Renewable power: Boosting the green credentials of tomorrow's telecom networks

The challenges and benefits of adopting advanced energy solutions

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Executive summary

The rollout of 5G represented one of the latest step-changes in the telecoms industry fuelled by innovation.

Technological advances like this help meet the needs of a world ever hungrier for digital speed, capacity and connectivity.

But with exponential increases in global data flows come equally significant rises in energy demand. This sits contrary to efforts by telecom networks to make their operations more sustainable, and therefore more efficient and less costly.

Installing renewable energy sources such as wind turbines and solar panels across telecom networks can play an important role in efforts to optimize energy consumption and reduce emissions - both for large telecom centers and distributed networks of small base stations.

Integrating clean energy into network operations provides many benefits, including curbing emissions, reducing reliance on grid consumption and increasing security of the energy supply. Furthermore, in rural areas, renewables can be more cost-effective and energy-efficient than relying on a new grid connection.

However, they may not be sufficient to keep telecoms operators running on their own, and may need to be complemented by other forms of energy, and by other cutting-edge technologies.

Fourth Industrial Revolution technologies such as AI and the Internet of Things (IoT), increasingly underpin efforts to transition to a better future. They are leading to innovations in a number of areas that can generate additional network efficiencies for telecom operations. These include:

Hybrid cooling
By combining existing heating, ventilation and air conditioning technology with smart controls to optimize temperature management, network sites can minimize energy consumption and ensure an environment where equipment can operate reliably.

Super high- and ultra-high-efficiency rectifier modules
Advances in rectifier technology have resulted in the development of modules with exceptionally high efficiency.

Metering and monitoring
There is a growing need for both AC and DC metering to increase the transparency of base station energy consumption.

Smart power
AI-enabled grid services like tariff management, peak shaving and load shifting can control energy consumption at base stations to minimize costs.

Remote management
Smart software platforms can optimize operations at telecom base stations.

As smart technologies continue to transform our world, there is enormous potential for network operators to make their operations more efficient, more sustainable and keep the vision of a net-zero future firmly in sight.

Contents

Section 1 - Introduction

Data fuels the technical revolution transforming our world, and humankind's appetite for all things digital is seemingly boundless.

In 2018, around 90% of all the information ever generated - about 20,000 years' worth - was done so within the previous two years, according to Forbes[1]. And global data use has continued to increase exponentially since then.

Advances in technology constantly create new ways to integrate our smartphones, laptops, tablets, smart TVs and other devices with the world around us, increasing processing speeds, capacity and functionality.

As a result, demand for data centers and transmission networks to process this growing tide of data is increasing, with each accounting for 1-1.5% of global energy use, according to the International Energy Agency (IEA)[2].

While advances in efficiency have helped keep data center and transmission networks' energy demand growth in check, consumption is increasing.

Combined energy use by Amazon, Microsoft, Google and Meta more than doubled between 2017 and 2021, for example. While electricity consumption by data transmission network reporting companies increased by 1% between 2015 and 2018, as data traffic tripled, IEA figures show.

This could leave the information and communications technology sector generating 14% of global CO_2 emissions by 2040 unless significant action is taken to make operations more sustainable, according to the Boston Consulting Group[3].

[1] Forbes, [2] IEA, [3] BCG

The telecoms industry is one area of this sector seeking to decarbonize by integrating clean, renewable energy sources into its operations. This forms part of efforts to improve costs and the resilience of passive networks while reducing emissions. Mobile network operators have so far focused their energy management efforts on large-scale facilities that require equally large energy resources to power them.

However, managing the distributed energy consumption of a dispersed network of radio base stations has presented more of a challenge, partly because of prohibitive costs and technological barriers. Small sites typically consume a relatively small amount of energy, but with thousands of radio base stations spread across wide geographies, they can be responsible for the bulk of a mobile operator's total energy bill and its carbon footprint.
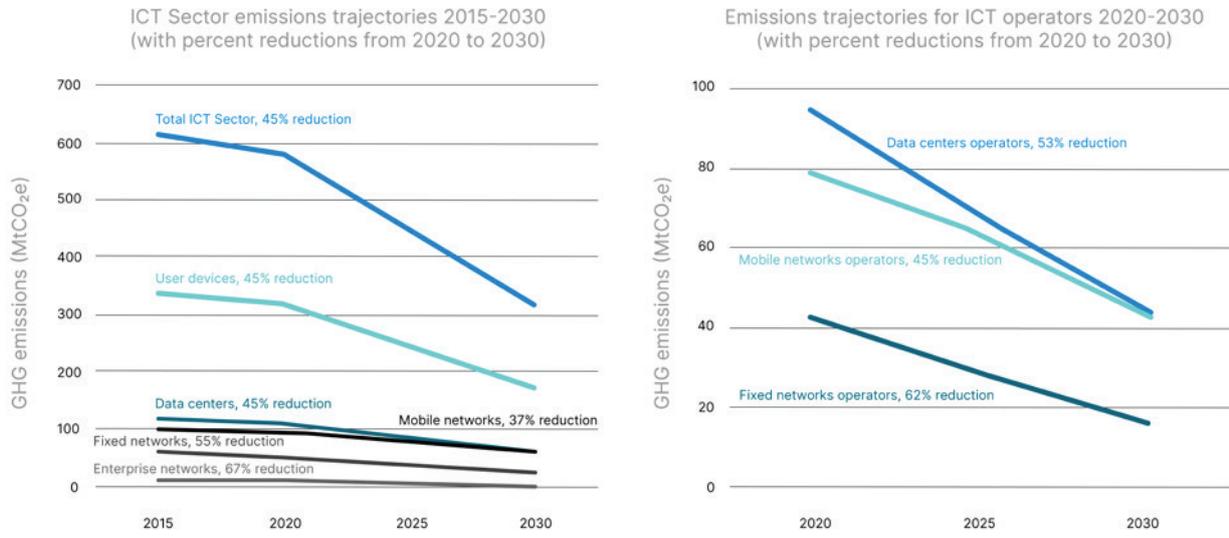
As the impact of the Fourth Industrial Revolution looks set to trigger a huge surge in power consumption - 5G implementation alone could increase power demand by 160% by the end of the decade[4] - network operators have some tough decisions to make. Challenges like exploding demand, network security, the pace of technological change and mounting pressure to "go green" mean the telecoms industry may have to reinvent itself more than once.

