GSMA Intelligence

5G energy efficiencies

Green is the new black

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Contents

Executive summary

The imperative for change

The impetus for reductions in energy emissions in the telecoms sector is anchored in the global fight to combat and mitigate climate change, as enshrined in the 2015 Paris Agreement. Urgency has grown markedly over the last two years as governments seek to garner private sector commitments towards the central objective of keeping a global temperature rise this century to a maximum of 2 degrees Celsius above pre-industrial levels. This implies net zero for most countries by 2050.

In telecoms, a number of industry-specific factors rooted in countering rising network costs have further shaped efficiency efforts. The mix effect of LTE and 5G upgrades in emerging and advanced economies (led by the US and China) will result in these technologies accounting for 60% and 20% of the global mobile connections base respectively by 2025. The impact of this shift will be a continued rise in mobile data traffic, estimated at 6.4 GB per user per month in 2019 and forecast to grow threefold on a per-user basis over the next five years. Combined with the rising costs of spectrum, capital investment and ongoing RAN maintenance/upgrades, energy-saving measures in network operations are necessary rather than nice to have.

5G New Radio (NR) offers a significant energy-efficiency improvement per gigabyte over previous generations of mobility. However, new 5G use cases and the adoption of mmWave will require more sites and antennas. This leads to the prospect of a more efficient network that could paradoxically result in higher emissions without active intervention.

The way forward

Alongside technical improvements to reduce energy leakage as power passes through the network phases, a range of measures are available to improve efficiency holistically across the network. These include the following:

- user equipment and devices – energy consumption and extended battery life of end-user terminals, mostly handsets
- site-level innovations – new lithium-ion battery solutions, rectifiers, liquid cooling, air-con systems and simplification of site set-up
- RAN and network equipment innovations – AI-driven software focussed on maximising sleep states to avoid unnecessary energy consumption in the RAN
- network planning and optimisation – including the sunsetting of legacy 2G and 3G networks and long-term purchasing contracts for renewable energy.

The big picture for operators of ultimately reducing emissions to net zero depends on wrapping energy-efficient technologies into a broader 'green' strategy that encompasses all facets of operations. In an effort to put teeth behind public commitments, many large operators have implemented KPIs and reporting targets in line with the independent Science Based Targets initiative (SBTi).

Emissions reduction goals have been set in a phased approach to first reach carbon-neutral status before the more difficult and ambitious objective of net zero. Verizon and Vodafone have set targets to reach net zero by 2040. Telefónica has committed to this status for its top four operating markets by 2030. The milestones en route to these goals are, however, front loaded, with Verizon and Vodafone aiming for 50% reductions in electricity usage by 2025 and Telefónica down 70% by 2030. Our analysis indicates that progress has generally been solid so far, enabled by advances in the renewable energy markets.

Despite this progress, reporting targets are not yet in place in a majority of operators. There are also a number of persistent barriers, including emissions data availability and tracking mechanisms, lack of partnerships with energy sector producers and, in some cases, outdated organisational structures that augur for more cross-team working and less hierarchy.

The data aspect is of particular importance; we hope this research will help raise awareness of the issue. The construction of comprehensive data 'pipelines' with associated analytics would help uncover costly anomalies. Deploying smart sensors at various points of the network would help measure equipment-level energy consumption, battery status, active hours of generators, fuel levels, outside and indoor temperatures and air conditioning. Operators would need to build their comprehensive and real-time data repository, but we believe this would be money well spent. With reliable measurements and data pipelines established, big data applications can monitor and adjust network power – a key ability for the software-defined networks set to be the default option in the 5G era.

1 The imperative to reduce emissions in the 5G era

Drivers for increasing efficiency and reducing emissions

The impetus for reductions in energy emissions in the telecoms sector is anchored in the global fight to combat and mitigate climate change, as enshrined in the 2015 Paris Agreement. Urgency has grown markedly over the last two years as governments seek to garner private sector commitments towards the central objective of keeping a global temperature rise this century to a maximum of 2 degrees Celsius above pre-industrial levels. This implies net zero for most countries by 2050.

In telecoms, efficiency efforts have been further shaped by a number of industry-specific factors rooted in countering rising network costs. The mix effect of LTE and 5G upgrades in emerging and advanced economies (led by the US and China) will result in these technologies accounting for 60% and 20% of the global mobile connections base respectively by 2025. The proximate impact of this shift will be a continued rise in mobile data traffic, estimated at 6.4 GB per user, per month in 2019 and forecast to grow threefold on a per-user basis over the next five years. Combined with the rising costs of spectrum, capital investment and ongoing RAN maintenance/upgrades, this means energy-saving measures in network operations are necessary rather than nice to have.

