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REPORT

the sustainable telco: engineering networks for net zero

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the big picture

At the end of September, Reuters ran a story claiming Europe could be heading for mobile network blackouts in the face of energy shortages. The story was a stark reminder of why sustainability is front and center of all communications service providers' (CSPs') thinking. Even if energy continues to flow uninterrupted to Europe's mobile towers, the warning underscores the extent to which the energy crisis, combined with environmental concerns, have put telcos' energy efficiency strategies in the spotlight – and not just in Europe, but worldwide.

By the end of the third quarter of this year some telcos were citing rising energy costs as a reason for issuing profit warnings. But not every operator faces the same increases. The size of the jump depends on a mix of factors, including how successfully a company has hedged against future energy price rises, how much networks are made up of legacy copper or 2G and 3G equipment, the efficiency with which telcos manage operations, as well as the energy source used to power a network.

Yet every CSP faces the same pressure to optimize costs and continue delivering positive profit margins while investing in 5G – all amid a backdrop of economic unease, uncertainty about future revenue growth and increases in data traffic. They also need to meet demands from regulators, customers, employees and

> **"CSPs have been harnessing renewable energy to control greenhouse gas emissions, but it can only take them so far if they fail to cap their networks' hunger for more power.**

investors to develop more environmentally sustainable businesses and reduce greenhouse gas (GHG) emissions. CSPs, most notably in Europe, have been harnessing renewable energy to control GHG, but it can only take them so far if they fail to cap their networks' hunger for more power.

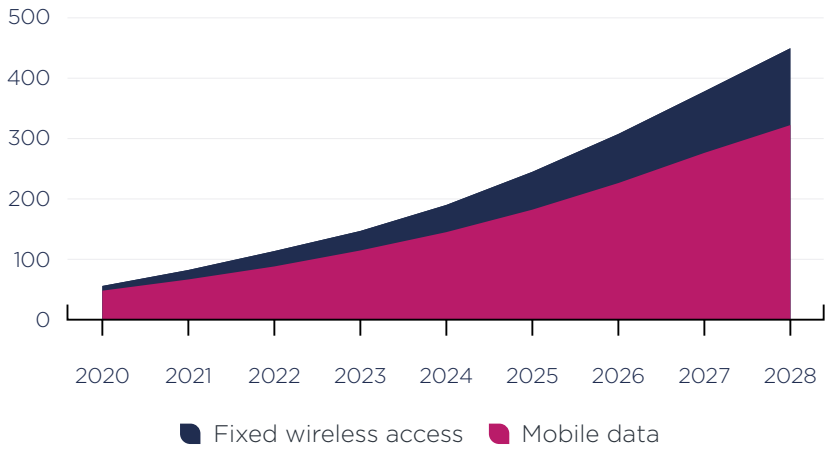
Growth in data usage among telecoms users globally illustrates the challenges CSPs face. According to Ericsson, total global mobile data traffic – including traffic generated by fixed wireless access – will reach around 115 exabytes per month by the end of this year and is projected to reach 453 exabytes per month by the end of 2028. The International Energy Agency, meanwhile, shows continued growth in data center and network energy consumption in the face of increasing internet users (see table on p.5).

Concern about energy efficiency is not new for telecoms network operators, as demonstrated by its importance in early 5G network design. The difference today from several years ago, however, is that energy efficiency is increasingly a board level concern.

One simple reason for this is cost. Networks typically account for upwards of 90% of a telco's energy consumption according to the operators we spoke to for this report. Energy, in turn, makes up between 5% and 6% of a telco's operating expenditure, according to analyst company MTN Consulting. A hike in energy costs can therefore deliver a sizeable hit to a company's profitability.

Another reason for board level concern is investors, which increasingly will threaten to withhold funds from telcos that lack a convincing long-term sustainability and energy efficiency plan. As a result, network operators are working with their suppliers and partners to find more efficient ways to process, store and transport data. Their investments, which include the decommissioning of legacy networks, have been paying off. Although MTN Consulting reports an average 10% increase in network operator power use in 2021, the rise in data traffic has been much faster.

Global mobile network data traffic (exabytes per month)



TM Forum, 2022 (source: Ericsson)

The indication, then, is that CSPs are starting to mitigate the effects of that continued rise in traffic. Telefónica, for example, says it has managed to keep energy consumption stable despite data traffic increases of 45% in 2020 and 31% in 2021.

Network operators are also being helped by their wider digital transformation programs, some of which intertwine with sustainability projects. Those initiatives – from automation and the use of AI and machine learning, through to cross-enterprise approaches to collaboration, the development of Open RAN, and network disaggregation – are opening up new ways of thinking about operational and service models. And as we will see in this report, they are having a positive knock-on effect on energy consumption.

Read this report to learn more about:

- The trends driving change in sustainability strategies
- How some of the world's leading CSPs are harnessing AI and machine learning to reduce power usage
- The role of network technology and data center equipment in driving energy efficiency
- The potential impact of Open RAN and network sharing
- Why digital transformation supports smarter energy usage.

> **"The difference today from several years ago is that energy efficiency is increasingly a board level concern.**

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REPORT

section 1:

managing energy consumption and network efficiency

Whichever way you look at it, CSPs' data networks are having to deal with fast-growing levels of traffic to meet user expectations and, as a result, are consuming ever-larger amounts of energy. Consequently, the debate has turned rapidly towards how to maximize network efficiency and mitigate those energy rises.

Globally, data transmission networks consumed in the range of 260-340 terawatt-hours (TWh) in 2021, or 1.1%-1.4% of total global electricity use, according to estimates from the International Energy Agency (IEA). Global data center electricity use in 2021 was 220-320 TWh, or around 0.9-1.3% of global electricity demand (see table).

In addition to the environmental cost, these figures represent a growing financial burden as quarterly average wholesale prices for selected regions demonstrate. The IEA says average wholesale electricity

Digital and energy indicators worldwide

	2015	2021	Change
Internet users	3 billion	4.9 billion	+60%
Internet traffic	0.6 zettabytes	3.4 zettabytes	+440%
Data center workloads	180 million	650 million	+260%
Data center energy use (excluding crypto)	200 TWh	220-320 TWh	+10-60%
Crypto mining energy use	4 TWh	100-140 TWh	+2,300-3,300%
Data transmission network energy use	220 TWh	260-340 TWh	+20-60%

TM Forum, 2022 (source: International Energy Agency)

prices in the fourth quarter of 2021 in France, Germany, Spain and the UK were three to four times higher than the fourth quarter 2016-2020 average. Even in the US, where wholesale prices grew decidedly less than in Europe, average prices in the fourth quarter of 2021 were almost 75% above the fourth quarter average of 2016-2020, according to the IEA.

It should come as little surprise, then, that telcos' partners and suppliers are increasingly finding that conversations about energy efficiency are being driven by senior operator executives. "Quite often the sustainability...and energy efficiency [impetus]...is coming from the CEO and the CFO, who will have a huge opex, and the energy spend will be top of mind," says Jen Hawes-Hewitt, Strategic Growth & Solution Development, Global Telecom Industry, at Google. "And then that trickles down into the VP for network and the CTO, CIO, who all have targets around operational expenditure reductions and... specifically energy efficiency."

In 2021, for example, Telefónica's board of directors approved linking executives' remuneration to sustainability objectives, giving the elimination of CO_2 emissions a 10% weighting. Telefónica's COO, in charge of IT & operations, for example, has financial incentives to increase energy efficiency by 90% in MWh/petabyte terms by 2025.

But CEOs' growing interest in energy usage doesn't only spring from concerns about the environment and operational expenditure. It also reflects growing pressure from company investors interested in sustainability. A small but growing number of network operators, including Telefónica, are issuing sustainability-linked bonds to fund the decommissioning of legacy networks and the building of more energy efficient 5G and fiber access infrastructure.

Reducing energy

Yet by many measures the telecoms industry has been doing a respectable job of managing its energy consumption, particularly given that it has had to add new network capacity to cope with rising data traffic demands.

In particular, the decommissioning of legacy copper, 2G and 3G networks has had a profound impact on performance. Telia, for example, estimates that replacing copper-based access networks with mobile and fiber connectivity means that today it now consumes less energy in its largest market, Sweden, than it did in 2012, despite data volumes increasing by 1,800% over this time. It also estimates that fiber-based broadband is more than 15 times as energy-efficient per unit of data transferred than the copper-based equivalent.

Other CSPs tell a similar story. "We just completed our all-IP program that basically means the shutdown of our legacy networks," said Paul Slot, Executive Vice President, KPN Infrastructure, speaking at Digital Transformation World 2022. "If you compare our energy consumption right now with about 10 years ago, that did lead to a 45% energy reduction in our network."

