Perspective

Controlling energy use: the role of AI-based solutions

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Contents

List of figures

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1. Executive summary

Building and running energy efficient networks is becoming a strategic imperative for all telecoms CSPs.

Commitment to reducing energy consumption is a common issue in many businesses, driven by increasing energy prices as well as by regulatory demands to control and be more transparent about energy management and carbon emissions. However, 5G deployment, which risks increasing CSPs’ energy use, is intensifying the need to improve energy efficiency in the telecoms industry. Even though 5G technologies were designed to reduce energy consumption by 90% compared to 4G on a like-for-like basis, the greater density of 5G means that, without intervention, adding 5G to existing networks will increase CSPs’ energy use.

CSPs have plenty of opportunities to reduce energy consumption in the mobile network without affecting user experience. CSPs have a vast choice of energy-saving measures, each with different implementation time-scales and potential savings, that go beyond just the natural deployment of more-modern networks. Measures to reduce energy consumption can address all elements of the network and can be grouped into four categories: network modernisation, intelligent power-saving features, efficient use of assets and alternative ways of sourcing energy.

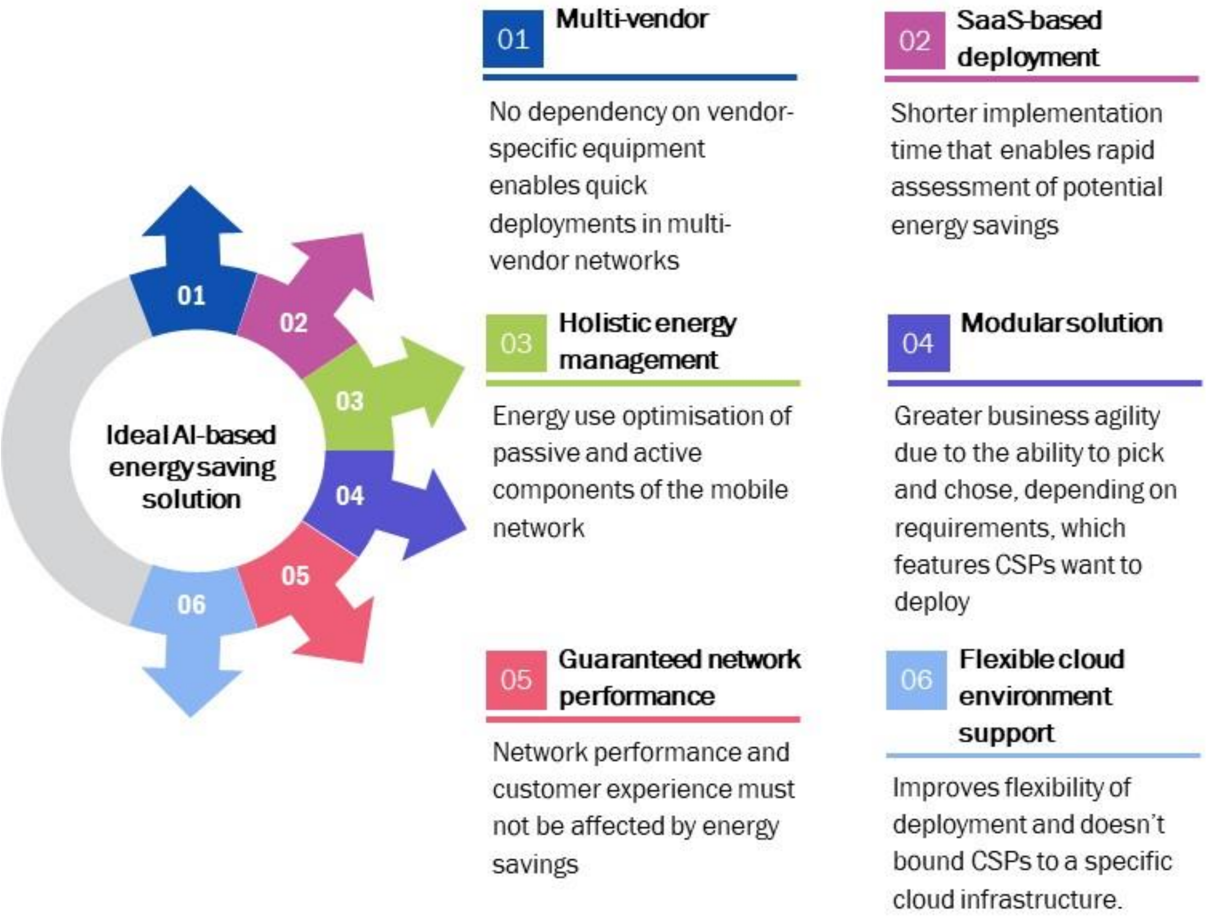
CSPs need initially to prioritise the solutions that can be implemented in a short time-scale and that can deliver results quickly. AI-based software solutions offer CSPs the opportunity to implement energy-saving measures as soon as possible. Most importantly, the unique advantages that AI can deliver to energy management efficiency can be enhanced by the technical features of 5G connectivity.

AI can expand the potential of traditional energy-saving features. For example, AI can be applied to static switch off/on networking equipment to enable it to adjust for dynamic changes in customer behaviour and usage. It can also help to tap into new energy-saving opportunities across the network. AI can be used to predict traffic patterns and fluctuations, forecast network utilisation and weather impacts, provide maintenance and fault management data, and suggest the most actionable approach to energy management in even the most complex of network scenarios. Energy savings will be dynamically adjusted to align with network performance, ensuring that CSPs’ goals and KPIs are met but customer experience is not compromised.