Climate change

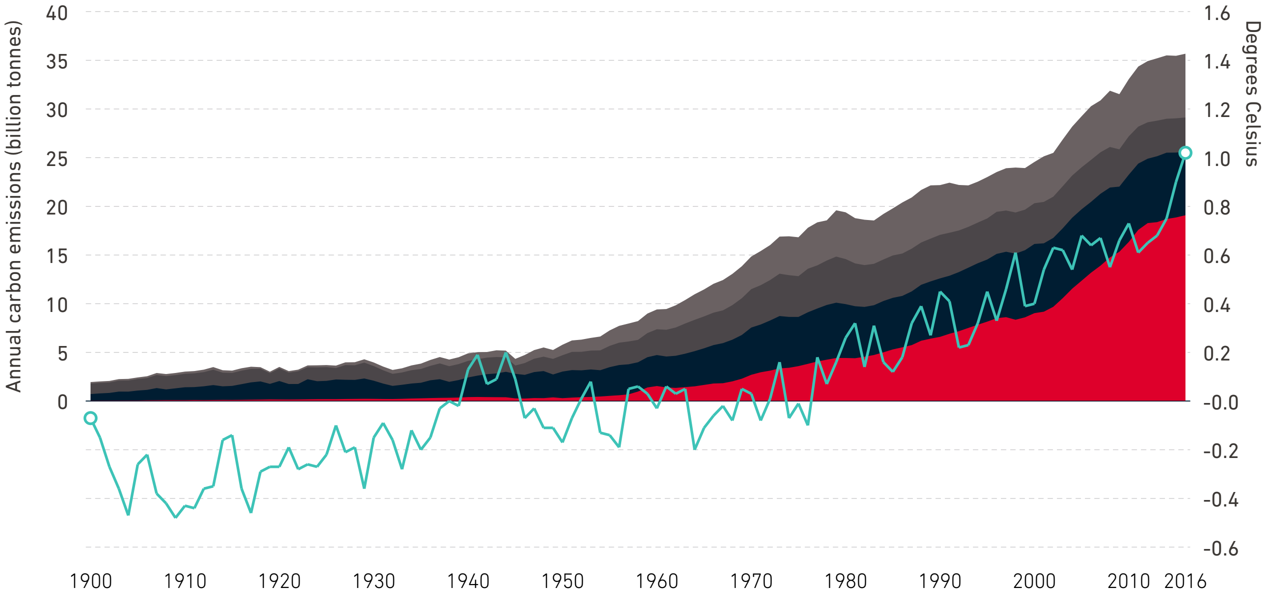
The response to climate change and, specifically, alignment with the central resolution of the Paris Agreement has catalysed a wave of industry action in support of broader national commitments. The agreement stipulates that worldwide efforts should limit the rise in global average temperatures to a maximum of 2 degrees Celsius above pre-industrial levels this century, though with a preferred objective of 1.5 degrees Celsius. The scientific consensus and evidence in support of man-made warming has now been established over an extended period of time; surface temperatures have been on a steady upward path relative to the historic baseline, with 14 of the 15 hottest years on record occurring since 2000 (see Figure 1).

As of October 2020, 189 countries (out of 197 signatories) had ratified the agreement – a 96% conversion rate. Most of those yet to ratify are nations with political instability and/or outsized economic dependence on oil; their participation would not have a significant influence on the outcome, though. The US is a major exception. Its formal exit is planned for November. A full assessment of the Paris Agreement resolutions is out of scope for this research but details can be found via the UN.[1] Ultimately, achievement of the goals depends on individual nation states setting and implementing their own emissions reduction targets.

Governments have generally co-opted private sector involvement to help achieve national objectives, rather than purely using legislation to mandate curbs in emissions. This strategy confers buy-in and has so far proven an effective stimulant for the rapid development of new technologies and a large-scale shift in energy use away from fossil fuels and towards renewables. The telecoms sector has emerged as a vocal supporter of proactive emissions reductions plans. This is enshrined in an industry-wide commitment to reach net-zero emissions by 2050 and bolstered by a growing group of operators that have embraced carbon reduction efforts as a core business objective, with strict reporting targets. Those of Vodafone, Telefónica and Verizon are used as examples in the rest of this section.

Figure 1

Global carbon emissions and long-term temperature variation



*Surface temperature for a given year relative to the long-term global average from 1951 to 1980. Values above zero indicate rising temperatures relative to the long-term average, while values below zero indicate the opposite.
Source: Carbon Dioxide Information Analysis Center (CDIAC), Global Carbon Project, Nasa

1 What is the Paris Agreement? UNFCCC

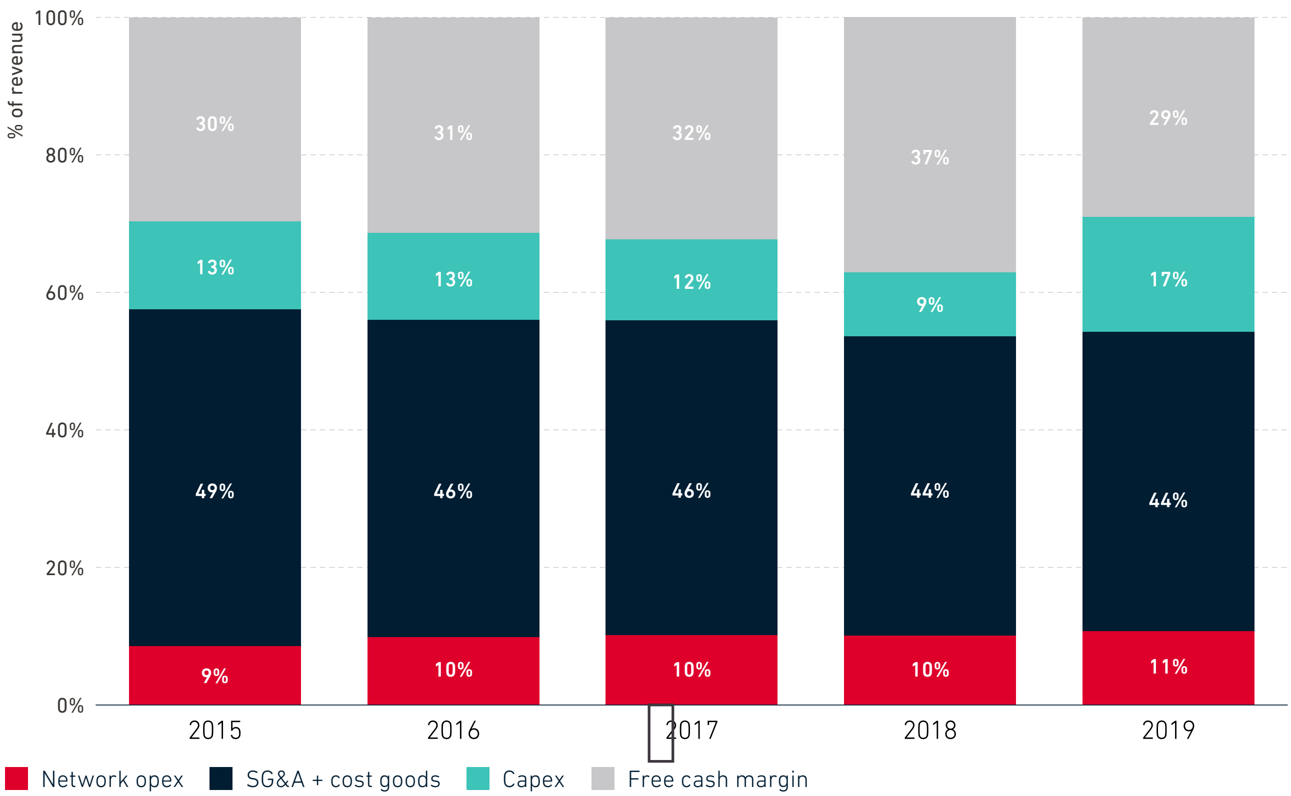
Network costs and performance

Irrespective of climate change, impetus for energy-saving measures from telecoms operators has grown as a result of sustained increases in network costs in a low revenue-growth environment. The telco business model is based on network scale. In times of growing revenues, margins expand as the largely fixed cost base is monetised (positive operating leverage), unless the operator is sub-scale. This is broadly what happened in the 2G and 3G eras in the 1990s and 2000s when mobile phones were still new to people and subscriber growth consequently steadily rose. However, in periods of low or negative revenue growth, fixed costs are exposed, with resulting pressures on cashflow and longer term investments.