The holy grail is greater efficiency in the radio access network (RAN), which typically represents more than 75% of a service provider's network power consumption, according to Ericsson. Here, again, figures suggest the industry has made considerable progress and is now starting to reap the benefits of more energy efficient design of 5G networks. A study by

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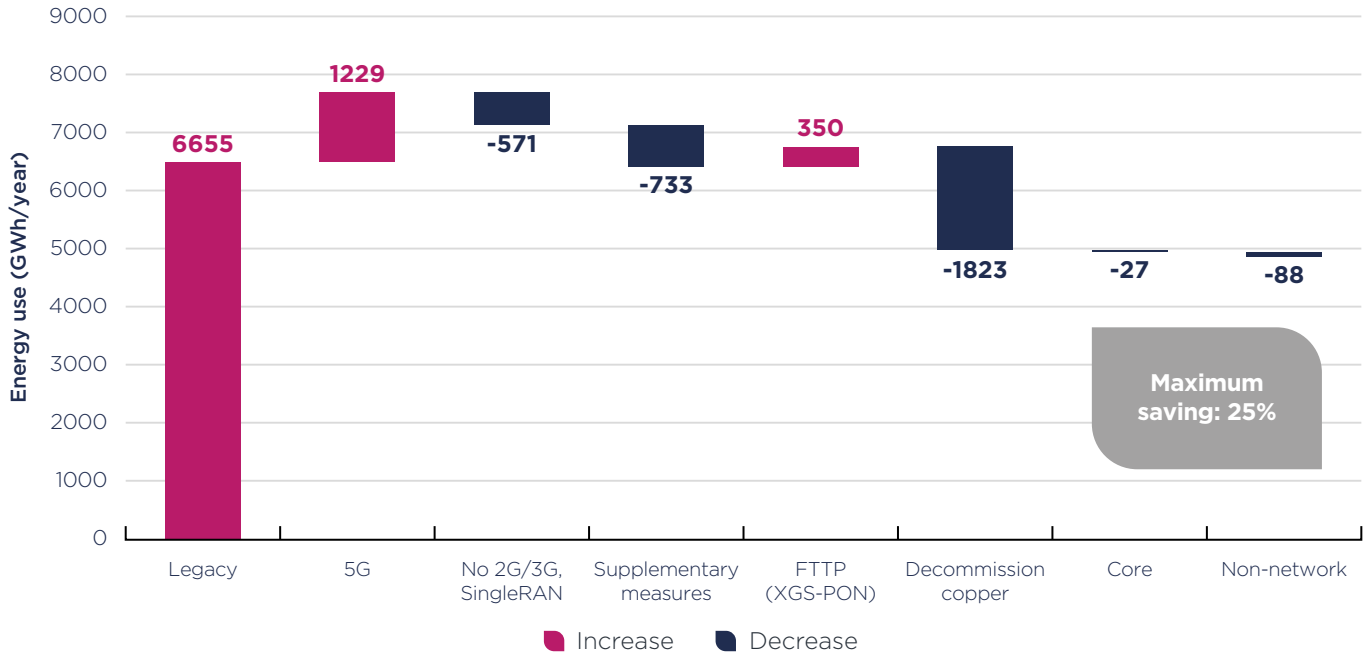
French telecoms regulator, ARCEP, shows that although deploying 5G networks alongside 4G infrastructure will incur an initial spike in energy consumption, it should result in a 10-fold decrease between 2020 and 2028, compared to using only 4G networks.

Analysys Mason in its report Driving down energy usage across telecoms networks: 5G RAN and beyond, shows a best-case scenario for energy reduction, in a country the size of the UK, through decommissioning legacy networks and introducing new RAN technologies (see graphic on p.7). "Decommissioning copper is the biggest step that most operators can take to reduce their energy usage," say the report authors. "Indeed, FTTP [fiber to the premises] is much more energy efficient than copper. Moving to a 4G/5G Single RAN deployment that eliminates the need for a separate 2G/3G RAN also provides a significant direct reduction in energy use."

Potential network energy reductions



TM Forum, 2022 (source: Analysys Mason)

Additional challenges

But greater network efficiency is not alleviating CSPs' ongoing concerns about energy costs just yet. Telia sums up the dilemma in emailed answers to our questions for this report: "Based on market futures, our estimated consumption and hedging levels... we estimate our energy costs will increase by around SEK 900 million in 2022 and by SEK 600 million in 2023, highlighting the importance of our existing energy efficiency measures and the need to make further improvements," said the company. "While we are taking action to lower our energy cost base by, for example, hedging energy costs and working to lower our energy consumption, the dramatic increase in energy costs can't easily be compensated for. And, while we are implementing new price plans to reflect the value of our services, we can't just pass on the massive energy cost increases to our customers."

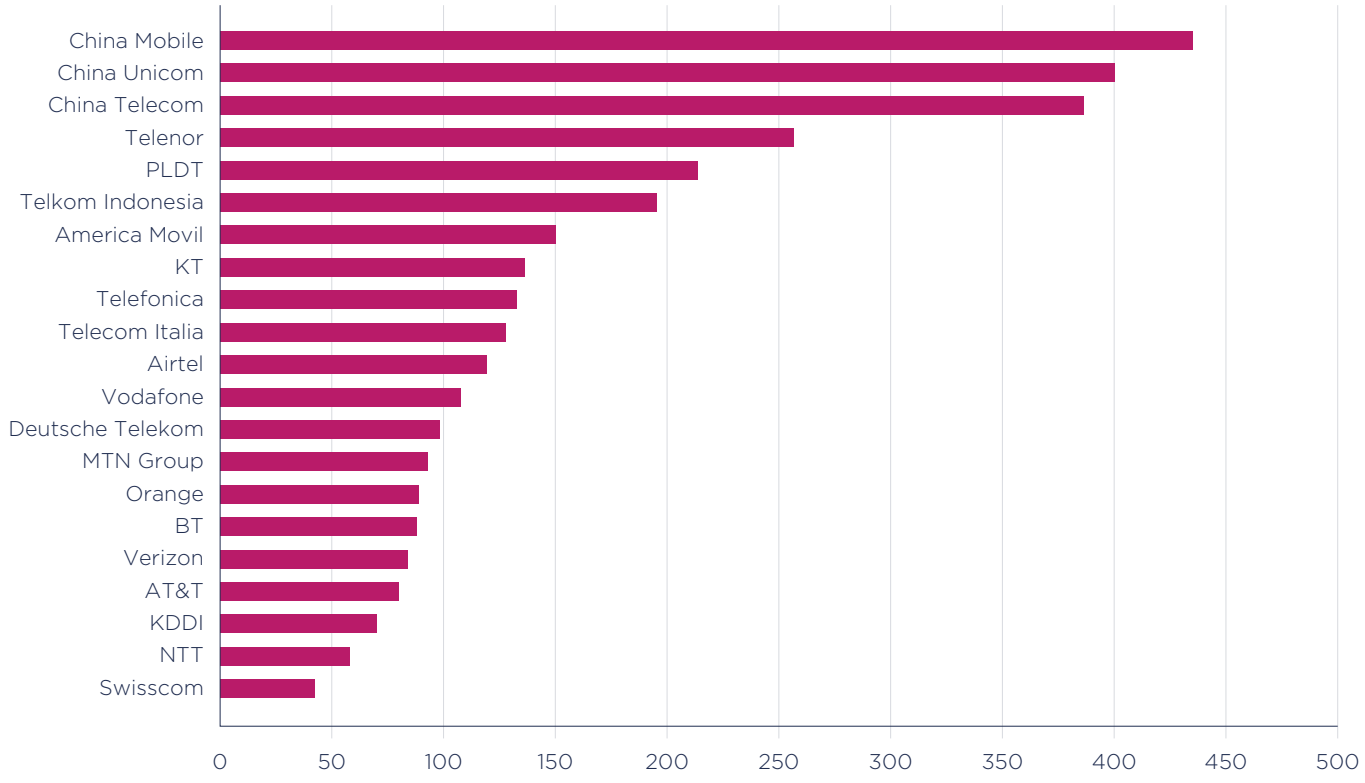
Geography is also an issue. In a country the size of India, for example, the challenge to consume less energy becomes immense. "There are more than one million radios out there in the field that are serving the length and breadth of the country," says Yashesh Buch, an engineer at Jio. "And the radios that go on the top of the tower consume the maximum amount of energy. So, it is important that we save energy in the radio equipment." For this reason, he says, "energy efficiency was very, very important" to Jio when planning and designing its new 5G network.

China, too, has challenges in terms of scale and geography, but analyst company MTN in a recent research brief also points to "the country's lack of emphasis on clean energy". Author Matt Walker adds: "What stands out is how much more power reliant the Chinese telcos are than the rest of the pack. (Their total consumption is also high, but their consumption per unit of revenue is the focus of this chart.) Telenor, PLDT and Telkom Indonesia – three telcos with a big footprint of mobile stations in challenging geographic areas to cover – are also on the high side." The chart on p.8 shows power intensity in 2021 for 21 telcos, which collectively represent more than 60% of the global telco sector, says MTN.

Vendor targets

Although decommissioning is today's silver bullet for long-established telcos, its benefits are finite. CSPs are therefore turning to additional measures, such as: network automation, which will improve areas such as fault detection and self-optimization of systems; the dynamic shutdown of unused network elements; the use of Open RAN, which could reduce power consumption and maintenance costs; and network sharing, even including the 5G Core.

Power intensity for selected operators (MWh consumed per US$1m in revenue)



TM Forum, 2022 (source: MTN Consulting)

CSPs are also applying greater pressure on their suppliers to find new ways to make equipment more energy efficient, as well as developing their own solutions. Network suppliers are responding to the call and have already "shifted the focus of equipment improvement towards the green agenda", says Gaurav Arora, Director, Sustainability & Operational excellence, Telenor Group IHQ. "For example, new radios which are coming have better efficiency."

But CSPs need more relieving measures, and Telenor is just one of the CSPs that is setting its suppliers more exacting targets. "We give [vendors] a yearly target that [says] this is an existing network operating model, this is your benchmark, and you need to be, for example, 5%-10% lower," says Arora. And although Telenor currently does not penalize vendors that miss targets, this could be set to change. "Under network behavior monetization there is going to be a certain commitment when they are selling the equipment...and if they're not achieving that, we're going to [apply] penalties," explains Arora.