Runaway energy demand to power data flows cannot be avoided, but telecom companies can work to diversify energy sources to embrace more sustainable operations. This will not only build greater resilience, reliability and efficiency into their networks but also reduce long-term costs.

Mobile network operators need to achieve a 45% reduction in operational emissions by 2030, compared with 2020[5], according to a GSMA industry scenario consistent with limiting global warming to within the Intergovernmental Panel on Climate Change's 1.5°C target.

[4] InterDigital, [5] GSMA

ICT Sector emissions trajectories 2015-2030
(with percent reductions from 2020 to 2030)

GHG emissions (MtCO₂e)

- Total ICT Sector, 45% reduction
- User devices, 45% reduction
- Data centers, 45% reduction
- Mobile networks, 37% reduction
- Fixed networks, 55% reduction
- Enterprise networks, 67% reduction

Emissions trajectories for ICT operators 2020-2030
(with percent reductions from 2020 to 2030)

GHG emissions (MtCO₂e)

- Data centers operators, 53% reduction
- Mobile networks operators, 45% reduction
- Fixed networks operators, 62% reduction

Source: Science Based Targets

However, advances in power efficiency and software solutions have greatly increased opportunities to boost operating efficiency, cut costs and curb emissions. And this trend is set to continue.

Telecom service providers can play a key role in reducing the industry's carbon footprint, and many have signed up for sustainability programs like the RE100 global corporate renewable energy initiative[6] to rely on 100% renewable energy by 2030.

This white paper looks at some of the challenges facing telecom providers and the technological advances and solutions that could help put them on the road to a more sustainable future.

[6] RE100

Section 2 - Clean and transparent energy

The global population generates more than 2.5 quintillion bytes of data daily[7], and the exponential growth of technologies like IoT, AI and machine learning require an ever-greater abundance of energy. In short, the technological revolution, together with the growing climate crisis threat, have pushed sustainability to the top of the telecoms industry agenda.

Operators and tower companies have spent a great deal of time and money attempting to reduce the amount of energy that base stations consume, which can comprise more than 60% of an operator's energy costs. But faced with ever-increasing flows of data traffic, this is only part of the solution.

The industry will need to make efficiency gains throughout telecom networks and incorporate low-carbon energy sources in place of reliance on fossil-fuel power. This transition is vital to reduce costs, curb emissions and improve sustainability across the industry.

As well as reducing energy consumption at large telecom sites, companies like Delta are harnessing their extensive experience to develop solutions that can extend energy savings to the many smaller sites across a network.

Unlike the common practices deployed across large sites, applying solutions to smaller sites is not so simple and presents unique challenges. However, combining customized energy-efficiency methods with Delta's remote monitoring software and hands-on industry experience can create significant savings across an entire network.

[7] Domo

2.1. Benefits of switching to renewable energy

Using renewables is no longer a case of *if*, but of *how*. Telecom companies need to take an integrated approach to reducing both the costs of energy consumed by networks and the emissions their operations generate.

Swedish telecoms network equipment vendor Ericsson has recently increased its forecast of the annual energy costs of running the world's mobile networks, saying that the prediction of $25 billion it made in 2020 is likely an underestimate[8].

Today, at the utility level - given the abundance of new clean energy capacity coming online - renewables like wind and solar energy can be cheaper than reliance on traditional means of power generation[9]. This trend is likely to continue, making the capital expenditure needed to embrace renewables a sound investment.

Generating power on-site can reduce energy costs by as much as 40% in some cases: Japanese mobile phone operator NTT Docomo reduced its grid power consumption by around two-fifths at some base stations by installing solar panels and higher-capacity batteries, according to McKinsey & Company[10].