However, it is extremely important that CSPs select a business and delivery model for AI-based energy-saving solutions that is best-suited to address the urgency of CSPs’ current cost challenges. The software-as-a-service (SaaS)-based business model, as an alternative delivery mechanism to on-premises and hosted cloud deployments, can greatly reduce time to value. CSPs can quickly have access to SaaS solutions because they are kept as standardised as possible, often including a set of blue-print services, which allows for minimum customisation and reduced time spent on installation and configuration. Similarly, continuous and automatic updates and upgrades can be efficiently managed and delivered by the software vendors. As a result, CSPs benefit from faster engagement with vendors, meaning shorter time to value.

We have provided an overview of an ideal AI-based energy saving solution (Figure 1.1) that effectively aligns energy consumption reductions with network performance requirements. This solution will allow CSPs to realise quantifiable energy and cost-saving benefits across the entire mobile network; and can be achieved in the short term with limited upfront investment.

Figure 1.1: Overview of an ideal AI-based energy-saving solution



Source: Analysys Mason

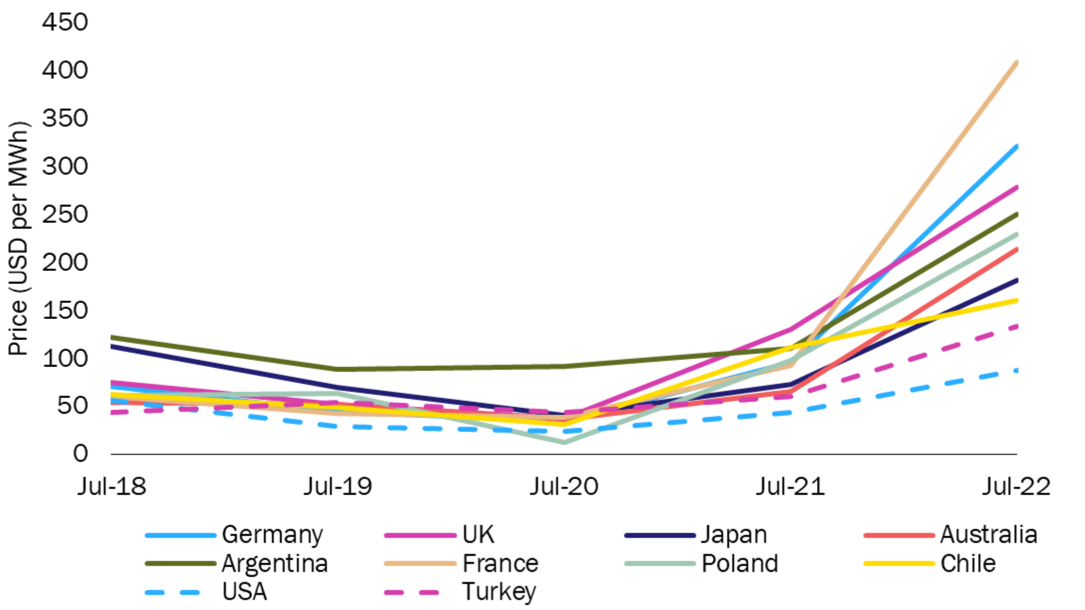
2. Rising energy costs and usage are forcing CSPs to focus on efficiencies

Energy management and energy savings in mobile networks are becoming a clear priority for most CSPs. The recent surge in the cost of electricity, the deployment of 5G networks and commitments to environmental, sustainability and governance (ESG) goals have brought power consumption and management to the top of CSPs' agendas.

For a mobile operator, energy costs account for up to 7% of their operational expenditure (opex) and depending on the type of networks they run, CSPs can spend from 3% to 20% of their total revenue on energy bills. The mobile radio access network (RAN) accounts for a large part of their energy costs and for over half of their energy consumption (70% in a typical 5G macro network). In a typical 5G macro network, the core accounts for 8% of the total energy consumption, while the digital baseband units and the radio account for 16% and 76%, respectively. Around 55% of the RAN energy is consumed by passive components such as air conditioning, fans and power systems. The RAN's share of energy usage is continuing to rise and will continue to put pressure on opex. In the current climate, this pressure is further intensified by the increase in energy prices. Even if an operator can keep its energy consumption flat, costs will still be increasing.

Recent geopolitical events have put pressure on the global supply of natural gas, resulting in a significant increase in the wholesale price of gas and electricity in 2022 (Figure 2.1). This has resulted in many CSPs citing high inflationary environment and increased energy prices as factors behind growing operating expenses. Those same factors are also pushing CSPs to take additional action to maintain the cash flow needed to support network investments (for example, BT in the FY23 half year results announced an increase in its cost savings target from GPB2.5 billion to GPB 3.0 billion by the end of FY25).

Figure 2.1: Wholesale electricity prices, selected countries worldwide, July 2018–July 2022[1]



Source: Analysys Mason

Customers, governments, standards/specification bodies and policy makers are also urging CSPs to actively reduce emissions and energy consumption. Legislation, such as the Paris Agreement and the EU Green deal action plan, is pushing towards more-sustainable management by mandating disclosure of carbon emissions and energy-saving strategies.[2,3] As a result, sustainability is becoming one of the biggest priorities in the transformation strategies of many CSPs and an important trigger to scrutinise energy consumption. It is vital for CSPs to maintain up-to-date datasets on energy efficiency and communicate their progress and vision transparently. Some major CSPs have already outlined their carbon-neutral targets; for example, Orange aims to be carbon-neutral by 2040, with 50% of its energy coming from renewables by 2025; and Vodafone plans to eliminate all carbon emissions from its own activities by 2030.