Figure 2 shows Verizon's financial ratios, but the effect can be observed across the sector over the last five years; revenue growth rates – pre-Covid-19 – have on average remained in low single digits. Without even showing the revenue growth line, it is clear that as network capital investments have increased to fund LTE and early 5G rollouts, free cash flow margins have been mostly preserved through reductions in personnel and other costs.

Figure 2

Network cost and investment evolution (Verizon example)



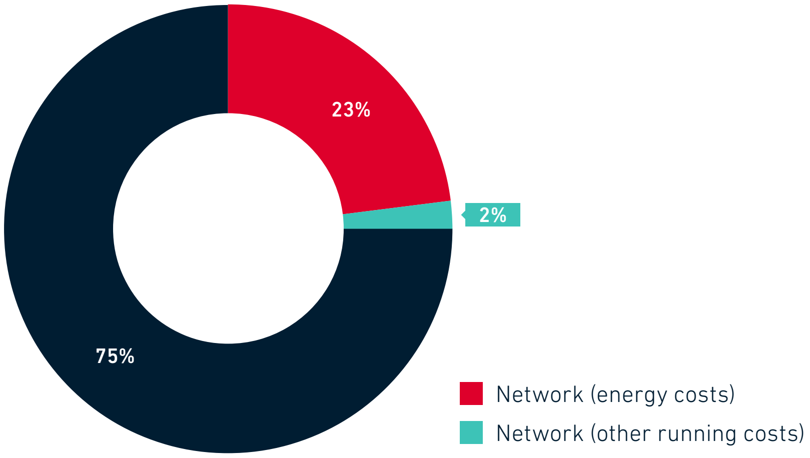
Note: free cashflow calculated as EBITDA minus capex and expressed as a share of total revenue.
Source: GSMA Intelligence, Verizon

Given the industry imperative to invest in networks, capex is followed more closely than the costs of ongoing maintenance (opex). However, this is changing with the rapid adoption and incorporation of energy-efficient technologies. Both offer material savings in opex. Network opex tends to account for around 25% of the operator cost base, or 10% of revenue. Over 90% of network costs are spent on energy, consisting mostly of fuel and electricity consumption (see Figure 3). Most of this spend powers the RAN, with data centres and fibre transport accounting for a smaller share.

The good news is that the shift from fossil fuels to renewables has started to feed through to opex savings, as have the phased retirements of legacy 2G and 3G networks that are less energy efficient than LTE or 5G NR standards. Looking ahead, however, as LTE and 5G progressively account for larger shares of the overall global user base, data traffic rises are inevitable – and with this comes the pressure on energy consumption. There is no one method of increasing energy efficiency or reducing power usage. Instead a mixed approach is generally being used, comprising renewables, AI-driven network sleep states, more efficient batteries and decentralised site deployments with compute power pushed towards the edge. The results will feed through over a period of years.

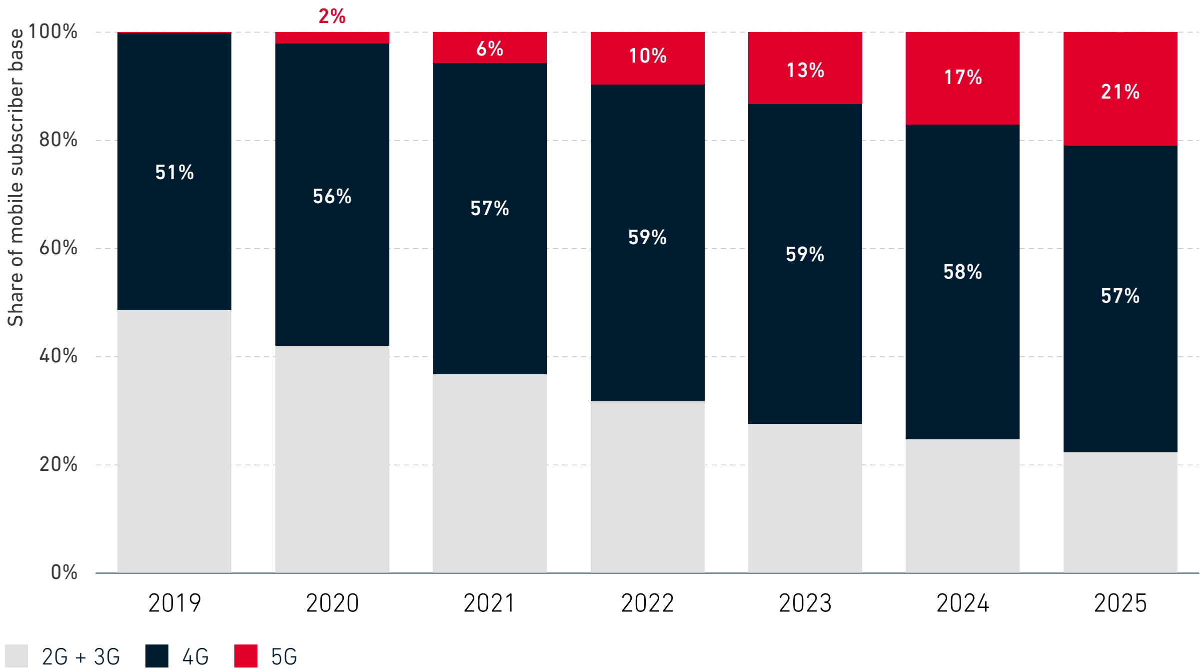
Figure 3

The vast majority of network costs are spent on energy (fuel and power) consumption...