The benefits of integrating renewable energy into telecom networks go beyond simply reducing the CO_2 footprint of sites. It can also help to avoid the price fluctuations of fossil fuels, and allows companies to manage business costs by fixing their energy costs for a 10 or 15-year period, reducing exposure to sudden price spikes.

[8] Ericsson, [9] Science News, [10] McKinsey & Company

Global prices of commodities like oil, coal and natural gas are heavily influenced by the supply decisions of groups like OPEC, petro-states such as Russia and oil-producing firms[11]. Events like natural disasters that could disrupt production, while geopolitical unrest in oil-producing countries, spikes in production costs, storage availability and other factors also contribute to price instability and uncertainty.
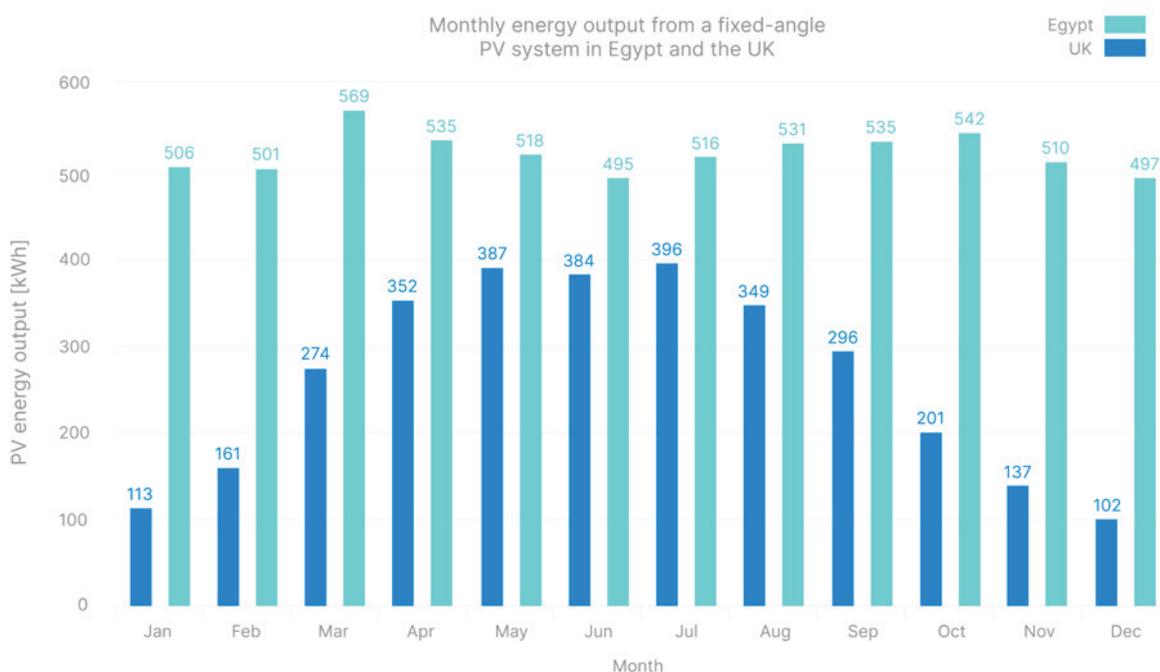
Installing renewables not only helps telecoms networks avoid energy price spikes, but can help increase energy security and guarantee power supply, as it makes sites less dependent on power from the grid. This is particularly significant in countries where underinvestment in traditional energy infrastructure over time has led to regular power outages. In South Africa, daily power cuts typically last between 6-8 hours, for example[12].

However, the availability of natural resources, such as sunshine for solar and wind energy to power turbines, is important.

A solar array in sunny Egypt, which provides a stable and predictable power source year-round, can generate approximately 6,250 kWh annually, with a variance between the highest and lowest production months of 75 kWh (around 13%), for example.

Compare this to the same array in the UK, which would only generate roughly 3,200 kWh annually, with a high-low month variance of around 300 kWh (around 75%).

As the same configuration renders different results, depending on location, installation type or load energy consumption profile, its development is more complex than in the case of a simple rectifier system.

Monthly energy output from a fixed-angle PV system in Egypt and the UK

Egypt / UK

Month	Egypt	UK
Jan	506	113
Feb	501	161
Mar	569	274
Apr	535	352
May	518	387
Jun	495	384
Jul	516	396
Aug	531	349
Sep	535	296
Oct	542	201
Nov	510	137
Dec	497	102

PV energy output [kWh] / Month

[11] Investopedia, [12] Reuters

2.2. Challenges of integrating renewable energy

Installing clean energy solutions across telecom networks is not without its challenges.

Base stations come in numerous different shapes, sizes and physical locations, each with unique attributes, accessibility and traffic conditions. As such, not all stations are suitable for installing renewables.

Antennas must be located in high positions. This can make it difficult to conduct maintenance work or install wind turbines or solar panels, as suitable ground space may be limited in some high-ground areas.

And although telecom operators face high upfront capital costs when deploying clean energy solutions, these can quickly be recovered through energy savings - especially with current high fossil-fuel energy prices.