1 For more information see Analysys Mason's *Managing telecoms energy consumption using inventory solutions*.

2 Paris Agreement, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

3 EU Green Deal, A European Green Deal | European Commission (europa.eu).

2.1 5G was designed to be energy efficient but its use cases risk a rise in consumption

The deployment of 5G networks is another element that is driving CSPs to consider energy consumption and energy management as a top priority. While 5G New Radio (NR) was designed to support greatly improved energy efficiency compared to previous generations of mobile technologies, rising numbers of cell sites and antenna elements compared to 4G mean that energy usage can actually increase significantly. Furthermore, because mass adoption of 5G is ongoing and the number of 5G subscriptions is still a small percentage of all mobile subscriptions, the connectivity and bandwidth of the network are not used to their full extent and the energy used to power 5G networks is partly wasted.

5G technology is more efficient than 4G when considering single base stations with a study concluding that 5G new radio access technology can decrease the energy consumption by more than 50% while providing around 10 times more capacity.[4] The architecture of 5G NR was designed to support a higher capacity than 4G and to deliver greater energy efficiency for low-to-medium traffic levels. This results in lower average load in terms of the total capacity that a given traffic volume uses and higher percentage of 5G traffic falling into the 'low-to-medium' category, which is subjected to the greatest efficiencies. The design of 5G cells also supports power-efficient features such as micro-sleep functions, which puts radios into sleep mode whenever there is a gap in transmission and hence helps to save energy.

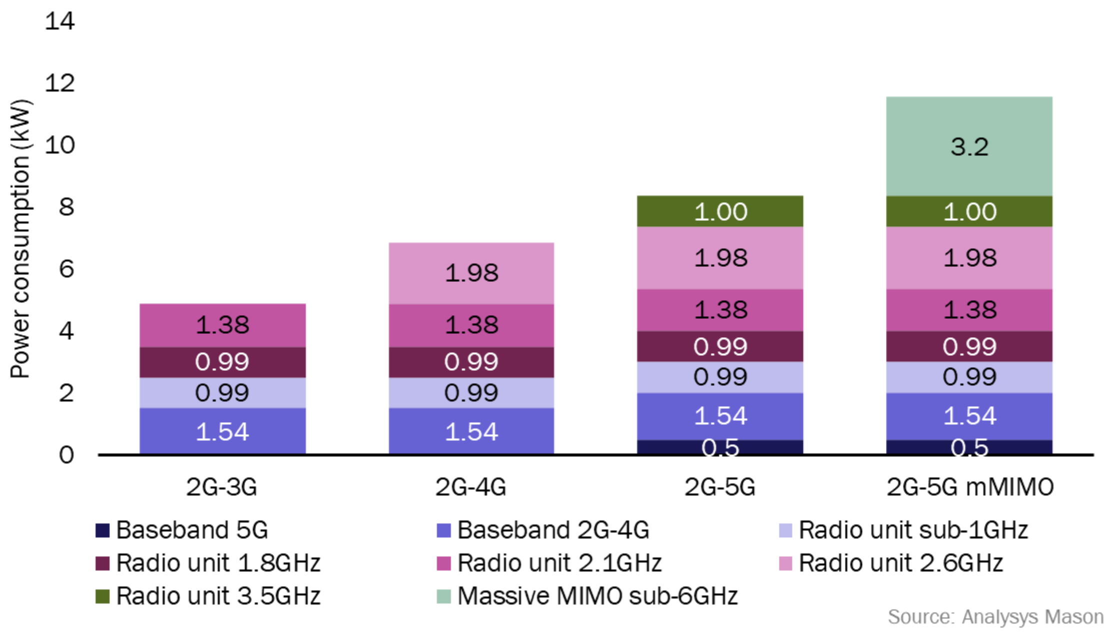
In general, the architecture of 5G base stations reflects one of the key objectives set for 5G by the International Telecommunications Union (ITU) to reduce energy consumption by 90% compared to 4G, on a like-for-like basis (same type and number of base stations with the same traffic and signalling load).

However, the use of increasingly high-frequency spectrum for 5G mobile networks together with the implementation of high-capacity and ultra-reliable low latency (URLL) use cases, will affect the density and the type of cell sites required and can cancel out the energy efficiencies of 5G NR.

5G uses a variety of spectrum bands, including mid-band (3.5–4.2GHz) and millimetre wave (26/28GHz and 39GHz) ranges that are unique to 5G. Base stations in higher-frequency bands have a shorter signal range and so coverage is reduced when compared, for example, to low-band spectrum. This requires CSPs to either increase the number of cells or to deploy large arrays of antennas (massive MIMO (mMIMO)), which can maximise effective signal reach through beamforming technology. In both cases, CSPs' energy consumption will increase: on the one hand, operator will be required to build denser networks with a higher number of elements of passive and active equipment, while on the other hand, the deployment of mMIMO will increase the power consumption of RF circuits due to the high levels of compute processing required (Figure 2.2).

[4] Tombaz S., Frenger P., Olsson M. and Nilsson A. (2016), 'Energy performance of 5G-NX radio access at country level', 2016 IEEE 12th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob), pp.1–6, doi: 10.1109/WiMOB.2016.7763183.

