GSMA Intelligence

Going green: benchmarking the energy efficiency of mobile

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Executive summary

Background

Sustained cost pressures and commitments to net zero in support of the 2015 Paris Agreement have made energy efficiency a strategic priority for many telecoms operators around the world. This will be compounded by data traffic rises associated with LTE and 5G migration. To help provide an evidence base for measuring progress, we partnered with a group of operators to develop an Energy Efficiency Benchmarking tool. The tool is based on real-world data inputs from operators on a fully anonymised basis to quantify network energy consumption and efficiency levels, and fuel sources.

Seven operators participated in the project: BT, Deutsche Telekom, Etisalat, Globe, KPN, Smart and Vodafone. Data provided from these groups spans 31 networks in 28 countries.

Highlights

Our modelling and analysis resulted in a number of findings at a global level:

- 73% of the energy of the participating operators is consumed in the radio access network (RAN). The network core (13%), owned data centres (9%) and other operations (5%) account for the rest.

- In the markets covered, the primary energy efficiency ratio in the RAN reached 0.24 kWh/GB in 2020.

- In terms of secondary ratios, one mobile connection required an average of 14.8 kWh of energy during the 12 months, while one network site used 28,665 kWh for the same period.

- 46% of total energy consumption was supplied by renewables, 43% from traditional grid and 11% from diesel (which is more concentrated in developing regions where grid and renewables access is less prevalent).

These figures are averages from a specific subset of operators. Even within the sample group, there is significant variation – and this would apply for the industry overall too. The results should therefore be interpreted at a high level rather than be predictive for any one country or operator profile.

2022 edition

2021 is our first year of tracking energy efficiency. It is our intention to extend this into a multi-year study with a wider group of industry participants to increase the representativeness and direct applicability of the research. Future iterations may expand the scope to cover a wider range of ratios and fixed line networks. We hope the benchmark will aid best-practice guidance on the rationale and means of becoming more energy efficient, given this is an industry rather than company-specific challenge.

1. Project rationale

Sustained cost pressures and commitments to net zero in support of the 2015 Paris Agreement have made energy efficiency a strategic priority for many telecoms operators around the world. This is a long-term story. As mobile data traffic continues to grow dramatically with the rise of LTE smartphones and the expansion of 5G, energy consumption is consequently increasing. To help provide an evidence base for measuring progress, we partnered with a group of operators to develop an Energy Efficiency Benchmarking tool. The tool is based on real-world data inputs from operators on a fully anonymised basis to quantify network energy consumption and efficiency levels, allowing for comparisons at the network and regional levels.

The research is set against a context of broader efforts to help tackle climate change and embed sustainable business practices into the telecoms industry and its supply chain:

- The GSMA Climate Action Taskforce – which now has more than 40 operators globally as members – shares, promotes and works together on climate topics such as energy efficiency, renewables, supplier engagement and using connectivity for climate mitigation and adaptation.

- To help the industry move towards a more sustainable future, the GSMA has developed a Sustainability Assessment Framework to better understand the landscape of operator efforts in social and environmental sustainability.

Seven operators participated in this project: BT, Deutsche Telekom, Etisalat, Globe, KPN, Smart and Vodafone. Data provided from these groups spans 31 networks in 28 countries.

Figure 1: Countries included in the Energy Efficiency Benchmarking 2021 project

Afghanistan	Greece	Netherlands	Saudi Arabia
Albania	Hungary	North Macedonia	South Africa
Czechia	Ireland	Pakistan	Spain
Democratic Republic of the Congo	Italy	Philippines	Tanzania
Egypt	Lesotho	Poland	Turkey
Germany	Montenegro	Portugal	UAE
Ghana	Mozambique	Romania	United Kingdom

Source: GSMA Intelligence

Based on a range of energy-related metrics and more than 3,000 data points gathered, we derived insights on:

- energy efficiency
- diesel versus renewable energy usage
- consumption distribution across different parts of an operator network – RAN, core network, data centres and operations related to mobile networks.