It's also important to note that renewables generate power on a use-it-or-lose-it basis. Unlike fossil fuels, which can be combusted on demand, renewables like solar and wind power only generate electricity when the sun shines or the wind blows.

As such, while renewables are a more cost-effective, energy-efficient and low-carbon alternative to traditional means of electricity generation, they are not sufficient to keep networks running on their own. However, well-designed systems overcome these challenges.

And while wind turbines can be less reliable than solar panels in generating consistent power supply, cutting-edge solutions like Delta's can mitigate this unpredictability.

2.3. How the industry is overcoming these challenges

Advances in technology are helping to address some barriers to renewables adoption, including the provision of on-site backup power, likely in the form of batteries, an AC grid or a generator connection.
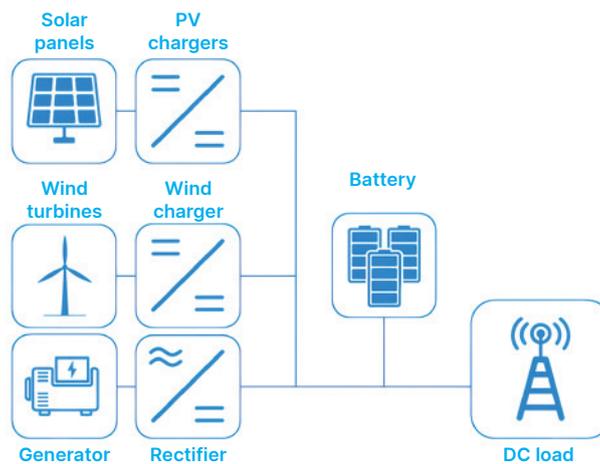
When incorporating renewable power sources into telecom systems, they are usually designed to operate below the site load level to avoid over-production of energy; this overcomes the use-it-or-lose-it intermittency issues associated with renewable energy sources.

Alternatively, renewables can be combined with cyclic battery use to ensure battery storage systems have enough spare capacity, meaning generated renewable energy isn't wasted.

Upgrading existing telecom power systems to become hybrid power systems requires flexible solutions to future-proof devices.

Leading solutions providers take a modular approach that enables systems to expand in line with the specific needs of each site - adding solar or wind power converters together with shelves that contain all the elements required for seamless integration.
This enables network providers to upgrade their systems while spreading the capital costs of buying new infrastructure, rather than committing major investment upfront.

Where small telecom sites use batteries to store and reuse surplus energy from renewables, switching to lithium-ion batteries offers major advantages over other commonly used types, such as lead-acid or nickel-cadmium batteries[13].

[13] Electronics

Lithium-ion batteries are generally more expensive to buy than lead-acid batteries, but have a longer working lifespan, better charging and discharging cycles, are smaller, lighter and offer much higher energy density. These units are also fitted with a battery management system, which gives insight into the battery's health and performance, helping to protect it from negative effects like overcharging or overheating.

With limited maintenance required to sustain performance levels, the characteristics of lithium-ion batteries make them better suited to the constant charge-and-discharge cycle needed to store surplus energy from renewables.

As mentioned previously, in practice, telecom companies are integrating renewable energy sources into their networks to increase resilience and sustainability while reducing operating costs, rather than replacing grid power to rely on renewables completely.
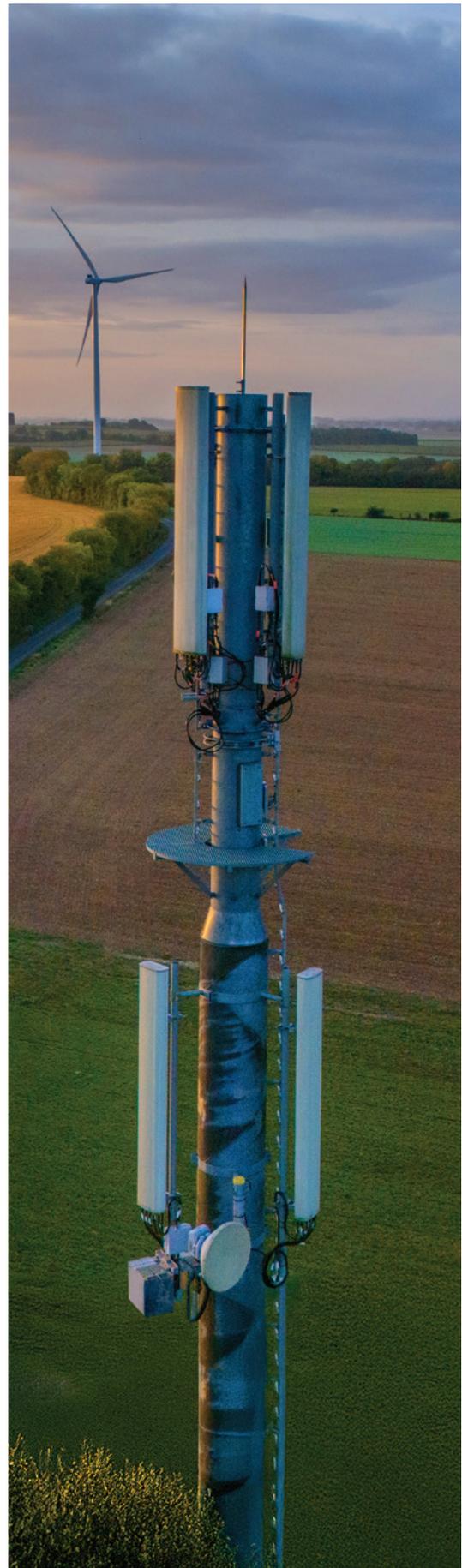
Section 3 - Cool and efficient operations

Keeping telecom equipment at the optimal operating temperature is an essential part of secure and stable network operations.