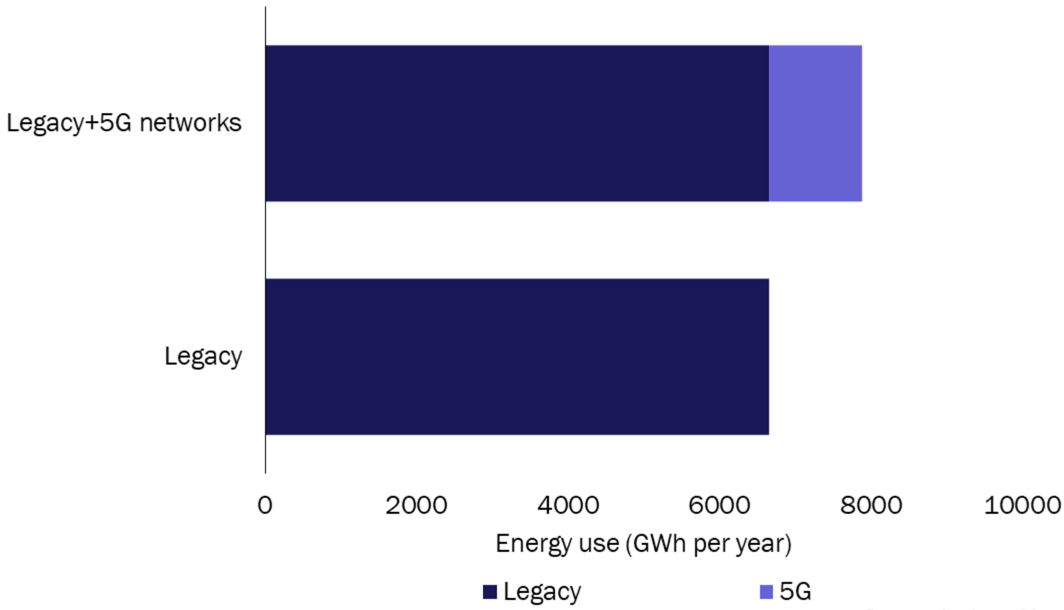
Figure 2.2: Maximum power consumption of a base station that supports multiple mobile generations, by component[5]



Source: Analysys Mason

Therefore, adding 5G without mitigating steps can add significantly to energy usage. In Figure 2.3, the energy increase incurred by the introduction of 5G is calculated for an operator in a developed country in a market similar to the UK.

Figure 2.3: Energy increase, generic developed country that is similar in size to the UK, 2022



Source: Analysys Mason

5G is not the only network that CSPs should consider when focusing on energy efficiency

In devising energy-efficiency strategies, CSPs also need to consider older technologies within their networks and take a holistic approach to energy usage. Integrated fixed–mobile players need to consider both the

5 For more information, see Analysys Mason's *Driving down energy usage across telecoms networks: 5G RAN and beyond*.

challenges and the synergies arising from running a fixed network alongside a mobile one. On the mobile side, 5G usually has to coexist with older technologies, namely 2G, 3G and 4G, greatly increasing an operator's total power consumption. Applying intelligent management solutions to already deployed base stations and equipment is not trivial and, in most cases, will require significant investments (which, at times, are not worth the energy saving efforts because the networks will soon be disconnected).

CSPs will need to consider how to efficiently run a multi-technology network. Decommissioning older generation networks is the biggest step that most CSPs can take to reduce their energy usage. Alternatively, they should consider the modernisation of the legacy 2G, 3G and 4G base stations with energy-efficient Single RAN software and hardware, in which multiple legacy networks can be replaced with a set of multiple radio access technology (multi-RAT) base stations, while rolling-out 5G radios.

It is worth noting that regulators are offering the possibility to refarm legacy 2G, 3G and 4G spectrum for 5G use. This can incentivise CSPs to take steps in transitioning from legacy technologies and/or in encouraging the investment in energy-saving solutions.

3. CSPs can adopt a variety of strategies when it comes to tackling energy usage

There are plenty of ways to reduce energy consumption in mobile networks and adopt new energy management solutions. Measures to reduce energy consumption can be taken in all elements of the network, but some will have a greater impact than others. The core accounts for only 8% of the total energy consumption in a 5G network (excluding transport), and the majority of the RAN's energy (83%) is used by the cell site equipment rather than the digital baseband. A large proportion of the energy used to power the network is wasted in operating cooling systems (55%), running idling equipment and in powering amplifiers and other unused network elements. Only around 15% of mobile network energy is used for transmission, which is the only activity that generates revenue within the cell site.

Some other savings lie in architectural and network transformations, including network modernisation and the introduction of intelligent power-savings features, some in more efficient usage of network assets and some in alternative ways of sourcing energy. We have classified them depending on the timescale across which the solution can be implemented, the timing when benefits can be achieved and the drawbacks of the solution (Figure 3.1).

Figure 3.1: Energy management solutions for CSPs' networks

Approach	Solution	Timescale	Description	Solution drawbacks
Alternative ways of sourcing energy	Renewable energy sources	Short-term	This is a quick and effective way to reduce an operator's environmental footprint and secure power supply by reducing reliance on non-renewable energy sources.	Renewable energy relies on external factors such as climate, regulatory environment, availability and the price of renewable energy through the grid. At times, green energy is offered by traditional utility provider at a premium price.

Approach	Solution	Timescale	Description	Solution drawbacks
Alternative ways of sourcing energy	Self-generation of power supplies	Long-term	Increasing the use of self-produced energy to reduce dependence on external power grid supply and prices.	The extent to which a company can scale such a model will depend on the suitability of the site locations for alternative power source, such as solar and wind, availability of space, and cooperation of the site's landlord.
Alternative ways of sourcing energy	Establish power purchase agreements (PPAs)	Short-term	PPA is a multi-year contract taken out by CSPs with energy suppliers that guarantees a more stable price for CSPs and facilitates the lender in planning the necessary energy capacity.	PPAs are temporary solutions. After the agreement expires (it usually lasts a few years), CSPs need to renegotiate or seek other ways to control energy prices.
Network modernisation	Network decommissioning	Long-term	Shutting down 2G/3G networks and moving to 4G/5G single RAN could help CSPs to save 571GWh/year. Without the straightforward retirement of legacy networks, 5G simply adds to energy consumption. The early decommissioning of 3G could reduce mobile energy consumption by 10%.	The decommissioning of networks requires large resources (labour and capital) and is a long-term investment, meaning cost reductions and energy savings will not be realised until a much later date.
Network modernisation	Liquid cooling	Medium-term	Traditional air-cooling systems account for 55% of the energy consumption of the RAN. This, as well as requiring regular maintenance, filters changes and re-gassing. Liquid cooling solutions convert heat into liquid and remove it from the site by liquid circulation. CSPs have claimed a 30% reduction in energy costs by switching from air cooling to liquid cooling.	Liquid cooling is more expensive than traditional cooling methods. The installation can be complex and if not fitted correctly could result in leaks and damage to electornic components.
Network modernisation	AI-driven network design	Long-term	Customising RAN, processors as well as passive infrastructure specifications site by site, depending on load conditions.	Only applicable on new networks and ideal for those sites where a large set of data about traffic and usage are available.
Network modernisation	The use of thermal management materials for base stations	Long-term	Thermal interface materials transfer heat energy away from the base station components and into a heat sink. Thermal gels and polymer-based materials are optimal for thermal management and can dissipate heat at high rates.	Not convenient for legacy networks. The installation and maintainence requires a high level of expertise, labour and expenses.