But first CSPs need to have a detailed understanding of what is happening in their networks. In the next section we will look at how CSPs are harnessing AI and machine learning to understand, manage and optimize the energy efficiency of their networks and operations.

> **"CSPs are also applying greater pressure on their suppliers to find new ways to make equipment more energy efficient.**

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section 2:

using AI and machine learning to lower footprint

The telecoms industry has spent much of the past decade trying to put machine learning and artificial intelligence (AI) to work on understanding and improving energy usage. Typically, communications service providers (CSPs) have been seeking a bird's eye view of network and site operations, based on standardized data, which allows them to unify energy efficiency governance and to build operational synergies across business units and different geographies. Then people and systems can see what works best and adapt it for their needs.

Telcos' network sites and operations are complex, however, and a lot of work must go into cleaning and structuring diverse data streams before AI and machine learning systems can harness them. But as we see in this section, many operators are already making those intelligent management systems a reality.

Ana Maria Galindo Serrano, Head of Orange's Green ITN (IT & networks), sums up the position of a growing number of CSPs when she says: "An energy management information system (EMIS) is something that we wanted to do for a long time and now we are really doing it." She adds: "[Our EMIS] shows how [our] networks are using energy in different countries in near real time. We are then able to apply on top of it data intelligence and big data use cases that we have developed ourselves."

Orange has developed eight use cases available to every country in

"Telcos' network sites and operations are complex, and a lot of work must go into cleaning and structuring diverse data streams before AI and machine learning systems can harness them.

the Orange Group on a centralized cloud platform for each country. These use cases include detecting anomalies in billing, as well as energy usage, battery temperature and the energy efficiency of individual radio sites based on parameters such as coverage and frequency.

"Every country will be able to view the information and...will have the intelligence that will let them exploit this data...as well as an anomaly management system to track savings," explains Galindo Serrano. Potential savings on use cases vary between 4% and 8%. "For example, using the analysis to optimize radio sites can save countries 4% of the electricity consumed by regular sites," she says.

Aligning consumption

Telenor has also developed a global program for energy efficiency, which is led out of Asia by Gaurav Arora, Director, Sustainability & Operational Excellence, Telenor Group IHQ. During 2019/2020 Telenor introduced analytics tools from a variety of vendors to gain more visibility into site and network operations."We started by doing a benchmark and looking into what we were actually consuming at the site level," says Arora. "In some cases we found a major gap of 30% to 35% between our spend on energy and the amount of energy we needed to operate our active network. So we focused on bringing energy consumption in line with what we required to generate signals, transfer data and serve customers."

The strategy soon reaped benefits. "Within less than a year of starting we saw a 2% reduction in energy [consumption], while at the same time increasing network capacity to support a 35% rise in traffic." In addition, he says: "We were able to challenge the bills of [energy suppliers] who could not go physically on the site during Covid to take the meter reading and say energy consumption should be at this level."

Verizon, meanwhile, has developed a data analytics platform which provides a virtual representation, or digital twin, of its physical network to analyze and predict the performance, cost and efficiency of its network sites and equipment. Part of the company's wider investment in predictive analytics, the digital twin provides important insights into how Verizon can save energy costs and work with suppliers to improve network efficiency and performance.

"We were able to gather the power consumption data for all of the cell sites and see some crazy anomalies," says Michael Raj, Vice President of Network Enablement (AI & Data), at Verizon. As a result, "we could question why this costs $1,000 versus the same configuration elsewhere, which only costs $500...and identify specific problems related to that outlier, as well as make recommendations for how to remediate those situations when found in the future."

Verizon's digital twin allows the company to visualize and compare how different vendors' equipment consumes energy in the field as opposed to in a lab, and uses the results to push for better performance. "Let's say for 100 gigabytes of capacity vendor A proves to be 35% more efficient in practice than vendor B, now we can push vendor B to create a more energy efficient solution," says Raj.

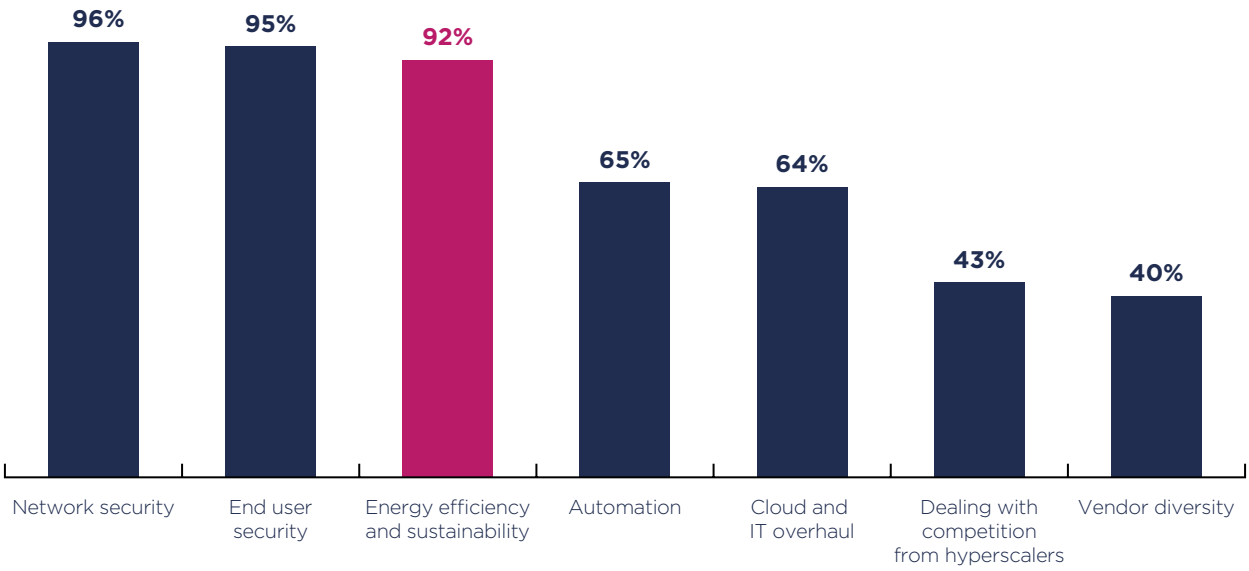
Orange goes green with global plan of action

Orange's Green ITN action plan is part of its aim to achieve net zero carbon emissions by 2040. It sets out to modernize electronic equipment to make it more efficient; deploy new architectures, such as passive data center cooling and standby mode on its networks; use renewable energy to power networks; use AI and data to optimize infrastructure deployment; more accurately measure and reduce energy consumption; share infrastructure with other operators; and conduct research into greener IT and networks.

Networks and IT equipment account for 86.6% of Orange Group's energy consumption and 84.5% of its direct and indirect CO_2 emissions. The CSP says its Green ITN program has helped it save 2.7 million tons of CO_2 between 2010 and 2019, representing 5 terawatt-hours (TWh) of electricity saved and 260 million liters of fuel. At the end of 2021, the operator had reduced CO_2 emissions (scope 1 and 2) by 12.1% compared to 2015, and it is targeting a 30% reduction by 2025.

The program's aims include meeting 50% of the Group's electricity requirements with renewable energies by 2025, compared to 31% in 2021. Wind and solar power purchase agreements have been signed in France, Poland and Spain. It has also deployed 5,400 radio sites powered by solar panels in the Middle East and Africa region, including Jordan, where solar farms provide more than 65% of Orange Jordan's energy.

Importance of sustainability to transformation



TM Forum, 2022 (source: GSMA Intelligence)

AI and transformation

Being able to operate a vendor-agnostic AI and machine learning system is an important goal for Telenor. It is currently working with network equipment vendors' systems, but its analytics team is also busy developing an in-house framework that is not tied to a specific vendor and which enhances the effectiveness of applications as well as savings, according to Arora.

> **The GSMA found that 92% of the operators it surveyed saw sustainability and energy efficiency as very or extremely important to their network transformation strategy.**

"We have a pilot to deliver the AI/machine learning framework in-house and we have already started implementing it. Once it's mature, the advantage is [that] it's vendor agnostic. Business units often operate on multiple RAN equipment radio and [deploying] solutions from every partner is not cost-effective, or efficient, in terms of management."

Telenor's new AI and machine learning framework benefits from input from different stakeholders across the business, including data scientists, the network team and the finance department. It will also support wider digital transformation initiatives.

Indeed, digital transformation is often closely aligned to CSPs' strategies to improve sustainability. In a 2021 report the GSMA found that 92% of the operators it surveyed saw sustainability and energy efficiency as very or extremely important to their network transformation strategy (see chart above).

"Creating an AI and machine learning framework helps you mature your operations to a certain level…required…[by] 5G," says Arora. "We're rolling out different capabilities, high-speed networks. We're talking about beyond network services, and we are already building cloud-[native services] and…this kind of AI and machine learning solution is quite conducive for [supporting] these kinds of environment, because it means all the business units are already moving towards mature analytical tools."

Standardizing issues

Verizon points out that providing a standardized environment in which to visualize issues and test potential solutions in the form of a digital twin has encouraged teams to take a more creative approach

to improving operations. "It's allowed us to increase the ideation across our operations team now that they have a single source to look at how the standard differs across networks, lines of business, services and types of technology," explains Raj.

Arora, at Telenor, underscores the importance of ensuring the whole business is on board with the strategy underlying AI/machine learning-driven transformation. "It's a matter of bringing all the business units to focus on the requirements of the future business we want to build. It's not easy because sometimes it does not immediately align with the local business priorities," he says. "When 2G or 3G networks still have subscribers...it requires an effort by the business to educate and migrate subscribers towards [a new] technology."