Only 15% of the energy mobile networks currently consume is used to transfer data, while around 85% is wasted through heat loss in amplifiers, idling equipment, and inefficiencies in rectifiers, cooling systems and battery units, according to McKinsey[14].

Smart technologies like AI and IoT can enable networks to optimize temperature control at the site, reducing energy consumption and ensuring an environment where equipment can operate reliably.

Increasing monitoring can also boost transparency of energy usage and enable network operators to keep track of how renewables investments installed at base stations are performing.

[14] McKinsey & Company

3.1. Hybrid cooling

Processing data flows can generate a lot of heat, which in turn can require a lot of energy to prevent telecom equipment from overheating.

While nature provides a free, accessible, if sometimes unreliable form of cooling, it can also need a helping hand from technology, especially in hotter climates. That's where hybrid cooling comes in.

This is where different cooling techniques are combined, such as direct-air cooling with ventilation and air-conditioning units, a heat exchanger or a sealed system that uses air conditioning alongside a heat exchanger.

Of course, maximizing natural ventilation is the most cost-effective solution, and many operators in temperate countries have moved heat-generating equipment outside of buildings to exploit natural convection cooling. However, this approach has limits as it can't cool below the ambient temperature.

Air conditioning units are commonly used to supplement natural ventilation at sites like base stations. This form of cooling is less energy efficient than natural ventilation, being both more powerful and energy-hungry, but modern equipment can operate in higher temperatures so air conditioning is now only necessary in some cases.

As the climate crisis unfolds, the question of how to keep telecom equipment cool is an issue of growing concern for network operators around the world. Higher ambient temperatures and increasing loads in telecoms cabinets could require operators in parts of Europe and other temperate regions, which have previously relied on natural ventilation, to install artificial cooling to cope with extreme heat conditions.

The advent of 5G networks combined with warming global temperatures can also create challenges in countries where telecom operators regularly depend on air conditioners for cooling parts of their networks. Legacy cooling systems installed up to a decade ago may not be designed to cope with today's - and more importantly, tomorrow's - temperature extremes, leaving operators facing a costly bill to upgrade their cooling systems.

While this is a concern, automated systems can be installed in remote stations across telecom networks to balance cooling technologies. This helps to reduce energy consumption as well as optimize costs, efficiency and emissions reductions, providing more power only when additional cooling is needed.

Maximizing efficiency by reducing reliance on air conditioning

Case Study
- Location: Cairo, Egypt
- Outdoor cabinet (WxDxH 850 x 850 x 2000mm) with Power Supply System and batteries
- Cabinet with thermal insulation
- Installed Power 6× 2900W - Load 4000W
- Heat dissipated inside from telecom equipment 1000W

Min/Max temperatures by months (statistical data)
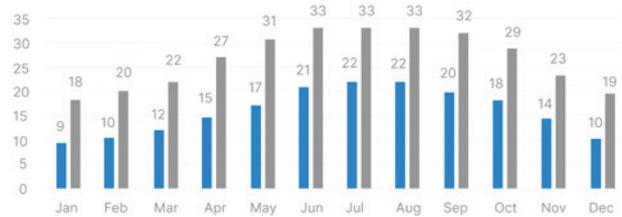
	Energy consumption for cooling per year [kWh]	Reduction [%]	Reduction [kWh]	Cost savings
Standard AirCon cooling with 300Ah batteries with AC 2000W/230Vac	6490	0%	0	€ ---
Hybrid cooling - AirCon + Ventilation with 300Ah batteries hybrid cooling AC 2000 L35L35 230Vac and AV 250W/K	3287	49%	3202	€ 384
Pure fan & filter cooling with 300Ah batteries with fan cooling AV 250W/K	317	95%	6173	€ 740

A controller with advanced technology embedded can optimize the speed of the ventilation unit and switch to air conditioning when temperatures exceed the limits of free-air cooling. Reducing a site's reliance on air conditioning helps both extend the life cycle of cooling equipment and reduce maintenance frequency and costs.

3.2. Super- and ultra-high efficiency modules

The majority of power systems in today's global telecoms market were installed during the rollout of 4G/Long-Term Evolution (LTE) systems in the early to mid-2010s. While these systems boasted faster data transmission speeds than the 3G systems they superseded, telecom technology has moved on since then.