Approach	Solution	Timescale	Description	Solution drawbacks
Network modernisation	IoT-enriched networks	Medium-term	IoT sensors are used to track parameters, such as energy consumption or site temperature, giving CSPs more control over their resources and enabling consumption optimisation.	The fitting of IoT sensors can be a resource- and time-intensive task. If not supported by an adeguate IoT platform, data analysis and AI-powered tools, the solution can lose part of its value.
Intelligent power-savings features	AI- driven shutdown solutions	Short-term	Smart energy management such as switch off/on of base stations. AI refines and expands the potential for energy-saving opportunities by analysing real-time traffic patterns and network-resource availability and taking automated decisions about which parts of the system can be put into sleep mode or shut down.	The solution relies on data analysis, therefore would be suitable for CSPs that have tools already in place for network analysis. It might be challanging to apply these solutions to legacy networks.
Intelligent power-savings features	AI-driven equipment control	Short-term	AI-powered equipment can couple smart shutdowns with cross-equipment optimisation by adjusting coverage or power consumption dynamically.	It might be challenging to apply these solutions to legacy networks.
Efficient use of assets	Reducing FWA usage or steering mobile traffic to Wi-Fi	Long-term	Minimising the use of FWA and steering substitutable mobile traffic to Wi-Fi (where the network usage per line is about 40 times lower) to help reduce the rate of energy-costly upgrades to the RAN.	For integrated CSPs only. The incentive to make this change is often outweighted by shorter-term commercial demand.
Efficient use of assets	Weigh the opportunities for energy consumption against commercial priorities	Long-term	Opt to scale back/delay deployment of power-hungry mMIMO to limit and control power usage.	While the impact on energy usage will be only delayed, CSPs face the risk of being less competitive in the market in terms of connectivity and technology offered.
Efficient use of assets	Engaging in mobile network sharing agreements	Long-term	Sharing a network with other CSPs optimise the use of network equipment and avoid duplication, enabling CSPs to achieve substantial savings in energy.	Establishing network sharing agreements is a lenghtly process that require regulatory approval. It has a big impact on CSPs' strategy so the rational of the agreement should go beyond energy savings.

Source: Analysys Mason

The potential savings that each strategy can deliver will vary by operator and country, and will also depend on engagement with third parties, such as regulators and government policy makers. These bodies must provide CSPs with clear guidance on ESG policies. This could include making it easier for CSPs to remove old technologies and switch users to more-energy efficient options. Often the incentive for CSPs to reduce energy consumption across the mobile network is outweighed by shorter-term commercial incentives to preserve user experience and to reduce longer-term TCO; and so, this is where policy interventions will be key to driving change.

Transitioning to more energy-efficient networks is extremely important for CSPs because those savings can reverberate across the whole value chain, including end users such as enterprises and retail customers. By reducing energy costs and protecting themselves from energy price spikes, CSPs could increase profitability and, ultimately, be able to pass those savings to customers, gaining a competitive advantage.

4. AI-based solutions can enable CSPs to achieve short-term energy and cost savings

Energy management solutions are not a new concept for CSPs, but to date the solutions have been inflexible and unintelligent. Most old generation equipment deployed by CSPs has energy-saving features, such as automatic switching on/off in networking equipment and sleep modes during periods of low traffic. However, these solutions work within pre-defined and static parameters that often do not align with real usage patterns, which can compromise both potential savings and quality of service. The lack of optimisation of power saving features may discourage CSPs because of the risk of a negative impact on network performance.

AI-based energy management could help CSPs to optimise their approach to energy management across both active and passive elements of the network. The ability to analyse large amounts of data relating to real-time traffic patterns and network-resource availability allows for real-time decisions on how different elements of the network can be operated while optimising energy usage. The unique advantages that AI can deliver to energy management are particularly relevant now because CSPs urgently need to cut energy consumption and are deploying 5G networks.

- AI-based solutions are quick to implement and set up due to their software nature, which means that energy cost savings are achieved within a short period (weeks). This feature addresses the urgency with which CSPs need to act to tackle increasing energy bills.

- The efficiency of AI-based solutions can scale according to the increase in the amount of available data. The growth in data consumption expected with 5G, where customer data usage on 5G can be 5–10 times greater than 4G, means that CSPs can tap into a larger pool of data that can help to deliver more accurate traffic behaviour prediction.

- The efficiency of AI-based solutions can also be enhanced by the technical features of 5G connectivity. 5G can support a massive number of devices that simultaneously access the network, which is far more than previous generations can handle. As this feature enables IoT applications, these applications can be purposed at monitoring energy and network equipment usage, which can be fed into AI-based solution. The low latency that 5G networks can deliver could also play a fundamental role in increasing the efficiency of AI because it can guarantee real-time data analysis and real-time decision-making, optimising both the energy savings and the overall network performance, including quality of experience (QoE).