But once the systems are in place, they can be their own best advocates. Verizon, for example, is now able to forecast energy costs based on factors such as the addition of a new cell site or decommissioning, as well as price fluctuations in energy markets. This gives financial officers a much more detailed energy price forecast against which to budget, which in turn helps them better manage expectations of financial markets.

"In a typical year what would happen is...one quarter of energy price spikes hit your margin, and the next quarter's energy price drops increase your margin. What we'll be able to show is [that] although we are trending lower [in terms of energy spend], months of hard energy bills are coming," says Verizon's Raj. "This more granular forecasting piece is underappreciated, but CFOs will get a lot of peace of mind."

And as business units experience more operational benefits from AI and machine learning, they become instigators of change, says Arora at Telenor. "Analytics means better operations and now we don't need to push the energy [side of the equation]. Now questions are coming from the business such as what can we do? What's the next step?"

In the next section we look at generating energy efficiencies from developments including cooling systems and field management.

China Mobile's green plans for autonomous networks

Progress by CSPs towards autonomous network operations is also helping to deliver greater sustainability. TM Forum, through Catalyst proofs of concept and the Autonomous Networks Project, is working with members towards self-configuring, self-healing, self-optimizing and self-evolving telecoms network infrastructures.

"Telcos in Asia are adopting TM Forum's Autonomous Network and Operations Technical Architecture, allowing the adoption of automation and AI applications to optimize RAN energy consumption," says Yang Gan, Regional Business Development Director, KPMG.

China Mobile and industry partners, including XL Axiata, have been taking part in a TM Forum Catalyst project to explore how autonomous networks (AN) and energy-saving technologies can help them deploy green 5G and achieve sustainable development goals. These include reducing China Mobile's carbon emissions by at least 20% by 2025, and saving more than 40 billion kilowatt-hours (kWh) of electricity.

The Catalyst project helps China Mobile apply AN to its own network applications as well as those of enterprise customers and reflects the Chinese operator's wider strategic goal of developing automatic and intelligent operation and maintenance (O&M) capabilities throughout the network lifecycle.

Watch the video

section 3:

how CSPs are adopting energy saving measures

As we saw in the previous section, telcos are using digital twins, AI frameworks and energy management information systems to help them understand and improve energy costs and efficiency at organizational, architectural and site levels. CSPs are also relying on AI and machine learning to power down network elements at periods of low traffic without impacting customer service, as well as other energy saving methods such as cooling systems and field service operation management.

The idea of switching off hardware components – putting them into sleep mode – is not new. However, as Ericsson explains in a blog, the 4G standard required most hardware components to remain active to transmit mandatory signals, which gave components only 0.2 milliseconds in which to sleep between data transmissions. In contrast, 5G new radio (NR) networks provide components with a much more generous lull between mandatory transmissions, of up to 20ms in standalone mode and 160ms in non-standalone mode. In addition, 5G NR requires far less always-on signaling transmissions in the frequency domain, says Ericsson.

Certainly, if telcos are to conserve energy they will have to take every opportunity they can to switch off network hardware components. Although 5G networks use less power to transfer each byte of data than 4G, both the business case and technical design of 5G assume more machines and devices will carry more traffic.

Every time a CSP adds capacity the network becomes denser, which drives energy usage upwards, as Paul Slot, Executive Vice President, Infrastructure, at KPN explains. As a result of modernizing its mobile network by closing down its 3G network and rolling out 5G, KPN has found that "if you look at energy usage per bit it's something like 27 times less" than before. Nonetheless, he says: "The total energy consumption of the mobile network did go up 1 or 2% [and] that's related to the densification. If you add mobile sites to your network, then you cannot avoid using more energy."

Harnessing sleep modes

Like other CSPs, Indian operator Jio already uses sleep mode for its vast 4G network, which numbers more than one million radios and spans three different frequency bands. For example, it intelligently shuts down the RAN power amplifier for microsecond intervals by detecting when there is no traffic.

"Certainly, if telcos are to conserve energy they will have to take every opportunity they can to switch off network hardware components.

"We found a significant amount of improvement, because there are microsecond intervals without traffic even during busy hours in the day," says Yashesh Buch, an engineer at Jio.

Now, however, Jio is going further and has developed a way to turn off radios altogether during extended periods of low activity. "For this feature, we imagined the radio network as consisting of layers, with each layer in a different spectrum," explains Buch.

Jio then designated capacity layers – which could be thought of as the workhorses of data transmission – and coverage

layers. In 4G, for example, Jio's principal capacity layer is the 2,300-MHz band, explains Buch. "Similarly, when 5G is deployed there will also be a capacity layer in the 700-megahertz band."

Jio's design will allow it to completely turn off the 4G and 5G capacity layers at times, such as in the middle of the night when there's almost no traffic. "Any traffic there is, will be handed to the coverage layer of the spectrum and only then is the capacity layer turned off. And in the morning when the capacity layer is turned on the users are again redistributed... based on the proportion of spectrum available," explains Buch.

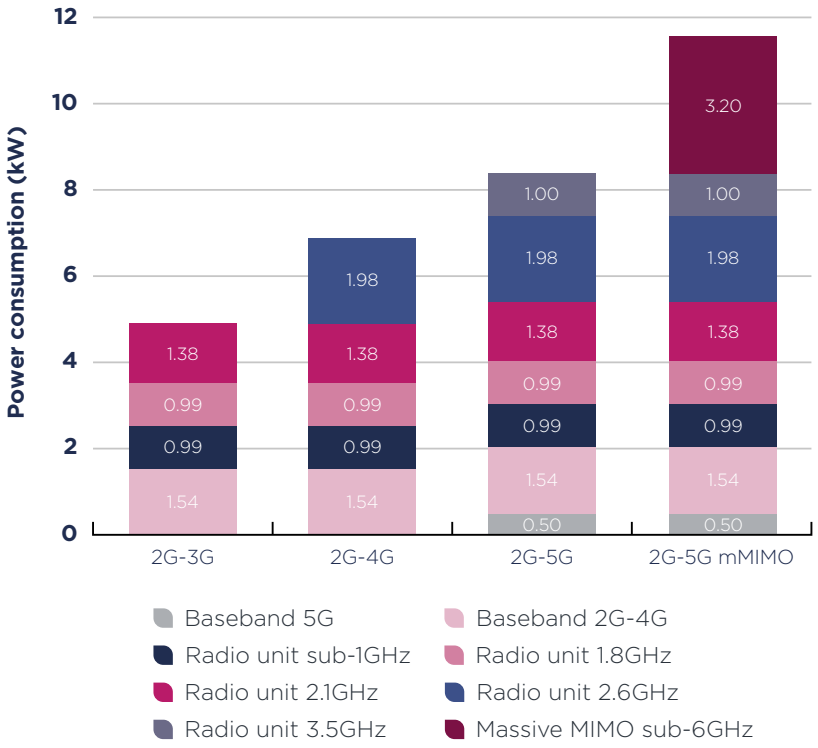
Jio's AI-driven Cognitive Platform manages the system, using RAN data from multiple vendors to ascertain when traffic can be safely concentrated on the coverage layer and the capacity layer switched off.

Such energy-saving measures are needed for traffic-heavy 5G networks as the graphic above illustrates. According to Analysys Mason, mobile RAN accounts for more than half of operators' energy consumption. 5G requires additional active powered elements, especially if massive MIMO (mMIMO) is deployed. In many cases, it will also require additional cells. This will cause operators' energy consumption to rise if there are no mitigating technologies or savings elsewhere.

Going outdoors

In addition to powering down network equipment for longer, CSPs are also trying to reduce how much energy they expend on cooling or heating RAN devices and fixed network exchanges. Electronic equipment typically operates best at 65-75 degrees Fahrenheit (18-24 degrees Celsius). Telecoms networks,

Maximum power consumption of mobile base stations (multiple mobile generations by component)



TM Forum, 2022 (source: Analysys Mason)

however, have to work night and day in some of the hottest and coldest places on Earth. Manufacturers therefore have invested in designing network equipment that can operate without air conditioning in hot climates or heating in cold ones.

"Most manufacturers are now supplying outdoor equipment, with which you can save 15% to 20%" on energy consumption, says Telenor's Arora.

Axiata is also reducing its energy use by replacing base station RAN devices that need shelter and air conditioning with RAN devices that can be installed outdoors. It has also discovered that a lot can be done with careful ventilation.

"In Sri Lanka, for example, in a lot of areas where we used to have cooling, now they don't use it any more because of the fuel crisis there," says Adelene Anthony Sinniah, Head of Sustainability, Axiata Group. "For some equipment that is part of the tower that used to be in a housing with air conditioning; they realized you can also do without air conditioning if you put in good ventilation."

Axiata Group has telecoms operations in Bangladesh, Cambodia, Indonesia, Malaysia, Nepal and Sri Lanka. A range of initiatives designed to save energy and reduce GHG emissions across its networks, including the growing use of solar power, have lowered its operating costs and improved its carbon intensity performance by 24% from 2020, according to Sinniah (see graphic on p.15).

And when equipment can't move outdoors, telcos are turning to AI to help them. As part of a TM Forum Catalyst, for example, Zhejiang Mobile worked with Nokia to apply autonomous networks to the task of optimizing the energy consumption of air

conditioning units of a data center and a 5G base station room. The Catalyst created what it calls an "energy smart brain", with Zhejiang Mobile reporting power savings on air conditioning in excess of 10%, thereby conserving 31 million kilowatt-hours of electricity per year.