Back then, peak efficiency in rectifier modules that convert AC mains power to the DC power used by most telecom equipment was around 96% (high-efficiency modules). However, some legacy power supplies operate with 92-94% efficiency.

Peak efficiency in ultra-high efficiency modules
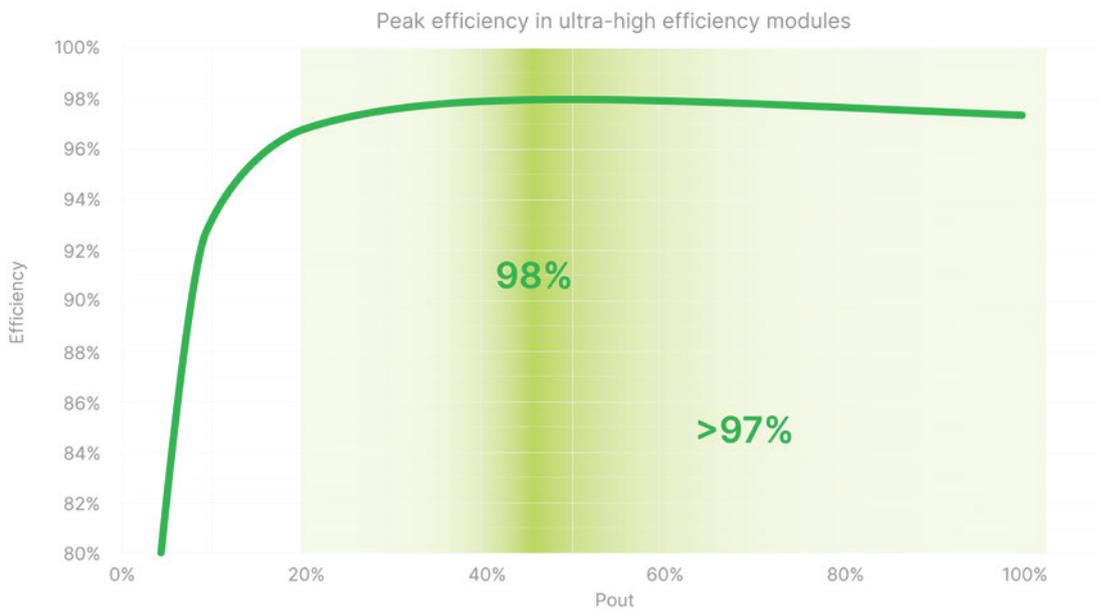
In recent years, advances in rectifier technology have resulted in rectifier modules being developed with peak efficiency exceeding 98% (ultra-high efficiency modules — UHE), and that provide exceptionally high efficiency across a wide load range.

While a few percent may not sound like a big difference, these efficiency gains are highly significant as losses are halved between 92% and 96% efficiency, and halved again between 96% and 98% efficiency. Here, small marginal gains can make a huge difference to overall operating costs, especially when energy savings and emissions reductions are multiplied through a network potentially containing tens of thousands of base stations.

A Delta simulation shows the efficiency increase of replacing old, 96% efficient rectifiers with UHE 98% efficiency units. Heat dissipation is halved by using less energy to supply the DC load, and less cooling is required. This saving, multiplied across a network, can recoup the upfront capital costs of installing UHE rectifiers in just a few years.

Installing or retrofitting sites with UHE rectifiers should pay for itself by consuming or losing less energy, however, not all rectifiers in a base station need to be replaced.

Consider, for example, a scenario of 10,000 base station sites. Each is fitted with six 3 kW rectifiers, where three are running constantly at almost full load (resulting in 94.25% efficiency), giving an annual consumption of 836.50 GWh on the AC level.

Upgrading three high-output modules that operate at full load at each of these sites, with more efficient modules that at maximum load provide 97.8% conversion efficiency (and 98.1% peak value), will reduce the whole network's consumption to 806.13 GWh per year on the AC level.

The reduction of 30.36 GWh per year translates into 3.63% savings, which may not seem much, but reduces the energy losses by a massive 63.13%.

However, it makes little sense to replace all six rectifiers, as modules planned for battery recharge or as redundant ones are used only occasionally - and sometimes never. That means replacing them will produce only marginal energy savings, which would incur high capital outlay for minimal efficiency gains.

Section 4 - Metering and monitoring

Deploying renewables at a base station or other telecoms site is an investment that needs to produce a return in the form of energy and emissions savings. As such, metering can help monitor how newly added wind or solar installations are performing - the metering for renewables is often DC-based, as energy from these sources is not normally converted to AC energy at the telecoms base-station level.

But there's a barrier to metering transparency because of the way most traditional telecom networks operate. AC metering has always been provided by the AC grid operator and real-time monitoring is not supported - standard updates with smart meters are restricted to the previous day's power usage, for example.

There is a growing need for both AC and DC metering to increase transparency between the base-station site landlord and the network operator, as its tenant, regarding energy consumption.

Currently, the AC pass-through billing model offers little incentive to integrate renewables into base stations or other telecom sites, as operators would need to pay the cost of upgrades. The landlord simply passes on the bill from the energy provider to the tenant, which offers no financial benefit to the landlord to save energy, whether through reducing demand or adopting renewables.