AI can expand the potential of traditional energy-saving features (for example, AI can be applied to traditional fixed switch off/on networking equipment that is largely not effective given the dynamic changes in customer behaviour and usage) as well as tap into new energy-savings opportunities across the network. AI can be used to predict traffic patterns and fluctuations, forecast network utilisation and weather impacts, in order to provide data-driven recommendations to help CSPs to effectively optimise their network configurations by pinpointing the most power-hungry network components and seeing which changes will have the greatest impact on costs. Energy savings will then be dynamically adjusted to align with network performance and customer experience; ensuring that it meets CSPs' goals and KPIs.

Other examples of AI-based energy management solutions include the following.

- **Intelligent power up/down management** can improve energy efficiency of network elements, including g base stations. AI-based algorithms and machine learning can be used to dynamically turn off and on (partially or wholly) passive and active network elements in response to changes in traffic load. AI can modify energy saving windows compared to static schedules and avoids disruption to network performance. This solution can help to offload macrocell traffic to a low-power small cell during a quiet time, so that the macrocell can stay asleep for a longer period. Intelligent power management can also be applied to Air conditioning (AC) elements, where savings can be achieved by adjusting the number of AC working hours, particularly at low traffic levels, according to the characteristic temperature of different computer rooms and the features of the equipment in use.

- **Equipment anomaly detection** provides a holistic view across active and passive network domains for real-time detection of service-impacting incidents and abnormal energy consumption such as wastage, leakage and theft. Intelligent anomaly detection can save energy across the network through faster localisation of energy anomalies. Some of these anomalies can be solved remotely, reducing the number of on-site visits that personnel must make to troubleshoot network issues and thereby cutting costs for CSPs.

- **Power source alterations.** AI can be used to actively choose the most efficient source of power during peak traffic hours. For example, AI can forecast and change the power source of the air conditioning units to either electricity grid or batteries depending on which is most energy-efficient during peak/off-peak periods.

4.1 Selecting the optimal business and delivery model

It is important that CSPs select a business and ownership model for AI-based energy saving solutions that addresses the urgency of their cost challenges.

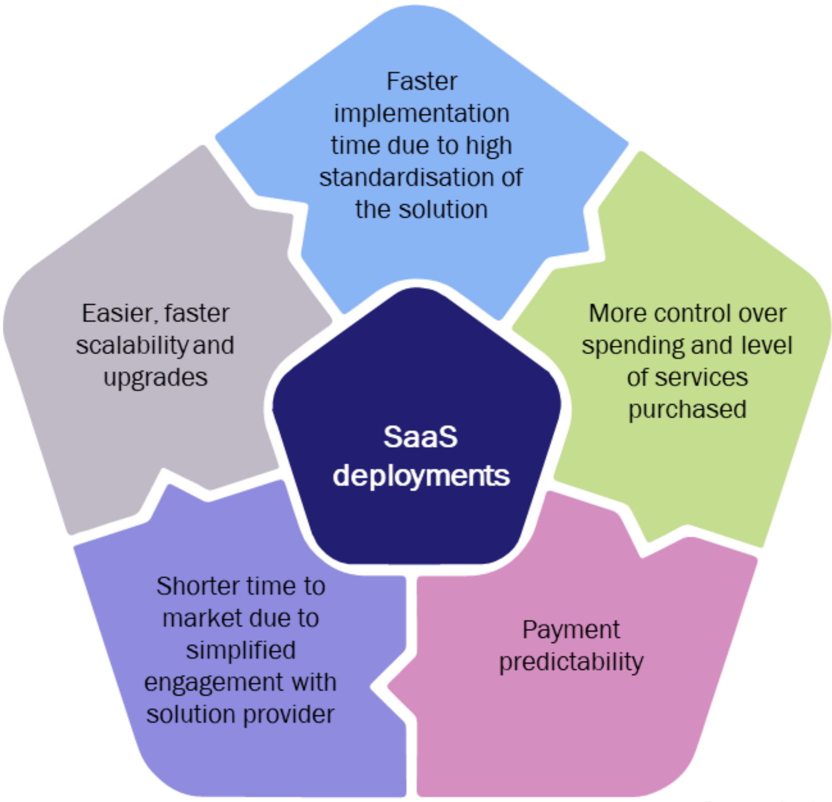
The software-as-a-service (SaaS)-based business model (Figure 4.1), as an alternative delivery mechanism to on-premises and hosted cloud deployments, can support a short deployment time. SaaS-based solutions radically differ from traditional on-premises models of software delivery because, with a SaaS solution, CSPs pay a regular fee for accessing software that is completely managed by the SaaS solution vendor, as opposed to owning, maintaining and deploying the solution on premises. With SaaS delivery, software vendors are responsible for the whole lifecycle of the software, including IT and software maintenance, updates, and security. The software is based on the vendor's own platforms and applications and is hosted in the public cloud. This reduces the level of maintenance and in-house expertise required from CSPs and enable them to focus internal resources and staff elsewhere. SaaS also allows CSPs to flexibly scale their operations up and down, with minimal service disruption. In the CSP market, SaaS solutions need to support the specific processes and requirements of telecom networks, and can be regarded as a distinct category of 'telecom SaaS'.

All the different costs associated with staff training, updates and upgrades, maintenance and security that CSPs had to incur in traditional ownership models are replace by subscription fees to SaaS service providers that take care of delivering and maintaining the software, cancelling out heavy upfront payments and reducing the need for lengthy contract commitments. This means that CSPs can be shielded from fluctuating hardware prices and do not need to consider additional hardware purchases. Such changes can enable them to reduce, and better control, the TCO of a new solution.

Moreover, CSPs can quickly get started with a telecom SaaS solution because they are kept as standardised as possible, often including a set of blue-print services, which allows for minimum customisation and reduced time spent on installation and configuration. Similarly, continuous and automatic updates and upgrades can be efficiently managed and delivered by SaaS service providers. As a result, CSPs can benefit of faster time to value and can achieve their targeted results quicker. CSPs will have immediate control of their spending and improved transparency and clarity regarding the level of service they are getting from the vendor. The agility offered by telecom SaaS-based solutions also grant a higher level of control to CSPs that want to add or modify features or services delivered by a SaaS provider. They can easily add features and benefit from rapid procurement, simply by modifying the subscription, and the quick deployment process.