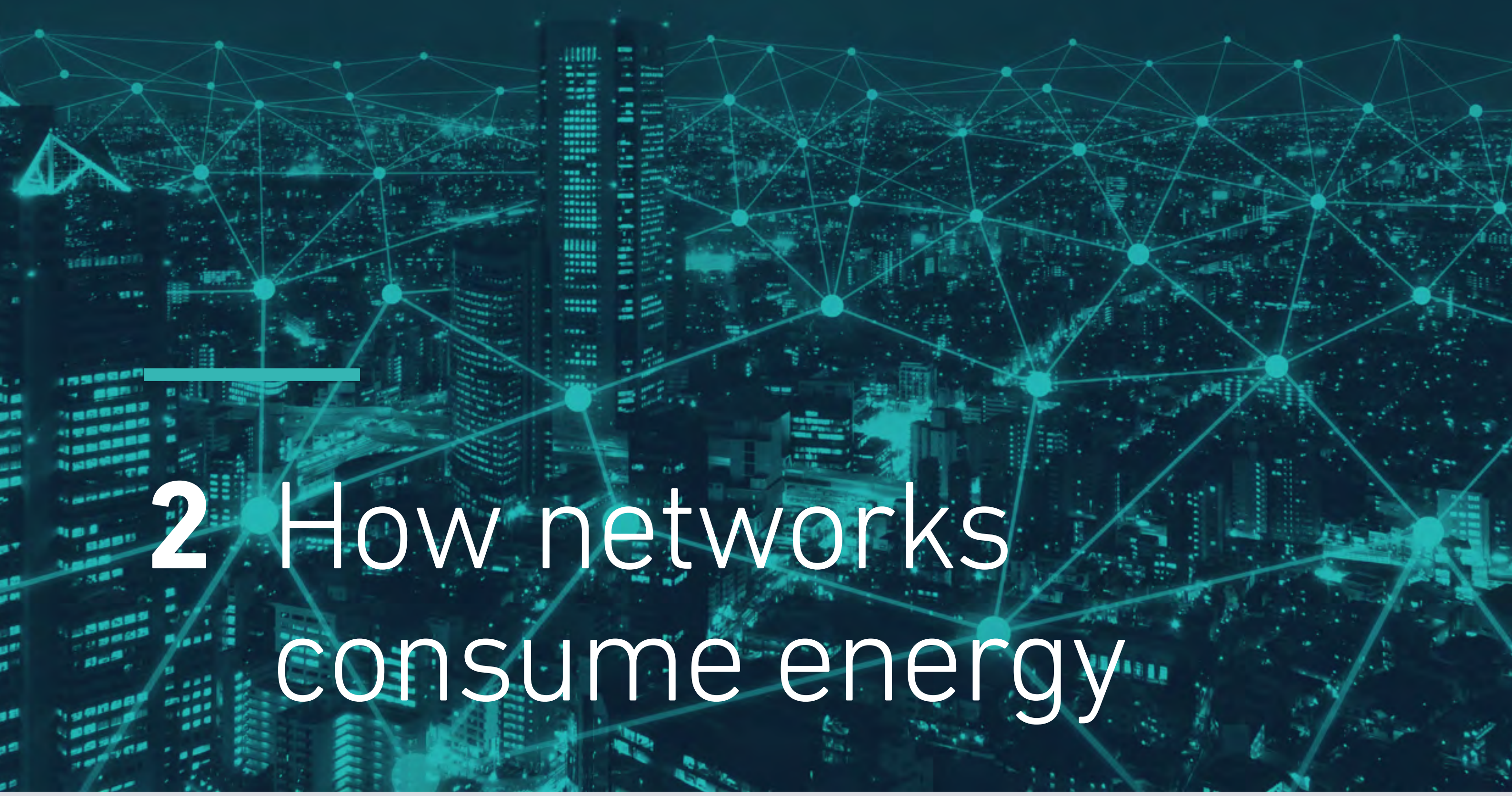


Note: percentage of total operator cost base. Figures are averages and will vary by operator.