However, many large operators are committed to harnessing renewables and lowering their energy consumption to meet CO_2 targets. This could prove a catalyst for forward-thinking network operators to push ahead with plans to embrace more clean energy by refitting base stations with wind turbines or solar installations.

With remote monitoring and control of the DC side, landlords can bill tenants for DC usage, benefit from adding renewables or smart power services and have a higher service level from remote power cycling of customer loads to avoid costly site visits.

Section 5 - Smart and remote management

As the telecom industry strives to become more sustainable, it also faces growing energy needs to power network advances like 5G. This alone will require two-to-three times more power than 4G-equivalent sites, according to industry forecasts[15].

However, technology can also help resolve this apparent clash of end-goal aims by deploying AI-enabled systems and IoT connectivity, such as smart power and remote management of network sites.

Powered by algorithms, these systems can optimize the volume, cost and distribution of energy used across telecom networks, reduce maintenance needs and help future-proof operations for the next wave of digital growth.

That's not to say that exploiting the benefits of smart technologies will be simple. Alongside the expense and disruption of switching to smart networks, a successful transformation requires a sizeable mindset shift by operators and staff to manage structural change.

However, the benefits far outweigh these concerns. AI-enabled applications can analyze performance data across sites and refine operations, optimize cooling systems and energy infrastructure to cut waste, and perform myriad other functions to improve network efficiency.
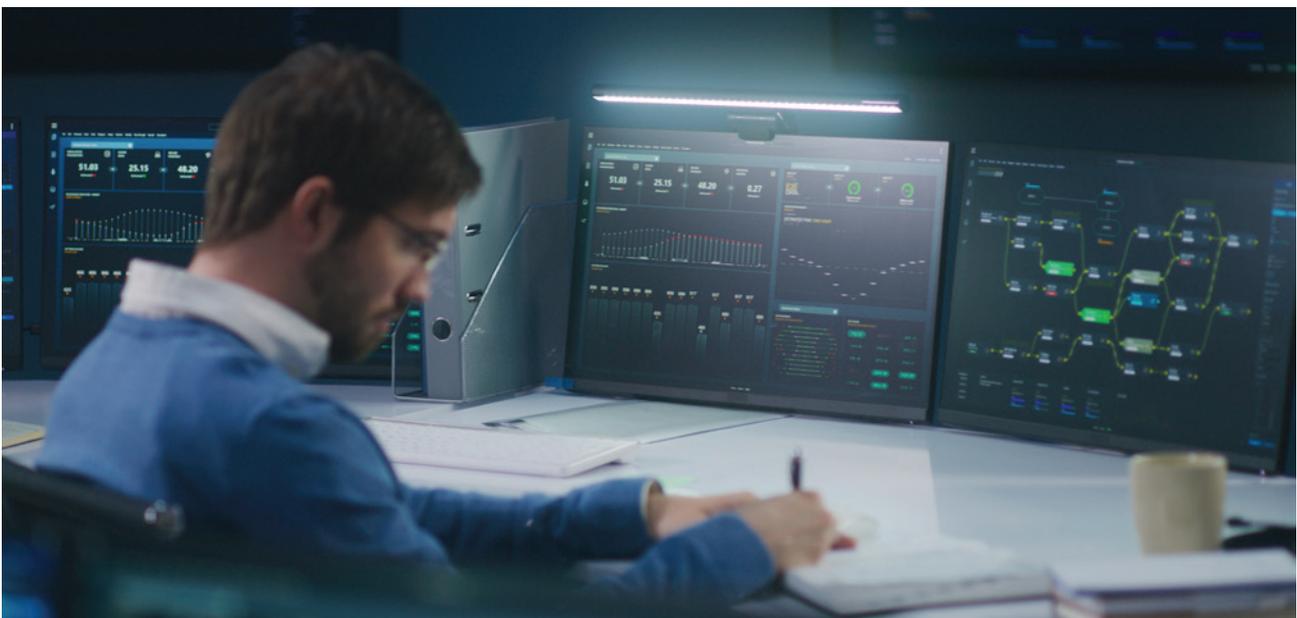
[15] McKinsey & Company
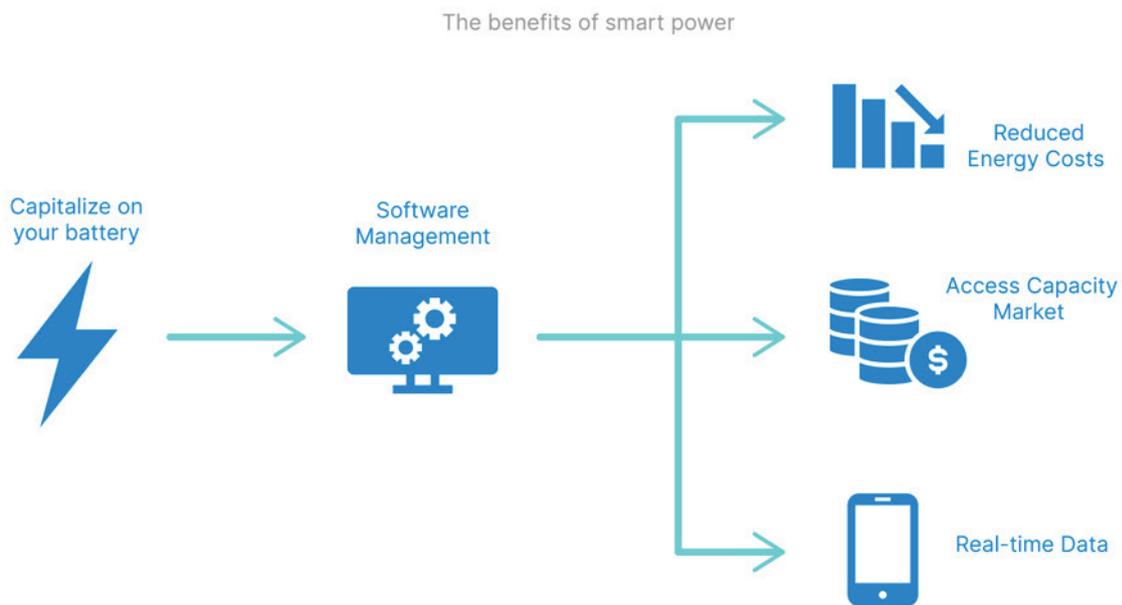
5.1. Smart power