BT, meanwhile, is among CSPs that are increasing the power use efficiency (PUE) at its fixed exchanges by using adiabatic cooling – which uses changes in air pressure to cool the surrounding environment – hot air containment and more efficient rectifiers.

Field services

Another area where CSPs expend energy and generate emissions is network support. Google sees many operators looking for support in using data analytics to optimize "the truck roll aspect of network maintenance", says Abhishek Jain, Director, Global Telco Partnerships, Google. In other words: "For a closer understanding of how you can be more efficient and effective in terms of which engineers you're sending to which cell sites and whether they have got the right tools."

Operators are also making moves to equip field engineers with electric vehicles. Orange has a fleet of 15,800 vehicles, according to Philippe Tuzzolino, Orange Group Environmental Director. "Moving to electric vehicles and car-sharing [is] not easy for technicians, managers and employees because it challenges how they drive," he says, particularly when it comes to planning journeys. "We implemented eco-training and car sharing. We have 3,800 vehicles in car sharing. It's a huge transformation." Orange's aim is to have 50% of the fleet electrified by 2025, representing more than 7,000 vehicles.

Other operators are taking a different approach to investing in electric vehicles, as we explored in our recent benchmark report Telco revenue growth: taking it to the next level. Turkish mobile operator Turkcell, for example, has taken a 23% stake in Togg, an electric car start-up company whose first models are due to come off the production line at the end of this year. Turkcell also owns a renewable energy business which it uses to both serve its own organization and to sell energy into Turkey's wholesale market.

In the next section we'll look at how the growing use of software in networks, automation, and moving operations into the cloud, could all impact energy usage.

Axiata Group is taking measures to reduce its energy consumption in Asia

Celcom (Malaysia)

- Decommissioned 63 diesel generators
- Converted 24-hour generators to commercial power supply at more than 50 sites
- Installed advanced metering infrastructure at more than 150 sites for smart grid, reducing electricity consumption for better energy management
- Installed solar hybrid solutions at more than 40 sites for significant savings in energy usage
- Installed charge-discharge batteries for more than 20 sites to reduce diesel consumption

Ncell (Nepal)

- Conversion of diesel generators to grid, reducing energy use
- Optimization of temperature at air-conditioned sites to set at optimal temperatures that will reduce energy consumption for cooling
- Enabled efficiency modes on rectifiers at sites and power-off features to conserve energy

XL (Indonesia)

- Dismantling of unused equipment, antennas and towers – based on their utilization and profitability
- By end of 2022, XL expects to shut down 1,603 unused network elements as well as dismantle 1,000 antennas and 250 towers
- Configuration of a power saving feature on equipment to allow it to switch off automatically during idle traffic. XL expects to deploy the feature at 4,000 sites by the end of 2022
- Electrification of sites, converting the use of diesel generators to grid-connected BTS in remote areas.
- Reducing usage of air conditioning by modernizing base transceiver station RAN devices from those that need shelter and AC to RAN devices that can be installed outdoors

tmforum knowledge

REPORT

section 4:

moving RAN functions to the cloud

In the previous section we saw how telcos are already using automated data analysis to save energy by powering down network elements. Because network functions increasingly operate as cloud-based software – whether through RAN virtualization, the development of Open RAN, or 5G standalone (5G SA) networks which have a cloud-native core – CSPs should be able to go further in using AI and machine learning to automatically collect, analyze and deploy data to improve energy efficiency.

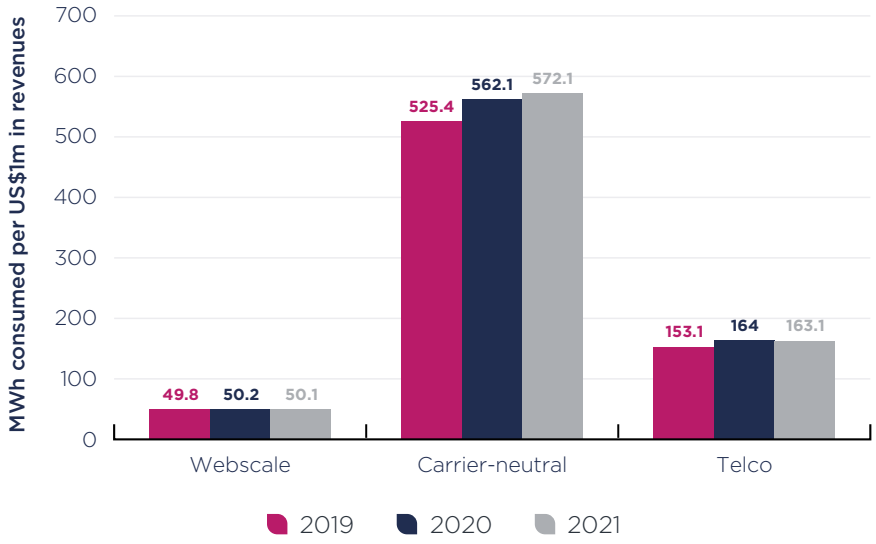
The terms RAN virtualization and Open RAN can be used interchangeably, but their aims differ. Whereas RAN virtualization refers to implementing RAN functionality as software and running it on generic server hardware, Open RAN may well involve virtualization, but its principal aim is interoperability. CSPs are pushing Open RAN because they want to use standards-based, interoperable interfaces to interconnect disaggregated radio access network elements, which makes it easier to build networks using a mix of suppliers. And the telcos behind Open RAN are also stressing its greener credentials.

In July this year, for example, Vodafone announced the result of trials which showed a reduction in "the power consumption of an Open RAN infrastructure by 9% and 12%, during high and low mobile traffic peak scenarios respectively" compared to other mobile networks. Vodafone is one of five telcos – the others are Deutsche Telekom, Orange, TIM (Telecom Italia) and Telefónica – that have signed the European Open RAN MoU as part of the Telecom Infra Project. The body says it expects that Open RAN networks will gradually become more energy efficient than traditional RANs, benefiting from Open RAN concepts such as cloudification, disaggregation and native AI.

The Open RAN Policy Coalition, which numbers AT&T and Verizon among its members, also describes one of the benefits of Open RAN as being able to tap into the energy efficiencies of cloud computing: "Compared with the traditional RAN, Open RAN's disaggregated, software-centric approach can accelerate the shift of compute resources to large data centers, leveraging advances in data center power optimization. By running as much software as possible in the cloud, Open RAN networks can take advantage of the economies of scale inherent to large data centers. Cloud data centers can leverage centralized cooling, lighting, and electricity purchasing agreements, bringing down power costs compared to local compute operations."

> **"CSPs are pushing Open RAN because they want to use standards-based, interoperable interfaces.**

Power intensity by operator type



TM Forum, 2022 (source: MTN Consulting)

A long path

However, even if Open RAN delivers on its energy efficiency promise, it won't happen any time soon. Rolling out an extensive Open RAN network is neither fast nor easy for CSPs with extensive networks using other technologies.

Vodafone, which is a strong Open RAN advocate, says it aims to have 30% of all its EU mobile sites using the technology by 2030. For other telcos, the speed of Open RAN adoption is likely to be slower. Nonetheless, Open RAN does point to telcos' determination to harness a cloud-native, software-based approach to the RAN as a means to improve energy efficiency.

When it comes to collecting data and improving management, an important element of future RANs – and not only Open RAN – is the RAN Intelligent Controller (RIC). A trial by Telefónica Deutschland has connected eleven RAN nodes that support 5G, 4G (LTE) and 2G (GSM) services to a RIC with the aim of testing whether it can deliver on applying AI in the network.

"The newly developed RAN Intelligent Controller forms an important element for our network on our way to a perfectly optimized mobile network," said Mallik Rao, Chief Technology & Information Officer at Telefónica Deutschland, in a statement. "With the help of its artificial intelligence, we want to be able to optimize our network faster and more precisely than before. The RIC is an important development step in this regard, as it can control both classic mobile networks and newer, Open RAN-based networks." If RICs do live up to their promise, more precise network optimization should help CSPs further improve energy efficiency.

> **"Open RAN points to telcos' determination to harness a cloud-native, software-based approach to the RAN as a means to improve energy efficiency.**

Certainly, operators are looking at such technologies to reduce consumption and therefore operational expenditure. "One of the major opex cost drivers for Rakuten Symphony's telecom customers is network energy consumption, with RAN being the key contributor to it followed by cloud infrastructure," says Anna Khoruzhaya, Vice President of Strategy, Planning and Go to Market, Rakuten Symphony.

Focus on efficiency

But how clean is the cloud? Power consumption by webscale operators globally rose by 19% and 25% in 2020 and 2021, respectively, according to MTN Consulting, while telco power consumption grew by 6.0% and 4.7% in the same two years.