...which will only rise as LTE and 5G account for a larger share of the base



Source: GSMA Intelligence



2 How networks consume energy

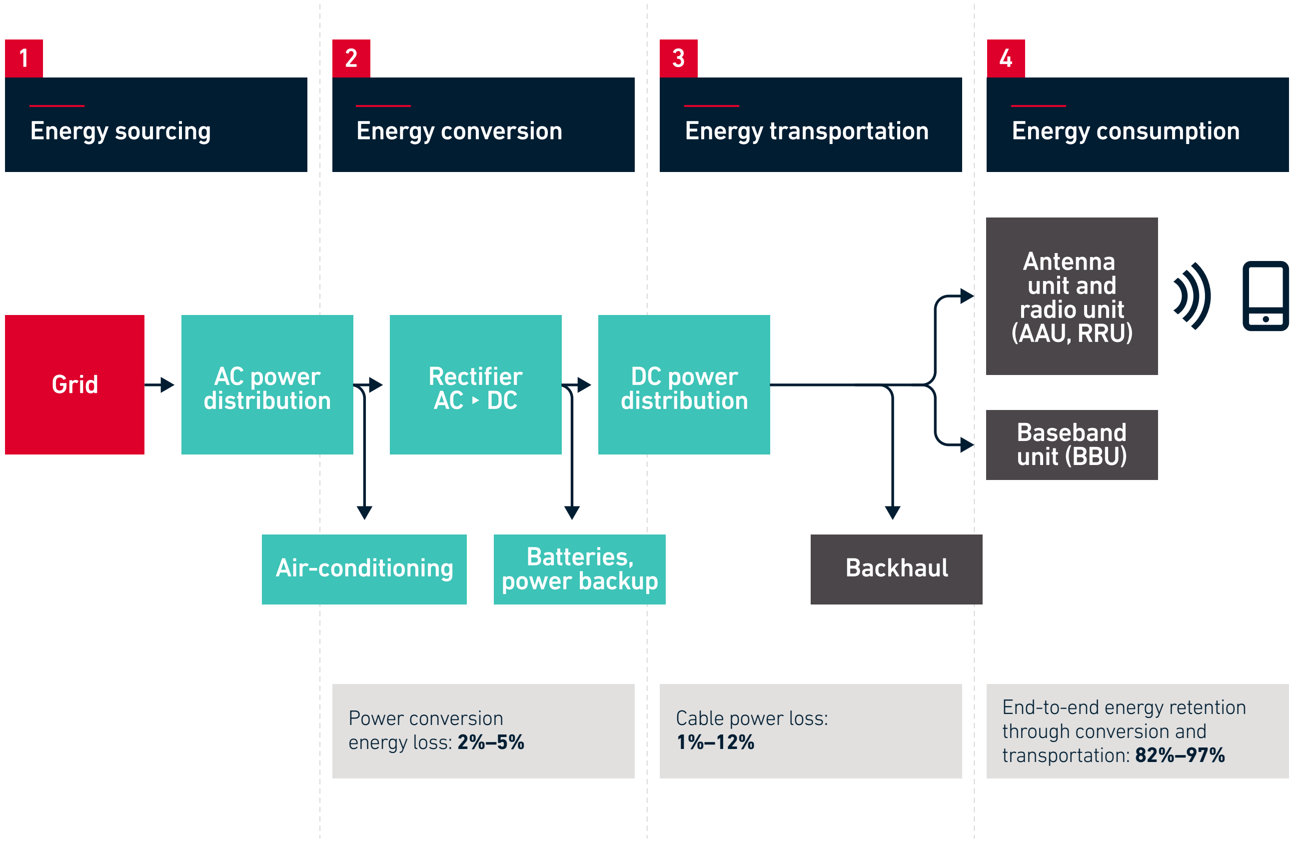
Past transitions to new wireless standards have entailed a significant improvement in the cornerstone metric of energy efficiency: kilowatt hours per gigabyte (kWh/GB). Though 5G NR also offers a significant energy-efficiency improvement per gigabyte over previous technologies, new 5G use cases and the adoption of mmWave will require more sites and antennas. This leads to the prospect of a more efficient network that could paradoxically result in higher emissions, without active intervention.

Energy consumption in running a network

One way to visualise a network is as a linear progression of stages, or phases, across which energy flows to provide power to base station sites, radio access nodes and backhaul links. Figure 4 outlines this journey, starting with energy sourcing from the grid and moving through to site and equipment consumption.

Figure 4

End-to-end energy loss from grid to the RAN



Source: GSMA Intelligence

Phase 1: energy sourcing

There are significant daily fluctuations in energy demand, while electricity supply is relatively static. This makes the price of industrial electricity vary on an hourly basis. Daytime energy prices in peak hours can be significantly higher than off-peak times during the night. Network operators can save money by buying energy at off-peak hours to be stored and used when data traffic peaks in the early evening, typically between 18:00 and 22:00. Operators can also sell excess peak-time energy back to the utility grid. This relatively nascent practice will require further investment in energy storage technology and batteries alongside partnership agreements with utility providers. Updated central energy management platforms to calculate and forecast site-level data traffic and consumption are also important to ensure each site has enough backup energy to operate safely, with no service interruptions.

Phase 2: energy conversion

Energy utility providers sell alternating current (AC) electricity, while most of the site-level energy consumption happens in direct current (DC). AC is an electric current that periodically reverses direction and changes its magnitude continuously with time; DC electricity flows in one direction only. For this reason, each cell site needs to have a rectifier module to convert AC to DC. Most cell sites in a typical portfolio are more than 10 years old and operate with less efficient passive infrastructure, including the rectifier module. The cost of upgrade is significant up-front but crucial to more efficient conversion and lower consumption over the long term. New rectifiers are also key to cover the potential increased energy consumption before installing 5G equipment and ensure smooth capacity expansion.

Phase 3: energy transportation

When power is transmitted at high voltages, the efficiency of energy transportation increases (with a lower rate of leakage) because of lower electric current in the conductors. Operators can improve efficiency and reduce power loss by increasing voltage with boosters, using power equipment closer to the load, and decreasing the power supply distance.

Phase 4: energy consumption

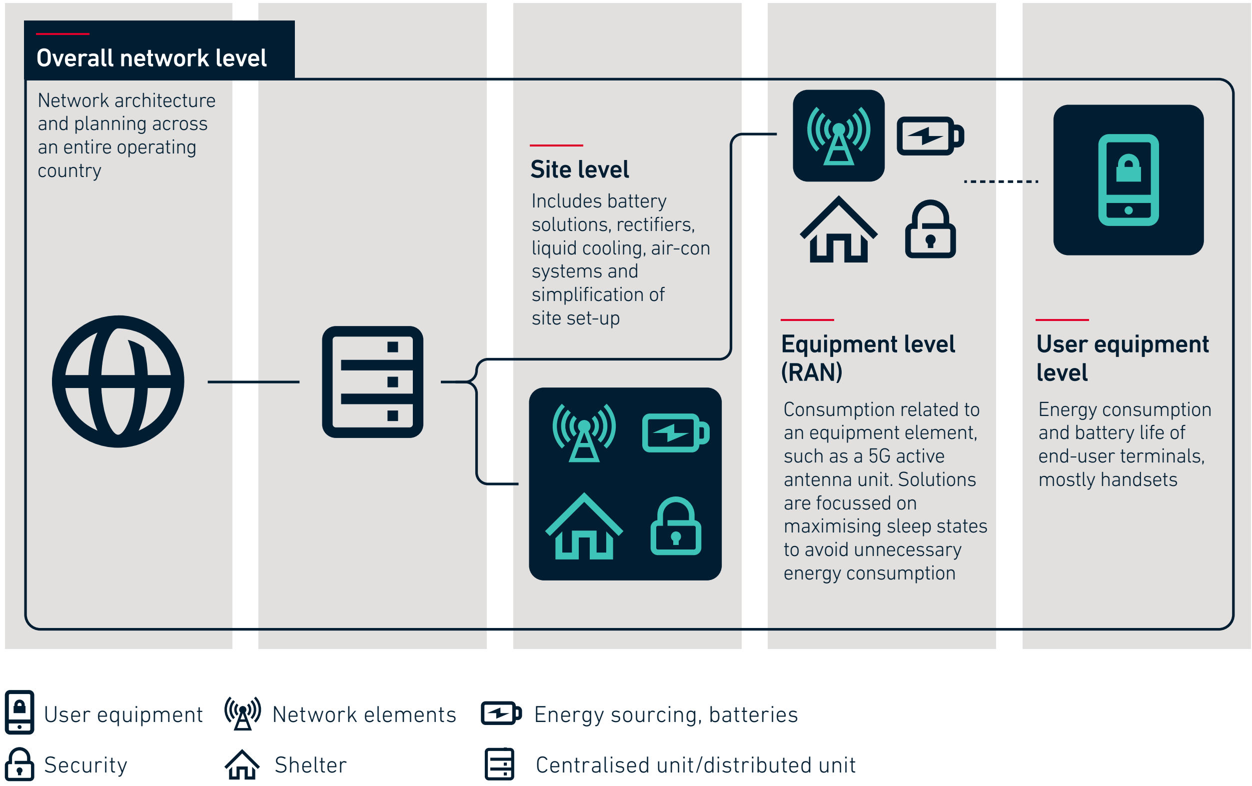
This phase represents the 'lowest hanging fruit' for efficiencies. Operators transform DC energy into radio waves, and receive and process incoming signals. This category can be further broken down into areas such as architecture optimisations, signalling, network shutdowns, cooling and beamforming.