SaaS-based models have increased in popularity in recent years; with operator spending on SaaS expected to increase from 11% in 2023 to 22% in 2027 growing at a CAGR of 17%. The growing adoption of this delivery model is also due to the maturing of this technology, which has increased CSPs’ confidence in adopting it. One of the key challenges around SaaS was related to the level of security and privacy that could be guaranteed; vendors have increasingly addressed this challenge and now often add layers of security on top of public cloud infrastructure.

Figure 4.1: Key benefits of SaaS deployments



Source: Analysys Mason

4.2 Overview of an ideal AI-based energy saving solution

We have provided an overview of an ideal AI-based solution (Figure 4.2) that can be used for achieving energy and cost reductions across the entire mobile network. The overview incorporates important features that will help maximising the success of the solution for both vendors and CSPs.

Solution providers should consider the importance of providing a single analytical tool in a network supporting a wide range of vendor equipment, particularly as we move towards Open RAN concepts. The solution should be able to provide holistic energy management, helping to reduce the large amount of energy waste occurring in both active and passive equipment of the mobile network. AI technology should be dynamic and mature and must be able to successfully align high network performance and quality of service with reductions in energy usage. A SaaS-based cloud deployment will enable CSPs and enterprises to have greater control of costs and outcomes, provides immediate use and allows for services to be flexibly customised, while also delivering sizable results over a much shorter space of time.

Figure 4.2: Features of an ideal AI-based energy saving solution

Features	Description
Multi-vendor	The solution should support a wide range of vendor RAN equipment by establishing a common set of standardised KPIs cutting across different vendors in the market. By removing the dependency on vendor-specific equipment, the solution can be rapidly and quickly deployed to optimise power consumption of RAN equipment across all layers in multi-vendor mobile networks.
Dynamic and holistic energy management	The solution should be able to analyse energy trends and optimise energy use of both passive and active components across the entire mobile network. Too often the impact of passive elements have been overlooked when analysing energy consumption. The solution should also be able to identify opportunities for energy optimisation in both complex and simple network scenarios, such as site level analytics like weather data and asset databases, as well as being able to deal with different base stations with different load requirements, such as urban or rural environments.
Guaranteed network performance and quality of service	It is important that quality of service is not compromised at the expense of energy savings. AI technology should be used to precisely and dynamically adapt energy consumption to traffic levels by predicting power off/on timings and optimising the use of resources such as wide wake windows and stand-by modes to shorten wake-up times. AI-based solutions can help to maintain high network quality and hence prevent poor customer experience while optimising power savings.
SaaS delivery model	CSPs should be able to consume and access the solution through flexible delivery models. Selecting a SaaS AI-based solution will enable CSPs to quickly engage with vendors, meaning they can benefit from faster time to value. The software nature of the solution also guarantees minimal disruption, short installation time and quick scalability across the network. CSPs can have more control over the solution and the benefits achieved.
Flexible cloud environment support	CSPs should adopt a solution that guarantees maximum flexibility of deployment options. This allow CSPs to implement one unique solution whether they choose to deploy it on public or private cloud or on hybrid deployments, giving CSPs the benefit of short delivery timescales and the flexibility of not being locked to a specific infrastructure.
Delivery of sizeable results	It is important that CSPs are able to rapidly quantify and assess the efficiency of the solution. Understanding the energy savings that have been achieved since the AI solution was implemented can help CSPs to tailor its performance as well as plan medium- to long-term energy savings strategies.

Features	Description
Modular solution	Selecting a solution that can analyse the energy performance of the whole RAN equipment is important. Equally important for CSPs is selecting a solution that has modular features, meaning that CSPs can benefit from greater business agility by picking and chosing, depending on their budgets and requirements, which features they want to deploy.

Source: Analysys Mason

4.3 Potential benefits of an AI-based solutions

AI-based energy saving solutions can provide multiple benefits for CSPs, including:

- reduced energy costs
- efficient use of energy and network resources
- more sustainable patterns of energy use and realisation of carbon-neutral targets.

Several global Tier-1 CSPs have already implemented AI-based energy solutions and have reduced their overall mobile network energy consumption (Figure 4.3). AI-based energy solutions have significantly reduced the power consumption of various elements of the network, with one operator reporting a 74% power reduction in air conditioning units, which accounted for nearly half of the energy consumption of a radio site. This was achieved by using AI to collect temperatures of different rooms within and outside the cell site and to regulate the air conditioner in the computer room while maximising the active exchange and cooling of the hot and cold air. Another operator achieved cost savings because the deployed AI-based energy-efficient solution was able to identify anomalies in the energy billing systems, highlighting an overpayment of 34% in 7% of its sites. It is important to highlight that these savings were achieved without disruption to network performance and quality of service; and at no point was customer experience affected.

Figure 4.3: Examples of major CSPs making cost and energy saving using AI-based energy saving solutions

	Tier-1 CSP 1	Tier-1 CSP 2
Total energy savings in the mobile network	**7%** short-term energy reduction **20%** medium-term energy reduction	**5%** energy reduction
Savings achieved by implementing specific measures	**74%** reduction in air conditioning energy use	**18%** energy saving by reconfiguring 5% of sites
Impact on network performance	0%	0%

Source: Analysys Mason

AI-based energy saving features can be applied to various components of the network (Figure 4.4) and it is important that CSPs consider deploying multiple features to achieve the greatest reduction in power. Ultimately, AI-based energy saving solutions can lead to both short-term savings, with CSPs recording overall savings of more than 5%, and medium- to long-term savings of up to 30%.