But the analyst company's comparison of the power usage effectiveness (PUE) of telcos, webscalers and carrier-neutral network operators (CNNOs) shows webscalers far ahead of the rest of the industry (see chart above). There is a simple explanation for this: energy accounts for much of the cost of running a data center, so hyperscale computing platforms have for a long time focused heavily on energy efficiency. And scale matters. CNNOs – which MTN Consulting describes as companies selling "independent, carrier-neutral access to network infrastructure, including fiber, data center and tower/small cell assets" – have higher power intensity precisely

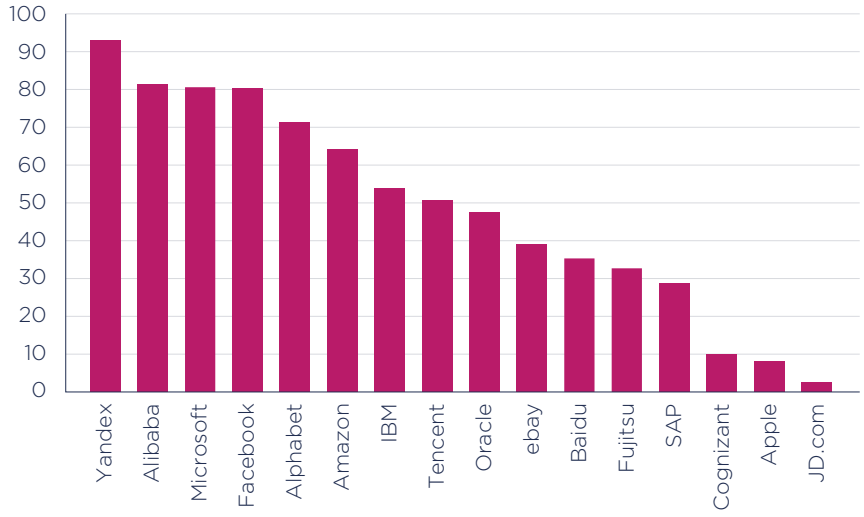
because of the scale of their data center operations.

CNNOs recorded 16% growth in power consumption in 2020, and 15% in 2021. The CNNO segment's data center specialists stand out as the biggest electricity users in the operator industry, as measured by power intensity – megawatt-hours (MWh) of power per unit of revenue. In 2021, for instance, Digital Realty consumed 2,094 MWh of power per US$1 million of revenue, versus 97.6 for American Tower, 82.9 for AT&T and 71.0 for Alphabet, a large tower CNNO, telco and webscaler, respectively.

Just looking at webscalers, Apple and China's JD.com are by far the most efficient in terms of power intensity, while Microsoft, Facebook (Meta), Alphabet (Google) and Amazon, which operate huge data centers, are all much higher (see chart above).

Hyperscalers take multiple measures to improve energy efficiency, and an important one is the development of energy-efficient processors. "If you think about machine learning algorithms and AI, those are energy intensive and data intensive activities, so [when] designing our own chips...we think about making our processing units more energy efficient than the industry standard," says Matt Anderson, Head of Cloud IT Solutions at Google.

Power intensity for webscalers (MWh consumed per US$1m in revenues)



TM Forum, 2022 (source: MTN Consulting)

A focus on energy-efficient processing is true for RAN suppliers, too. The transition from 4G to 5G involves a significant increase in RAN equipment processing requirements. Ericsson reports its "silicon processing hardware...plays a key role in creating high-performing and lightweight products and has increased energy efficiency by a factor of 10 from 2016 to 2022".

High telco consumption

Data centers, meanwhile, rightfully get a lot of attention for their high power requirements, says MTN. However, despite several years of heavy data center investments in both the webscale and carrier-neutral markets, these two segments accounted for 22.9% and 11.1% of total network operator electricity consumption in 2021, according to the analyst company.

Telcos are by far the biggest power consumers, accounting for 66% of the total combined electricity consumption – of telcos, webscale and carrier-neutral operators – in 2021, compared to 69.2% in 2020.

But telcos' impact on the environment is even higher than this 66% would imply, says MTN, because much of their electricity consumption is still largely based on fossil fuels. Moreover, telcos consume significant amounts of non-electric energy – diesel, propane, heating oil and so on – to power their facilities, and in particular mobile base stations.

But energy efficiency is not the only measure of success when it comes to sustainability, of course. In the next section we'll look at how the telecoms industry is working to reduce greenhouse gas (GHG) emissions.

> **"Telcos are by far the biggest power consumers, accounting for 66% of the total combined electricity consumption in 2021.**

section 5:

how telcos are moving towards net zero

So far in this report we have been looking at energy efficiency principally through the lens of operational expenditure. Bringing rising opex costs under control is an important catalyst for transformation, but it is not the only one. Achieving sustainability goals is also high on telco CEOs' agendas, with powerful stakeholder groups, including investors, regulators, customers and employees helping to drive change.

"The whole ecosystem is pushing for [more] disclosure," says Gan Zi Yang, Regional Business Development Director, KPMG. "Financiers, especially, are pressuring the telcos to disclose emissions data...There is also peer pressure [and] consumers are more aware as well."

Our recent e-book, 50 shades of green: using data to drive sustainability, explores how service providers are using data to up their game in sustainability reporting and taking key steps to ensure that data is helping them achieve tangible outcomes. To do so they must navigate complex benchmarks, frameworks, standards and targets.

A number of CSPs and hyperscalers have set net zero goals, which means reducing emissions of greenhouse gases (GHG) to as near zero as possible. Plans from BT, Deutsche Telekom, Orange, Telefónica and Vodafone are among some of the most ambitious, with each hoping to achieve net zero across all of their emissions by 2040.

A long way to go

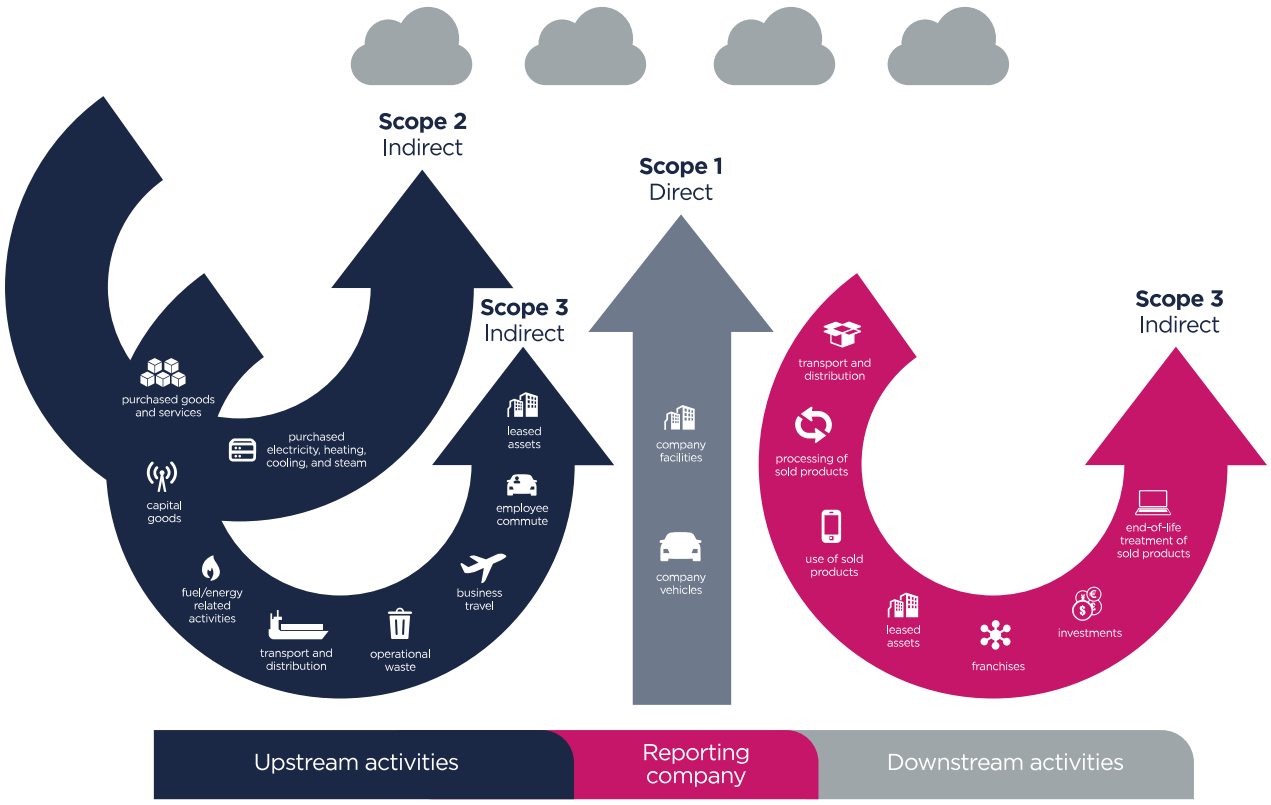
A near 20-year timescale to reach net zero, however, indicates how hard it is to reduce GHG emissions, particularly those in Scope 3, a sprawling category that refers to indirect emissions, including those from the production, use and disposal of purchased goods and services (see graphic p.20).

As Timotheus Höttges, CEO of Deutsche Telekom AG, puts it: "Sustainability is less about a great leap forward" and more about making "systematic progress at many different points".

Clearly, it is hardest to reduce emissions in Scope 3, which are beyond a company's direct control. In addition, investment in products, networks and services and increased service take-up can drive up Scope 3 emissions. Microsoft, for example, reported in its 2021 sustainability report that its total Scope 3 emissions increased by about 23% year-on-

> **"Achieving sustainability goals is high on telco CEOs' agendas, with powerful stakeholder groups helping to drive change.**

Companies are being pushed to disclose their different emissions categories



TM Forum, 2022 (source: ESI Monitor)

year for multiple reasons, including electricity generation to power end-user devices and the production of concrete and steel for use in construction.

But reducing Scope 3 is crucial, because these are typically the largest source of GHG emissions. Among the steps that telcos are taking include circularity: encouraging network equipment suppliers to design products for re-use, repair and re-manufacturing so that products and materials are recycled in a circular way.

"The key question all of us telco operators will ask the Nokias of this world and the Ericssons...is [around] circularity," said Paul Slot, VP Network, KPN, speaking at Digital Transformation World 2022. "As an industry we can do better...on standardizing this approach together with our suppliers to ensure it [across] the whole chain. Our customers are relying on us...but we're relying on the big technology companies."