Smart power relates to AI-enabled grid services like tariff management, peak shaving (using an additional power source to quickly cut consumption during peak demand periods) and load shifting (shifting energy usage to off-peak times) to reduce or increase consumption from the grid to minimize energy charges.

The majority of base stations have large battery capacity - which can support a site for up to four hours in some cases - providing a sizable opportunity to reduce power consumption from the grid.

Deploying smart power systems utilizes battery backup power and a grid connection, enabling automated energy saving across multiple sites, which would be impossible to conduct manually.

Smart power can also help integrate renewable energy into telecoms networks, by optimizing power use and battery storage from clean energy sources. When on-site batteries need to be recharged using the grid, smart power features can ensure this takes place during off-peak times when energy costs are at their lowest.

Smart power is a cost-optimizing technology, which results in more efficient energy consumption and can reduce emissions. Yet this technology rarely requires any major change to on-site hardware as a software upgrade is all that is needed. However, it will require some level of remote management or remote connectivity (see below).

The benefits of smart power

Capitalize on your battery → Software Management →
- Reduced Energy Costs
- Access Capacity Market
- Real-time Data

Stage two of installing smart power systems could earn telecom companies revenue. They can sell surplus energy that isn't needed immediately back to the grid at peak times and recharge storage batteries during off-peak times.

Alternatively, revenue can be earned by simply making power available to the grid operator in case it is needed, without needing to change normal operating behavior.

Automating hundreds or thousands of sites across networks could produce huge energy savings, reduce costs and generate revenue to fund the adoption of renewable energy in the telecoms network.

There is great potential to increase the adoption and capabilities of smart power systems across the telecom industry, which would both make telecom networks more efficient and help upgrade legacy infrastructure in preparation for post-5G technological innovations.

5.2. Remote management

There are more than a million telecoms network base stations spread across the Europe, Middle East and Africa (EMEA) region. As the majority of these sites don't have a daily human presence, individually consume relatively little power and are distributed across a wide geographical area, optimizing their power needs has historically been seen as something of a challenge.

However, times have changed. Advanced remote management platforms can elevate the performance of unstaffed telecoms base stations by controlling the sites from a distance, while collecting real-time operations data to refine performance.

Remote management software is inexpensive to install and can manage both telecom power systems and passive equipment, which explains its rapid growth in importance and adoption[16]. And this trend is likely to continue, as operator expenditure could double within five years without more deployment of automation in the telecom industry, according to study of leading telecom radio infrastructure suppliers.

Once installed, the automated system can maximize the amount of clean energy from renewable sources to make operations more sustainable. Operating in real time, it can remotely monitor, adjust and optimize every aspect of operations at thousands of sites, including cooling and remote fault-finding.

As such, the benefits of remote management go beyond reducing energy consumption and cutting maintenance time. Automated fault-finding could avoid network disruptions, extend the operational life of some equipment, require fewer human site visits for inspections and maintenance, and therefore lower the risk of accidents, while avoiding the CO_2 emissions associated with staff driving to and from multiple sites.

[16] Dell'Oro Group

Conclusion

While renewable energy can help boost the telecom sector's green credentials and is being integrated into the operations of major industry players, it is just one part of a wider industry push to build a more sustainable future.

Smart technologies like AI, automation and big data models continue to transform our world. They offer enormous potential when it comes to increasing energy efficiency, lowering consumption, cutting emissions and boosting the share of renewable energy used to power telecom networks.

Transitioning to clean energy ultimately presents a win-win solution for telecom companies and the people who rely on their networks, as well as for the planet. It makes not just commercial but also environmental sense too.

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