Figure 4.4: Maximum percentage of power reduction achieved using various AI-based energy-saving features

Type of feature	AI-based energy feature	Maximum percentage power reduction (kWh)	Description
Hardware	Hard switch off	14%	Turning on and off (partially or wholly) base station modules (RRM/RRU/AAU) in response to changes in traffic loads using AI.
Software	Soft switch	15%	Using AI to constantly adjust the relative timing of elements within the switching system. These savings on top of base stations energy features.
Hardware	Intelligent AC control	74%	Automatically alters the number of AC working hours, particularly at low traffic levels.
Software	Equipment anomaly detection	2%	AI identifies abnormal equipment consumption.
Hardware	Intelligent fresh air ventilation	31%	AI reduces the time that air conditioners are operating by using fresh air to cool down the site.

Source: Analysys Mason

Anomaly detection and the activation of different types of shutdown functions through AI-powered software can help CSPs to detect malfunctioning or improperly configured equipment, restarting cell sites and reducing the unnecessary use of equipment. These can increase the longevity of the network and hence the deployment of AI-based solutions can provide a better return of investment (ROI) for CSPs.

Opex reduction is ranked as one of the top priorities for CSPs and energy is expected to be one of the only major opex elements that is expected to increase within the next 3 years. AI-based energy saving solutions can help to mitigate the effect of increasing energy prices on opex and hence free up resources for other business-critical needs and commitments. For example, a South African operator has recently trialled an AI-based energy-saving solution and indicated that power reduction equated to a USD1.6 million saving each year based on 5000 sites after the solution was implemented.

Examples of where CSPs can achieve opex savings using an AI-based energy solutions include the following.

- The need for fewer on-site maintenance and engineer call outs. AI provides predictive maintenance and enhanced troubleshooting and can immediately detect network disruptions or faults. In most cases, these can be resolved remotely and without manual intervention.
- A reduction in unnecessary energy costs due to wasteful mobile network equipment. AI software can detect inefficient use of power across both passive and active network components and can reduce the run hours of equipment during low traffic periods.
- Less frequent replacement or upgrade of network components. AI can be used to optimise equipment lifetime.
- A reduction in the use of uneconomical power sources, particularly during peak hours. AI can be used to actively choose the most efficient energy source depending on network conditions and external factors.
- Minimised mobile network outages and widespread business disruption.

4.4 AI-based models will be essential in reducing CSPs CO2 emissions.

AI will play a crucial role in reducing greenhouse gas (GHG) emissions in mobile networks, where idling network equipment and energy-intensive cooling systems are the two biggest contributors to carbon emissions.

AI-driven power management solutions provide insights about immediate actions for shrinking carbon emissions, helping CSPs as they move towards a low-carbon future and ramp up their efforts to support the Paris Agreement's 1.5-degree climate change pledge.

AI-powered algorithms can be used to monitor, predict and reduce CO_2 emissions by collecting data across the entire mobile network and aligning it with CSPs' KPIs and reduction targets. AI-based simulations can recommend how to correct, upgrade or modernise an CSPs' network and will forecast how the proposed changes will affect emissions. This will help CSPs to be more aware and in control of their carbon emissions and will be an essential tool for planning how to reach CO_2 reduction targets.

The use of AI-based solutions can also help to reduce carbon emissions by detecting anomalies in energy usage across the network, which can point to network disruptions or faults. The role of AI in this specific case can help CSPs to detect and identify network faults, facilitate remote troubleshooting and avoid unnecessary on-site visits, which minimise the impact that a fleet has on CO_2 emissions.

5. Recommendations and conclusion

Focusing on building and running energy efficient networks is becoming a strategic imperative for all CSPs. This requirement is driven by increasing energy prices, as well as by regulations that mandate the reduction of energy usage and carbon emissions. We provide the following recommendations to CSPs that want to accelerate their progress in transforming their existing networks and operations into energy-efficient systems.

- **CSPs should actively introduce energy-saving measures that go beyond just the implementation of more-modern networks.** It is essential to deploy 5G in a way that mitigates the energy impact of increased numbers of cells and higher spectrum bands, it is even more important to adopt energy efficiency measures that work across the whole network, including legacy infrastructure such as 2G and 3G. In many cases, the older networks are the most energy-inefficient so a holistic approach is important to maximise savings.

- **CSPs should consider AI-based software solutions as a way of implementing energy-saving measures as soon as possible.** CSPs cannot afford to postpone dealing with the issue of rising energy costs; they need to take advantage of technologies that can be implemented in a short time-scale and that can deliver results quickly. It is important that CSPs choose suitable technology partners that can provide highly optimised solutions that:

    — support a wide range of vendor equipment
    — optimise both active and passive equipment
    — do not compromise the quality of the service at the expense of energy savings
    — can be consumed via SaaS so that CSPs can benefit from faster engagements with vendors and quickly achieve the targeted results
    — can deliver a sizeable outcome to CSPs in a timely manner.

- **CSPs should plan to adopt a variety of energy management measures that add up to a fully holistic approach.** CSPs need to have a comprehensive view of their systems when considering the overall potential energy savings within their networks. Their approach must go beyond energy consumption in the mobile network, and should extend to other assets, including fixed networks, or to more radical architectural and network transformations to make savings, as well as alternative ways of sourcing energy. Adding AI capabilities on top of existing or new solutions can help CSPs to develop a holistic approach for optimising energy consumption.
- **CSPs should assess regulatory and commercial environment to establish business priorities and the best timing to implement different energy saving measures.** CSPs should consider the impact of energy price rises and increased usage on their own business, for example by analysing energy waste in different elements of their network and by understanding where major gains can be achieved, in order to investigate and consider the suitability of a potential solution for the specific business goals they are targeting, in terms of energy savings and implementation time.

6. About the authors

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