Slot adds that circularity is a key element of KPN's RFP processes. "I think what we take out of the network is 86% re-used in a circular way...and we want to get closer to 90%," he says.

Telcos are also working to promote circularity with end customers. Telefónica, for example, works with consumers to buy back old phones and repairs routers instead of making new ones, citing the figure of 4.7 million devices re-used per year.

Telia is one of several telcos asking suppliers to abide by science-based climate targets. "After two years of engagement, 29% of Telia's supply chain emissions are covered, and targets covering another 21% are in the process of being externally approved," says the company in an emailed statement for this report.

Nearer to home

When it comes to their own operations, CSPs have more nearer-term goals. Deutsche Telekom, for example, says its own business operations are on course to achieve climate neutrality by 2025 (Scope 1-2), and BT Group has set a net zero target of 2030 for its own operational emissions.

AT&T, meanwhile, aims by 2030 to reduce its absolute Scope 1 and 2 GHG emissions by 63% compared to a 2015 base year, and to achieve net zero Scope 1 and 2 emissions by 2035.

An important route to reducing emissions is the use of renewable energy. However, it is not always easy to source reliably, particularly because telcos don't have the same luxury of location choice as large data center operators. CSPs have to build networks close to their customers, whether there are renewable energy sources nearby or not.

When it comes to using renewable electricity, though, operators in Europe are already making strides, largely through the use of power purchasing agreements (PPAs) and renewable energy certificates. Since July 2021, for example, Vodafone's entire European network, data centers and operations across 11 countries have been powered by renewable electricity. In the UK, where the operator targets net zero operations by 2027, this has helped to reduce operational carbon emissions by 77% as of March 2022, compared to a 2019 baseline, which amounts to 71,675 tonnes of CO_2e. And according to the ITU, Facebook, Alphabet and Microsoft all also claim to use 100% renewable electricity.

European telcos have relatively ready access to PPAs, which guarantee them a long-term renewable energy supply directly from the producer. Telenor and Telia, for example, this summer announced a joint ten-year PPA with a solar cell plant in Denmark. Telia also says it has been using 100% renewable electricity to power its network infrastructure in all markets since 2020.

But whereas in Europe's deregulated energy market "you can have private agreements between two companies for PPAs [including across borders], that's generally not possible in Asia," according to Kristian Hall, Vice President, Climate and Environment, at Telenor Group.

> **"Renewable energy, such as solar and wind power, is an important part of operators' carbon emission reduction strategies.**

In Asia, several countries are working with governments, regulators and industry bodies to source renewable energy. "In Asia, we see telcos work on a policy level with their respective governments and national grids to obtain cleaner energy," says Adelene Anthony Sinniah, Head of Sustainability at Axiata Group. Telcos in Asia are also replacing diesel-fueled off-site base stations with solar and hybrid solutions, she adds.

In addition, telcos can access International Renewable Energy Certificate (I-REC) schemes, although they do not offer the same guarantee of renewable energy as PPAs. Indeed, as the UN points out, constraints in electrical grids in some countries mean that signing up for renewable energy isn't the same as receiving it every hour of the day.

As a result, a group of energy buyers, energy suppliers, governments, system operators, solutions providers, investors and other organizations worldwide, which include Google and Microsoft, are collaborating to "accelerate the decarbonization of electricity grids by adopting, enabling, and advancing 24/7 Carbon-free Energy (CFE)".

Mobile disparity

The same disparity in access to renewable energy is evident in mobile operators' progress globally. As we have seen, outside Europe and North America getting access to renewable sources is difficult for operators in many regions due to regulatory uncertainty or lack of investment.

Renewable energy, such as solar and wind power, is an important part of operators' carbon emission reduction strategies. Today, 18% of the electricity used by mobile operators around the world is from renewables, according to the GSMA. This should be at least 50% by 2030 if operators are to meet net zero carbon emission goals by 2050, but the current supply of renewable energy cannot meet their demands.

The amount of renewable energy usage varies considerably according to region. European operators, for example, purchase on average 71% renewable energy, while mobile networks in 29 countries use less than 25%.

Some schemes are now emerging to help deliver telecoms services sustainably in emerging markets, with renewables front and center (see box p.22). Operators are also coming up with new, inventive ways to reduce their footprints to become greener organizations. They will need to if they are going to meet increasingly ambitious sustainability targets – or even, perhaps, to keep the mobile services we all rely on up and running without interruption.

Thinking outside the data center: Telia turns to innovation

Some telcos are using inventive technologies to reduce their, and their customers', footprints. Telia Sweden is working with real estate company SBB to recycle excess heat from its Haninge data center for use in school buildings, housing for the elderly and offices.

Telia explains that SBB built a bedrock-based borehole energy storage system on one of its properties to store the excess heat produced by the operator's adjacent data center. As a result, Telia's data center benefits from cooling, while 100,000 square meters of SBB property receives free heating, which corresponds to a saving of approximately 5,600 MWh per year.

Telia is also conducting pilots of smart battery energy storage systems with Swedish energy storage solution provider, Polarium, to optimize energy usage at its fixed and mobile sites. The system uses battery capacity when demand and prices for grid supply are high. Telia will also assess feeding power back to the national grid, which could help stabilize the grid in cases of power shortages.

Bridging the connectivity divide in a sustainable way

The International Finance Corporation (IFC) is working with operators to develop TESCOs – telecoms energy services companies – to deliver telecoms services in emerging markets and underdeveloped areas. The IFC says TESCOs are necessary to provide the energy required to deliver telecoms services to the remaining half of the global population that is still offline.

Expanding telecoms services in a sustainable manner to these areas with poor or non-existent energy infrastructure is challenging says the IFC, which says the mobile industry has made a commitment to reduce emissions by 45% by 2030 and achieve net zero greenhouse gas pollution by 2050.

TESCOs replace diesel-based solutions with solar panels and other renewable technologies and today control the power equipment at nearly half the world's renewable energy-powered sites, according to the IFC. By 2030 the number of TESCO sites is expected to quadruple to 166,000, with sub-Saharan Africa by far the largest market with 44% of the total followed by South Asia with 25% of the total. By 2030 TESCO solutions are expected to be adopted by 57 additional countries, triple the number today.

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REPORT

TATA CONSULTANCY SERVICES

TCS TwinX™

TCS in the Communications Industry

The Communications industry has been a focus segment for TCS for more than 25 years. Through this industry segment, TCS is working with over 160 Communications Service Providers (CSP) across the globe.

With more than 35,000 resources worldwide, the Communications, Media & Information Services (CMI) unit of TCS accounts for ~10% of TCS' revenue and boasts a CSAT score of 95%. TCS' CMI unit serves **5 of the top 10** global CSPs, **4 of the top 6** European CSPs and **6 of the top 7** North American CSPs. Our host of service areas includes , Digital transformation, API-fication, Cloud services, Network services, Infrastructure services, Automation, Agile/DevOps, Data and analytics.

TCS' domain expertise and knowledge allows customers to benefit from accelerated product innovation, scalability, faster go-to-market, reduced costs of product development, and reliability. Our solutions and services cater to the needs of different players across the communication value chain ranging from end-to-end information technology consulting and custom application development to product implementation and maintenance. Over one billion subscribers run on solutions architected, managed, and serviced by TCS' CMI division. We have a long-term partnership with industry leading CSPs including AT&T, BT, Verizon, Comcast, Rogers, Vodafone, and more. TCS is enabling CSPs to transform their customer experience and drive growth by building a digital core with technologies such as cloud, IoT, data, agile and AI; creating innovative business models driven by innovation and integration of best practices across industries; and by adopting ecosystems as an operating model to transform and grow.

TCS' industry-leading portfolio of intellectual property has played a pivotal role in accelerating clients' growth and transformation journeys.

Building on Belief: TCS rooting business in the community

TCS' proactive stance on climate change and award-winning work with communities across the world have earned it a place in the leading sustainability indices such as the MSCI Global Sustainability Index and the FTSE4Good Emerging Index. TCS follows the Tata group philosophy of building sustainable businesses that are rooted in the community and demonstrate care for the environment. We follow a 'basket weave' methodology, as part of which social, economic, and environmental issues are addressed both inside TCS as well as outside. We believe that corporate sustainability extends to the triple bottom line of people, planet, and purpose. We have increased the radius of business responsibility beyond immediate

benefit to long-term good, while ensuring the sustainability of the organization. TCS enables an environment of greater consciousness through a process of collaboration with employees, suppliers, customers, and the community at large.

TCS believes that sustainable futures are built using an ecosystem approach. Whether it's measuring progress on your sustainability efforts, automating and scaling them, or de-risking your investments, TCS' comprehensive set of 200+ solutions can help the CSPs to build resilience and grow sustainably.

How TCS is using digital twin to help CSPs become carbon neutral

The threat of climate change has become extremely critical to ignore, and the path of profitable sustainability is still unclear. Digital twin solutions can be leveraged here to enable risk-free experimentation around new sustainability initiatives.

Digital twins, the virtual replicas of logical and physical systems that can model, simulate, monitor, analyze, and constantly optimize the systems, are at the core of creating sustainable growth charter for the communications industry.

Digital twins' simulation- led approach creates a robust decision support system for CSPs to take the right decisions in driving the sustainability agenda across the value chain. By including the digital twin in a CSP's value chain, we can replicate the current state's model and also analyse the impact of service levels, cost, lead times, margins and other relevant business KPIs. If the outcome is as per expectation, then new initiatives can be launched accordingly.

