid to locally generated energy sources.

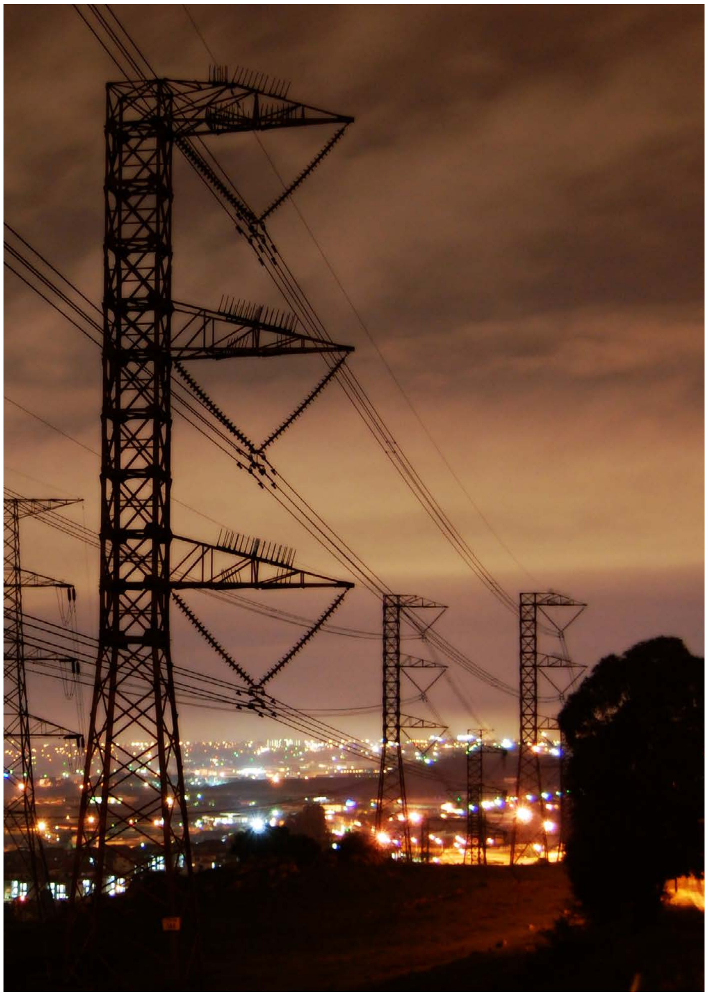
- **Peak Shifting for Planned Time of Use Utility Pricing**: With Peak Shifting, the telecom carrier can plan a repeating routine that defines high- and low-cost operating periods. In a high-cost period, the rectifier reverses its relationship with the battery and turns down, allowing the battery to support the load. The rectifiers never turn off completely, but maintain a hot standby position, always available and never compromising the ability to deliver service.

  Once the site enters its planned low-cost operational period, the rectifiers resume the primary role of supporting the load and recharging the battery, until the next planned cycle is scheduled. This technique marries well with lithium-ion batteries that use less space, recover faster, and are more robust than lead-acid batteries.

- **Peak Shaving for Unpredictable Utility Surge Pricing**: Peak Shaving allows operators to shift a site load in real time when demand spikes and Demand Pricing drives the cost of electricity up. This can happen during extreme cold or heat as consumer use of furnaces, space heaters, or air conditioning drives electricity demand beyond norms.

  A great example of the need for Peak Shaving is Energinet of Denmark, whose cost of electricity fluctuates by the hour, every hour. On December 14, 2021, the cost to operate was 34.52 euro cents per kWh at 5 p.m., but by 8 p.m. the cost dropped to 13.2 euro cents per kWh. If we look at the month of December, the cost of electricity (Energinet DK1) ranged from .57-62 euro cents per kWh.

Peak Shaving is an effective strategy for this unpredictable operating cost with the added benefit of reducing operators' carbon footprint by reducing the grid draw during high demand periods. By utilizing an integrated energy control center that can remotely change the primary power source, operators can reduce the draw from the grid during peak times. With Peak Shaving, operators move the site to battery and place rectifiers in standby in favor of an alternative local energy source, such as a generator or fuel cell.



Actions to Plan for Tomorrow

Operators can enact the aforementioned strategies today to reduce energy consumption and costs, but let's be clear: these steps alone will not solve the problem. To get where they want to go, operators must consider more creative, ambitious approaches to managing their energy consumption.

Taking these steps requires better planning and awareness of the implications of such actions. When deploying solar, for example, real estate needs change — potentially requiring a larger footprint and an unobstructed view of the sun. There will be local and regional policies and regulations to consider. In the past, operators could simply pursue the least expensive real estate they could find. As part of a larger energy management strategy, that is no longer the case.