3 Site, RAN and network-wide innovations

Alongside technical improvements to reduce energy leakage as power passes through the network phases, solutions to improve efficiency holistically across the network are available (see Figure 5). Our analysis focuses on sites, the radio access level and broader network planning considerations. We exclude efforts targeted at handsets and other end-user terminals as these do not directly contribute to a mobile operator's carbon emissions profile.

Figure 5

Energy-saving methods differ between site level, RAN equipment and network planning



Source: GSMA Intelligence

Site innovations

Battery solutions

In off-grid areas, mobile operators are often forced to use diesel generators to guarantee the reliability of power supply for base stations. This is less than ideal considering generators emit high levels of carbon dioxide and have onerous cost implications associated with refuelling, particularly if in hard-to-reach, sparsely populated areas (such as in African countries) requiring labour call-outs and security protection.

Lithium batteries have emerged as a more environmentally friendly and cost-efficient alternative. These have a smaller and lighter form factor compared to traditional lead acid batteries, saving space after installation. Lithium batteries have a significantly longer expected lifespan (five or six years on average). The commonly used lead acid batteries are expected to be efficient for a much shorter period – around three years.

Further favourable aspects of lithium batteries are the improved charge and discharge capacities and related savings potential from the battery configuration. Back-up batteries are fully charged at all times and discharge only when there is a power outage. By using a cycle-type lithium battery capable of daily charge and discharge, smart power control with a DC power controller can be performed, enabling flexible and efficient power supply to radio equipment. Voltage boosting is also an option with lithium technology; this can help operators increase voltage, save on energy transportation and serve newly installed 5G AAUs from longer distances more efficiently. In the event of theft, the battery is designed to automatically stop any output of power, rendering it useless to criminals. The batteries are also fitted with GPS modules, making them easily traceable.

Hybrid and renewable energy

Solar has become a competitive alternative to diesel in off-grid areas as the price of photovoltaic panels has fallen and base-station battery solutions have become more advanced.

Site-level hybrid energy solutions involve a mix of solar/diesel/wind/electricity and grid, providing a more efficient way to power sites. Custom-made hybrid solutions have a dedicated variable speed motor and a DC alternator which reduce losses caused by energy conversion. Advanced algorithms can select optimal energy sources and achieve significant energy-efficiency improvements for the estimated 1 million cell sites globally.

More broadly, the shift to purchasing renewables will accelerate as prices continue to decline and futures contracts enable long-term lock-ins. Operators can buy more of their energy from larger, centralised renewable energy sources and achieve long-term power purchase agreements, or utilise their assets and produce their renewables in their cell sites.

RAN and network equipment innovations

Turning off equipment even for a short period of time, or putting it into a sleep mode when there is no traffic to serve, saves energy. With 2G, 3G and 4G, there are recurring transmissions of always-on signals called cell-specific reference signals (CRSs) to secure cell coverage and a connection with users. Significant energy saving is possible from decreasing resources allocated to signalling and its 'ping-pong' effect between user equipment and the cell site.

The 5G NR standard allows more components to switch off or go to sleep when the base station is in idle mode and requires far fewer transmissions of always-on signalling transmissions. Overall, these factors allow deeper sleep periods for a longer time, which – everything being equal – confers a significant saving on network energy consumption per bit of data.

Massive MIMO requires an increased number of antennas compared with traditional MIMO technology. Laboratory tests suggest that the increased number of antennas improves energy efficiency, transmitting and receiving more data for a given amount of energy.

Network-wide planning and optimisation

Sunsetting legacy networks

A key challenge is to square the improvement in energy efficiency per bit of data in 5G networks with the inevitability of rising traffic and the risk that overall power consumption could still increase. In this sense, strategies to reduce energy emissions have to be considered at an overall network planning level, incorporating all generations of mobility and their associated spectral elements.

Sunsetting legacy 2G and 3G networks is a major means of emissions reduction. The energy per bit of data with each new mobile generation is constantly improving, so sunsetting 2G and 3G networks can boost overall network energy efficiency. As legacy mobile technologies approach the end of their lifecycles, the importance of decommissioning and refarming certain spectrum bands to LTE or 5G is growing. 5G is particularly attractive as it is more efficient than legacy generations, given the NR standard. Although the exact difference in energy efficiency between 5G and previous technologies varies, laboratory tests suggest 5G has an efficiency advantage. It can also save energy and space through using fewer active antenna units and other networking elements. The process of sunsetting is already in progress and will likely continue in a staggered manner over several years to balance the risk of stranded network assets if take-up of LTE and 5G tariffs lags expectations.

AI-driven network planning

AI-driven network management and planning applications are not a particularly new concept, but many vendors and network operators have recently launched energy management solutions that leverage AI and advanced data analytics to optimise energy consumption. AI can help operators increase energy efficiency and deal with the 5G era's increased data traffic in terms of network planning and optimisation.