By leveraging digital twins for earth, the overall impact of corporate initiatives can be simulated or visualized across the globe over months or decades. This step will not only paint the bigger picture for the leadership and people. but also will help in in further refining the scope of initiatives, eventually creating a library of tried and tested strategic sustainability initiatives that can be replicated globally.

At present, the ICT sector generates between 1-4% of global carbon emissions but this number is slated to rise sharply in the wake of digital transformations, Web 3.0 and other technological advancements. TCS is committed to working with its customers to create a sustainable IT landscape and move up the sustainable software maturity curve.

TCS TwinX™ for Sustainability

TCS TwinX™, a risk-free business experimentation platform helps create faithful and purposive replicas of enterprise entities in a virtual environment. TwinX for Sustainability is an effective tool to enable CSPs in their net zero emission journey by:

- **Creating scope- wise emissions visibility** – Through n=1 level modelling, a digital twin model can minutely track and predict the extent of emission across CSP value chain.
- **Discovering latent factors / contributors** - Narrow down ESG interventions by evaluating correlations of key organizational entities towards net zero and discovering top contributing factors to emissions.
- **Evaluating initiatives and policies** - Experiment different options to address the sustainability crises by identifying the high impact emission factors in the engineering / business divisions.
- **Optimizing net zero roadmap** - Evidence-based business decisioning in net zero investments and strategies by evaluating the choice of locations, choice of energy, choice of logistics, etc. for sustainable business practices and expansions in the long run.

Organizations are leveraging TCS TwinX to test their strategies around sustainability, refine the investment plans and understand human - carbon interactions on how to nudge its end customers to take up greener energy alternatives.

About TCS

TATA CONSULTANCY SERVICES

Tata Consultancy Services is an IT services, consulting and business solutions organization that has been partnering with many of the world's largest businesses in their transformation journeys for over 50 years. TCS offers a consulting-led, cognitive powered, integrated portfolio of business, technology and engineering services and solutions. This is delivered through its unique Location Independent Agile™ delivery model, recognized as a benchmark of excellence in software development.

A part of the Tata group, India's largest multinational business group, TCS has over 616,000 of the world's best-trained consultants in 55 countries. The company generated consolidated revenues of US $25.7 billion in the fiscal year ended March 31, 2022 and is listed on the BSE (formerly Bombay Stock Exchange) and the NSE (National Stock Exchange) in India. For more information, visit www.tcs.com

tmforum knowledge

REPORT

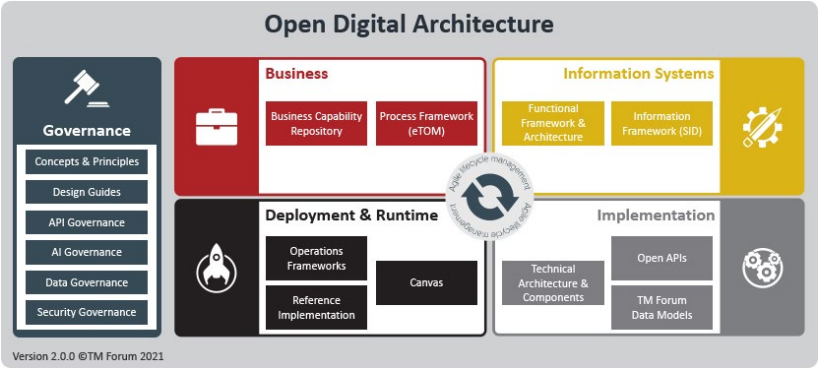
tm forum open digital framework

A blueprint for intelligent operations fit for the 5G era

The TM Forum Open Digital Framework (ODF) provides a migration path from legacy IT systems and processes to modular, cloud native software orchestrated using AI.

The framework comprises tools, code, knowledge and standards (machine-readable assets, not just documents). It is delivering business value for TM Forum members today, accelerating concept-to-cash, eliminating IT & network costs, and enhancing digital customer experience.

Developed by TM Forum member organizations through our Collaboration Community and Catalyst proofs of concept, building on TM Forum's established standards, the Open Digital Framework is being used by leading service providers and software companies worldwide.



The framework comprises TM Forum's Open Digital Architecture (ODA), together with tools, models and data that guide the transformation to ODA from legacy IT systems and operations.

Open Digital Architecture

- Architecture framework, common language and design principles
- Open APIs exposing business services
- Standardized software components
- Reference implementation and test environment

Transformation Tools

- Guides to navigate digital transformation
- Tools to support the migration from legacy architecture to ODA

Maturity Tools & Data

- Maturity models and readiness checks to baseline digital capabilities
- Data for benchmarking progress and training AI

Goals of the Open Digital Framework

The aim is to transform business agility (accelerating concept-to-cash from 18 months to 18 days), enable simpler IT solutions that are easier and cheaper to deploy, integrate and upgrade, and to establish a standardized software model and market which benefits all parties (service providers, their suppliers and systems integrators).

Learn more about member collaboration

If you would like to learn more about the Open Digital Framework, or how to get involved in the TM Forum Collaboration Community, please contact George Glass.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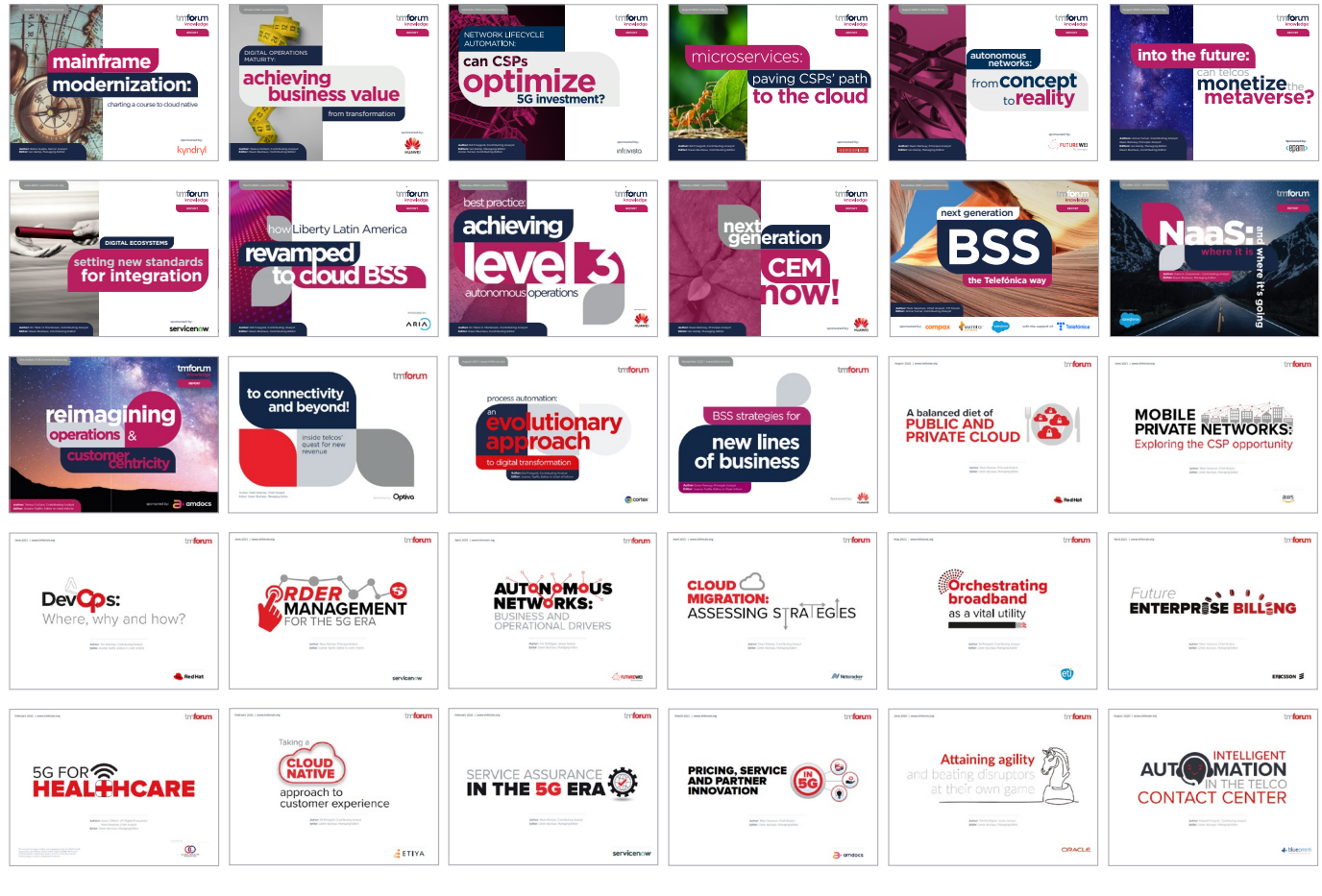
ENTERPRISE 5G THE ROLE OF THE TELCO
Ops From automation to autonomous networks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ORDER MANAGEMENT FOR THE 5G ERA
AUTONOMOUS NETWORKS: BUSINESS AND OPERATIONAL DRIVERS
CLOUD MIGRATION: ASSESSING STRATEGIES
Orchestrating broadband as a vital utility
Future ENTERPRISE BILLING
5G FOR HEALTHCARE
Taking a CLOUD NATIVE approach to customer experience
SERVICE ASSURANCE IN THE 5G ERA
PRICING, SERVICE AND PARTNER INNOVATION IN 5G
Attaining agility and beating disruptors at their own game
INTELLIGENT AUTOMATION IN THE TELCO CONTACT CENTER

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REPORT

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to find out more about
TM Forum's sustainability strategy
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