Alternatives to Diesel

Diesel generators are deployed at most access sites to provide extended backup power or off-grid power as needed. Diesel fuel produces greenhouse gas emissions, and they must be refueled regularly, which adds to the carbon footprint due to the realities of transporting fuel. Simply put, diesel generators get the job done, but they introduce other challenges.

Embracing energy responsibility at these sites requires new thinking, and likely an alternative to the traditional diesel generator. The most promising of these is the hydrogen fuel cell, and that technology is maturing in important ways that make applications in the telco access space viable.

Fuel cells are not a new technology, but traditional approaches have not always been green. One example is blue hydrogen[10], which is created using natural gas, another fossil fuel that contributes to global warming. Green hydrogen, on the other hand, is produced using electrolysis of water — a process that can be done using solar power or other types of alternative energy — and represents a valuable energy resource without some of the complications of the blue variation. A fuel cell using green hydrogen creates multiple opportunities for telecom operators.

Unlike diesel fuel, hydrogen can be stored indefinitely without going bad. This is perfect for remote access sites that only occasionally need extended backup power. When that need arises, relying on old, potentially ineffective diesel fuel can lead to an outage. A fuel cell powered by green hydrogen faces no such obstacles. In fact, as the cost of hydrogen decreases, such a fuel cell could allow operators to shift between utility power and the fuel cell more liberally.

[10] https://www.nationalgrid.com/stories/energy-explained/hydrogen-colour-spectrum

These types of technologies already are in use in parts of the world. Germany, for example, has invested heavily in its hydrogen infrastructure and is at the leading edge of green hydrogen technologies, including fuel cells. This is no small undertaking. Although hydrogen can be moved in pipelines, like oil or natural gas, it is much less dense, meaning existing pipelines must be modified to transport a sufficient amount.

The activity around green hydrogen and fuel cells is encouraging, and the commitment in Germany is bearing fruit already, but widespread adoption will take time. We likely will see smaller fuel cells sooner, deployed to pilot projects as early as this year or 2023 and shortly after to telco sites in limited numbers. More widespread adoption is likely to occur closer to 2030 and contribute heavily to the ambitious energy and carbon goals we've seen targeted to the end of the decade.

Opportunities on the Fringe

Any discussion of potential long-term innovations should acknowledge activities that may lack traction today but could present opportunities as different technologies mature. This could include new and emerging battery technologies like sodium-ion that may present additional opportunities for off-grid operation and energy management. High-voltage DC power has shown promise in reducing power conversions and improving energy efficiency in some limited applications and may be part of future solutions. And as on- and off-grid power management becomes more sophisticated, we could see networks evolving into microgrids that generate and share their own power across the network and with the utility. These aren't viable alternatives in the access network today, but innovation is fluid and unpredictable, and continued research in these areas is warranted.

The Reality of 5G

We can't discuss energy in the access space without acknowledging the impact of 5G.

5G networks are up to 90% more efficient than 4G[11], a data point that has been repeated often and unfortunately brings to mind the old refrain about "lies, damned lies, and statistics" (or as we've often appropriated it, "lies, damned lies, and data sheets.") That 90% figure certainly isn't a lie, but as a statistic, it's deceptive at best.

Yes, 5G is significantly more efficient than 4G on a per-gigabyte basis. But despite that impressive per-gigabyte efficiency, 5G networks still consume far more energy than their 4G predecessors. Current projections suggest a 5G-driven increase in network energy consumption that ranges anywhere from 150%[12] to 300%[13].

This is all true, but we are in the early days of 5G rollouts, and those early deployments are largely in urban centers in developed countries[14]. As such, 5G is a factor for some operators in some geographies, but remains a distant concern for many others. Simply put, while 5G may drive headlines, it is but one of many drivers of the current focus on energy efficiency and management, and a localized one at that.

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[11] https://www.fiercewireless.com/5g/nokia-affirms-5g-as-more-energy-efficient-cautions-rising-network-traffic

[12] https://www.vertiv.com/en-us/about/news-and-insights/corporate-news/2019/mwc19-vertiv-and-451-research-survey-reveals-more-than-90-percent-of-operators-fear-increasing-energy-costs-for-5g-and-edge/

[13] https://www.businesswire.com/news/home/20210209005153/en/Guidehouse-Insights-Report-Finds-Telecom-Networks-Are-Expected-to-Install-122-GW-of-New-Distributed-Generation-and-Distributed-Energy-Storage-Capacity-from-2021-2030

The Big Picture

In reality, even the most optimistic outlook on these strategies would concede that the telecom industry alone will be unable to fully mitigate the power demands of expanding and evolving telecom and data networks. The steps outlined here will help and will contribute to important energy management efforts, and the advances telcos are enabling will contribute to a holistic, global effort to combat climate change.

[14] https://www.speedtest.net/ookla-5g-map

Vertiv.com | Vertiv Headquarters, 1050 Dearborn Drive, Columbus, OH, 43085, USA

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