2. Methodology

Selection of a comparable KPI

The goal of the Energy Efficiency Benchmarking tool is to help operators measure the relative efficiency of their networks. The basic principle of efficiency is simple: how much energy is needed to deliver one unit of output. In the context of mobile networks, this means the amount of energy needed to transmit 1 GB of data (voice also requires energy but its load is negligible compared to data). However, measuring energy efficiency can be carried out in various ways:

- energy per unit of traffic (kWh / GB)
- energy per connection (kWh / connection)
- energy per cell site (MWh / cell site)
- energy per revenue (MWh / € million).

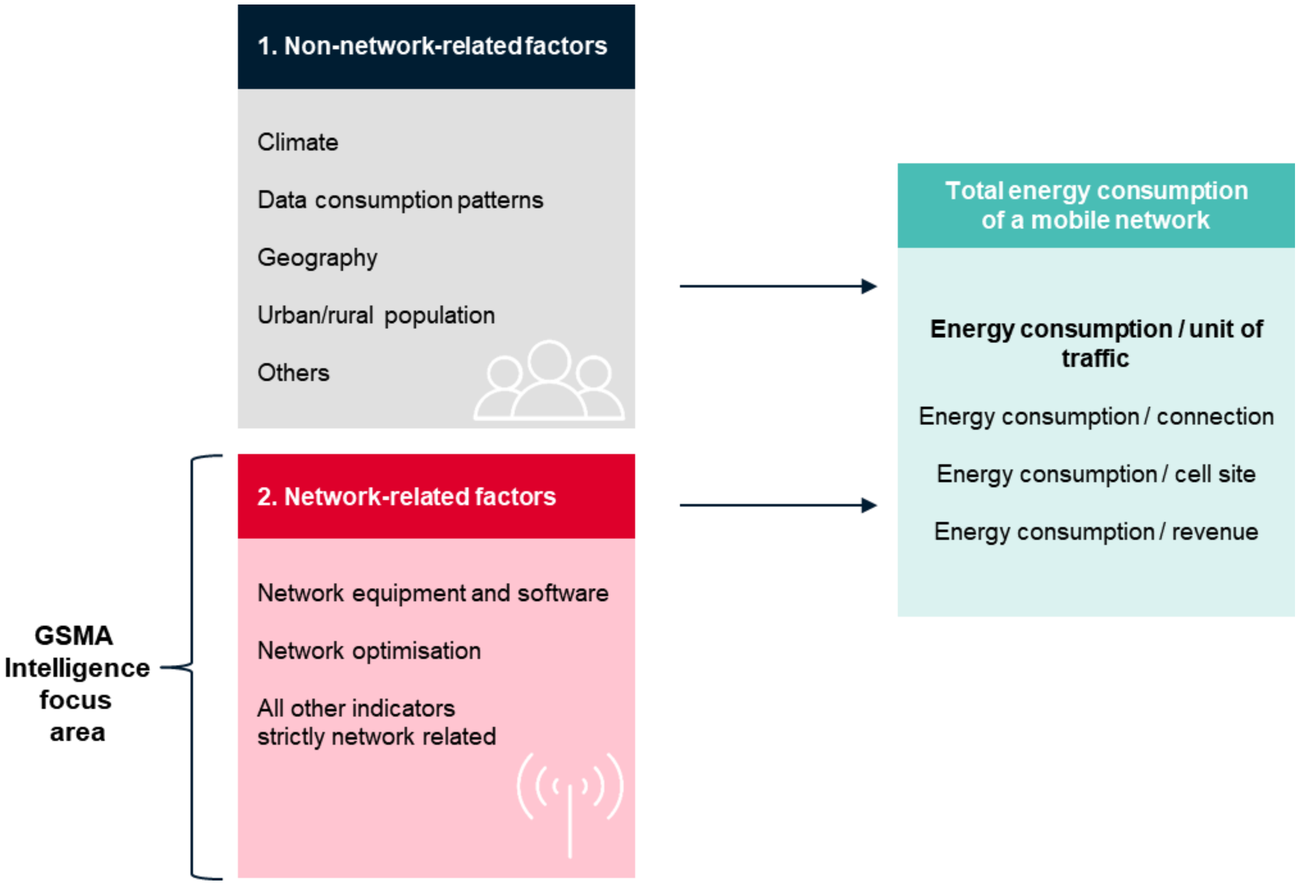
Each measure has pros and cons, so the exercise of selection becomes a question of balance. We have chosen the first method – energy per unit of traffic – as it is most easily comparable and meaningful as a KPI to monitor over time.