AI can help in network planning by gaining insights from coverage areas, building heatmaps for network usage and recommending an optimal location for new cell sites. New algorithms could also help understand spatial and temporal patterns in the ever-changing nature of mobile data use and predict future usage profiles in different coverage areas. AI algorithms can support the interplay between indoor and outdoor small cells, Wi-Fi hotspots and macro sites to maximise energy efficiency.

AI-driven network optimisation

Equipment vendors have started to offer AI-driven energy-saving solutions as an extension to existing network management platforms. Algorithms for power saving in base stations can already be used to shut down power amplifiers, transceivers and other network elements. However, AI can improve efficiency and lengthen sleep periods. Base stations are the 'low-hanging fruit' for such applications as they consume more than 70% of total energy. As each is unique, optimising their operation one-by-one would be labour-intensive. AI was introduced to enable more precise energy saving based on traffic and other site-related conditions, improving efficiency and reducing the manpower required. Large-scale deployments have shown an increase in power-saving activation of more than 80%.

In the 5G era, the energy optimisation offered by the first and second generations of algorithms is not sufficient to deliver the needed energy saving to keep up with growing data traffic. The third generation of AI-driven energy-saving solutions can take account of the different efficiency levels of frequency bands and factors in that the power efficiency of different networks can vary. The new AI can help base stations direct services to the optimal network, resulting in greater network energy efficiency.

Major vendors are currently offering solutions that can make energy savings of 5–15% on the RAN. New software can forecast data traffic based on historical patterns, weather, events nearby and other factors, before identifying the necessary thresholds, activation and sleep periods. Based on the information, the algorithm can shut down power amplifiers, transceivers and other network elements to save energy. Alongside this power-saving potential, AI-driven shutdown solutions can constantly monitor customer experience, network availability and data traffic to ensure there is no impact on network performance.

AI can also reduce energy consumption outside the RAN – in central offices, shops and data centres – by continuously calibrating the optimal settings of heating and cooling systems, pumps and fans. Engineers can use AI-driven building management systems to prioritise work, reduce unproductive travel time, identify equipment issues, avoid costly unscheduled call-outs and help ensure network reliability. Going forward, AI-driven energy-saving platforms are expected to focus more on data harvested from user devices. Anonymised coverage and data traffic insights from devices can help optimise the network further and adjust more capacity layers.

Overall, AI-driven shutdown solutions can be broken down into three areas:

- module (transceiver, baseband processing, etc.). The AAU components can be shut down in real-time during idle periods
- equipment (AAU, RRU). Equipment can be completely shut down during periods of low traffic, usually at night
- network. Large-scale, AI-driven solutions can schedule data traffic between different 5G bands (for example, from C-band to sub-3 GHz bands) or between 5G and 4G, in a similar way to the smart data mode seen in new smartphones.

Content caching nearer to the end user

A surge in the popularity of video streaming over the last five years has made placing content caching facilities closer to end users strategically important – to maintain quality and for competitive reasons. Most video content passes through content delivery networks (CDNs), which transfer media across hundreds of servers worldwide. CDNs can reduce power demand as a video stream only has to travel through the network once to reach thousands of customers.

The CDN market historically mostly comprised independent groups such as Level 3 and Akamai, but major internet and consumer tech companies (Google, Facebook, Apple, Amazon, Netflix) have established their own servers to ensure control over their own content.

Reducing the distance between cache points and users results in improved latency, which preserves the customer experience for high- and super-high-definition video. Should fixed-wireless access (FWA) over 5G gain traction as a last-mile alternative for home broadband, the requirement for caching nearer to end-user premises would become even more pressing. CDN analytics platforms and network management systems can together capture, locate and analyse trends and events across the RF, RAN, backhaul and core, providing operators with unprecedented insight to optimise their network, save energy and monitor the customer experience.

4 Outlook

Moving from CSR to KPIs with teeth

The big picture for operators of ultimately reducing emissions to net zero depends on wrapping energy-efficient technologies into a broader green plan that encompasses all facets of operations. In an effort to put teeth behind public commitments on energy efficiency, companies from multiple sectors have implemented KPIs and reporting targets. In telecoms, we have taken those of Verizon, Vodafone and Telefónica because of their large market share positions and pan-regional footprints. Table 1 summarises the current distribution of energy consumption and outlines key goals and timelines for carbon reductions along with the shift to renewables.

Each operator reports and sets targets in line with a scientifically approved methodology – the Science Based Targets initiative (SBTi) – that categorises emissions into three tiers, or 'scopes':

- **Scope 1:** energy consumption in buildings/offices, retail stores and other non-network aspects of the property portfolio (such as fleets). Approximately 5–10% of direct consumption.
- **Scope 2:** energy consumption in the network. Includes base stations (RAN), data centres and switching centres. Approximately 90–95% of direct consumption.
- **Scope 3:** energy consumption indirectly associated with company products or services, including supply chain, end consumer and business usage.

The vast majority of direct electricity consumption emanates from the network and is therefore the primary focus of efficiency savings. Scope 3 prospective reductions are generally outside direct control, with work ongoing to incorporate these into broader reporting.

Table 1

Energy consumption and climate targets from major operators

	Verizon	Vodafone	Telefónica
Energy consumption			
Networks (base stations, data and switching centres)	89%	95%	95%
Offices and retail	9%	5%	5%
Other	2%	-	-
Net zero	2040	2040	2030*
Emissions reduction pathway	Reduce carbon intensity by 50% by 2025	Reduce CO_2 emissions by 50% by 2025	Reduce CO_2 emissions by 70% by 2030
Renewables	50% of total electricity consumption by 2025	100% of electricity consumption in European network footprint by 2021	100% of total energy consumption by 2030
Network overhaul	2G/3G sunsetting; copper broadband decommissioning; RAN site efficiencies (batteries, air-con systems, power-saving/sleep mode)		