Normalisation

Comparing multiple networks in different countries with different characteristics – such as climate, population density and data consumption levels – is a complex task. To normalise the results and allow like-for-like comparisons, we divided the explanatory variables into two groups:

- non-network-related variables – those outside the operator’s control (e.g. population distribution and climate)
- network-related factors – those within the sphere of control of the operator.

Figure 2: Factors behind energy usage



Source: GSMA Intelligence

Regression analysis

Data inputs from the participating operators include energy usage, data traffic, number of cell sites and fuel consumption split between diesel and renewables. To avoid seasonality and outlier periods, the data covers the 2020 full-year period. After normalisation, we ran a regression analysis of variables against energy consumption to understand which have the highest correlations. Conclusions were then drawn on benchmark levels for energy consumption, fuel sourcing and efficiency ratios.

See the Appendix for more details of our methodology.

3. Benchmarking results

Categorising energy consumption

The direct energy consumption of the operators can be categorised into four groups:

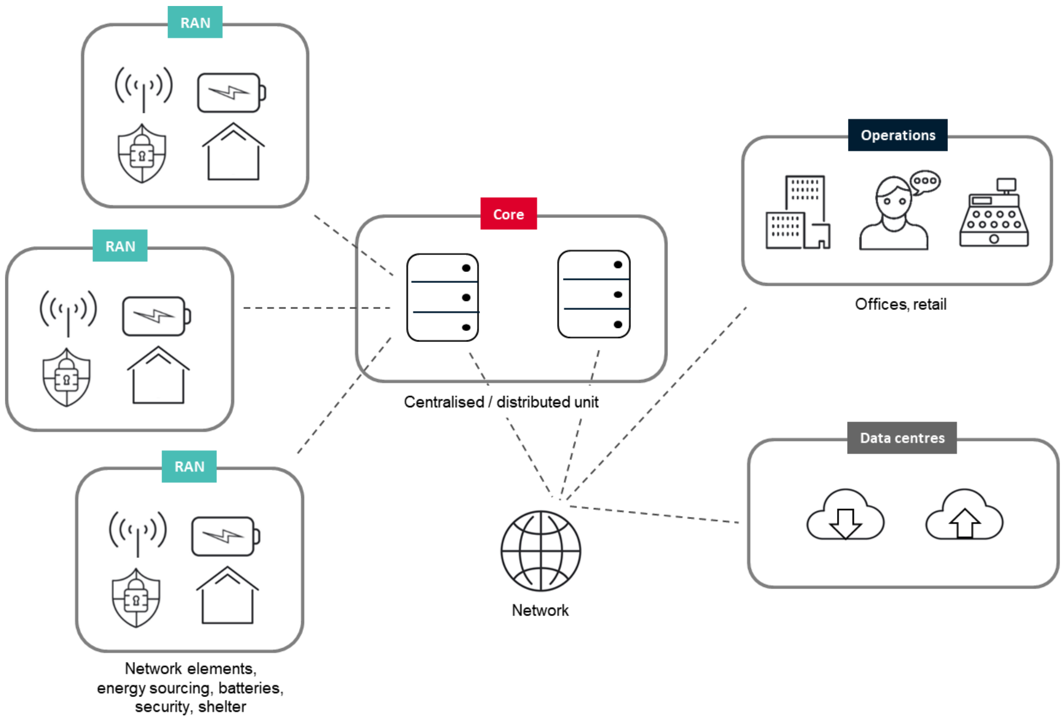
- **RAN energy consumption** – energy consumed by the radio access network (RAN). This includes BTS, Node B, eNodeB and gNodeB energy usage and all associated infrastructure energy usage such as from air-conditioning, inverters and rectifiers. It includes energy usage from repeaters and all energy consumption associated with backhaul transport. It excludes picocell, femtocell and core network energy usage, as well as mobile radio services.