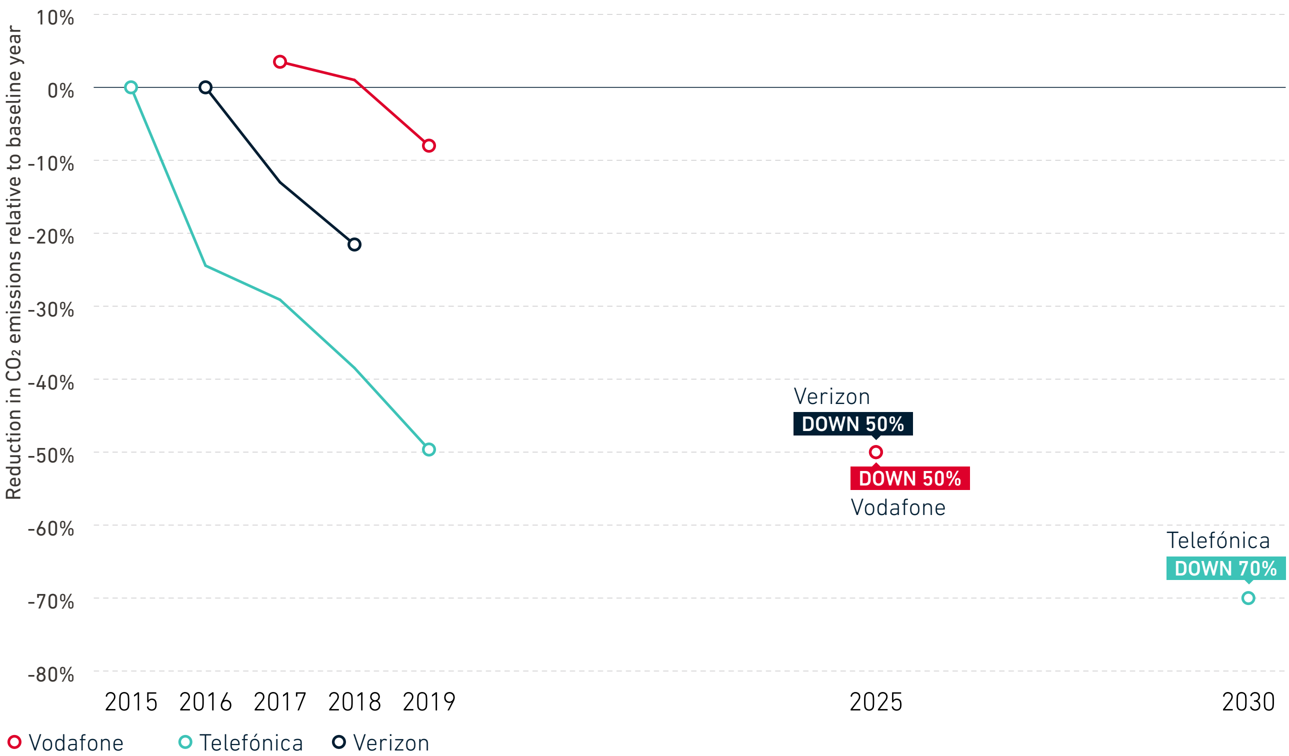
*Top four operating countries only (Spain, Germany, UK and Brazil)
Source: company reports and websites, GSMA Intelligence

Emissions reduction goals have been set in a phased approach to first reach carbon-neutral status before the more difficult and ambitious objective of net zero. Verizon and Vodafone have set targets to reach net zero by 2040. Telefónica has not yet stipulated a company-wide, net-zero timeline but has committed to this status for its top four operating markets (Spain, Germany, the UK and Brazil) by 2030. The milestones en route to these goals are, however, front loaded, with Verizon and Vodafone aiming for 50% reductions in electricity usage by 2025 and Telefónica down 70% by 2030.

Our analysis indicates that progress has generally been solid so far. The major enablers have come from advances in the renewable energy markets, including increased supply, trading liquidity and long-term purchasing contracts. Figure 6 shows the aggregate reduction in CO_2 emissions each year relative to the baseline year and in this way can be viewed as a glidepath to stated emissions reduction targets by 2025 or 2030. Telefónica is the most advanced; it had reduced CO_2 levels by 50% by 2019, implying it will reach the 70% reduction target well ahead of its 2030 goal. Verizon and Vodafone are also on a downward path, albeit less steep, which should accelerate as the higher share of renewables powering the network feeds through to lower emissions over the next two to three years.

Figure 6

Operator progress against CO_2 emissions reduction targets



Note: Vodafone fiscal year ends in March. Data shown for most recent calendar year (e.g. FY 2020 shown as 2019 above)
Source: company reports, GSMA Intelligence

Barriers and bottlenecks

Despite the progress of the above groups, it is important to caution that reporting targets are not yet in place in a majority of operators. This is exacerbated by a number of persistent barriers including data availability, lack of partnerships and, in some cases, outdated organisational structures.

Data availability

Most operators cannot harvest enough of their data to identify the critical weaknesses of their network – even though that data patently exists. Many active and passive network equipment elements do not measure energy consumption at all. Even if the equipment has the metering capacity, recording the data is labour-intensive and not in real-time.

The construction of comprehensive data 'pipelines' with associated analytics would help uncover costly anomalies. Deploying smart sensors at various points of the network will help measure equipment-level energy consumption, battery status, active hours of generators, fuel levels, outside and inside temperatures and air conditioning. Operators would need to build their comprehensive and real-time data repository based on several sources: sites energy measurements, data traffic estimates per site, energy invoices, site environments and technical characteristics. After establishing these reliable measurements and data pipelines, a big data analysis application can monitor the network, and AI can help accelerate the green transformation and support energy-efficiency improvements. Relevant actionable items can help the detection of abnormal equipment and sites, optimise power contracts with energy providers, and help decommission equipment.

Lack of partnerships with the energy sector

Even larger operators can fall short of the required amount of talent, knowledge and capacity to execute the necessary transformation alone, endangering their long-term competitiveness. Energy sourcing, transportation and optimisation can be outside their comfort zone. Companies from the energy sector have started to tailor offerings to the unique needs of operators (as have equipment vendors seeking a new-found competitive advantage), but most operators still have a traditional client-supplier relationship that does not offer proactive support for the 'how' in reducing emissions.

Organisational structures

Green transformation, energy efficiency and 5G are all interconnecting; no single team or department can deliver these highly complex, multi-year projects. This augurs for a shift towards smaller groups with cross-departmental representation and direct lines of reporting to senior and executive levels.

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