- **Core energy consumption** – energy consumed by the core network related to the mobile network. This includes the RNC, BSCs, MSC (or MSC-S and MGW), SGSN, GGSN, HLR (including AuC), SMS-C, MMS-C, MME, Serving Gateway and all associated infrastructure energy usage such as from air-conditioning, inverters and rectifiers. It includes energy usage from NOCs and value-added service platforms, and all energy consumption associated with backhaul transport. It excludes energy usage from BSS and OSS, fixed-network equipment, call centres and offices.

- **Data centre energy consumption** – energy consumed by data centres, which are the physical sites that host operators' IT, including OSS and BSS and intranet infrastructure. Our analysis only includes energy consumption for data centres owned by an operator; it does not include that related to leased or outsourced capacity from webscale providers such as AWS, Microsoft and Google.

- **Other operations** – energy consumed by the mobile operator for its own operations. This includes offices, shops, retail activity and logistics.

Figure 3: Where mobile operators use energy in their network operations



Source: GSMA Intelligence

Findings

Consumption

- The majority of energy (73%) is consumed in the RAN. Providing coverage across thousands of square kilometres, transforming energy into radio waves, and receiving and processing incoming signals is still an energy-intensive area.

- The remaining distribution of consumption comprises data centres (9%), core (13%) and operations (5%).

- While data centres appear to be a low contributor at 9%, it only reflects those owned directly by the operators. The share would be higher if consumption levels from hyperscale providers and other data centre operators (such as CDNs) were included.

Efficiency

- Energy efficiency was measured primarily using the energy per data traffic ratio across the RAN. In the markets covered, this reached 0.24 kWh/GB during 2020. We also used three secondary efficiency ratios, which aimed to measure energy efficiency from different angles:
    - For the 31 networks covered, one mobile connection required an average of 14.8 kWh of energy during the 12-month period.
    - On average, one network site used 28,665 kWh for the same period.
    - From a financial point of view, one network operator used 141 MWh of energy to generate €1 million in revenue.

Note that these values are averages. Standard deviation is high, sometimes as much as 10×.

Fuel sources: renewables versus diesel

- 46% of the total energy consumption was supplied by renewables, 43% from conventional supply and 11% on-site via diesel generators.

- Diesel usage is more concentrated in developing regions where grid and renewables access is less prevalent. Despite operators being at the forefront of the use of renewables, they need an immediately available energy source in bad-grid, off-grid and hard-to-reach areas to provide critical infrastructure in developing regions and bridge the digital divide for underserved communities.

- Renewables are mostly purchased via certified energy suppliers. While solar is becoming more price competitive, renewable electricity generation is still outside the operators' comfort zone. Directly produced solar accounts for a minority (less than 1%) of total energy consumption.

- Diesel usage is more common in regions where grid electricity is less prevalent – Southeast Asia, the Middle East and Sub-Saharan Africa. However, even in Europe, it accounts for 1–6% of consumption.

- European operators are at the forefront of renewables usage. European network operators can access renewable energy more easily via the grid, many have set ambitious goals and some already have network operations 100% powered by electricity from renewable sources.

4. Outlook and implications

The findings and implications from the benchmark analysis should be interpreted in the context of several broad shifts in the sustainability arena. We outline these below.

Climate targets

In February 2019, the GSMA Board, comprising members from the largest mobile network operators in the world, set a milestone ambition to transform the mobile industry to reach net-zero carbon emissions by 2050, at the latest. This action by the mobile industry not only made it one of the first sectors in the world to set such an ambitious target; it also put it ahead of all major world economies. It is not the first time the sector has shown leadership in sustainable development. In 2016, the mobile industry was the first sector to commit to the United Nations 17 Sustainable Development Goals (SDGs).

As of mid-2021, operators accounting for 50% of global mobile connections and 65% of industry revenues have committed to science-based targets. A significant proportion of operators have also committed to net-zero targets by 2050 or earlier: operators accounting for 31% of global mobile connections and 36% of the industry by revenue have a net-zero target. This makes the mobile sector one of the first to break through the 20% target as set by the UN Race To Zero campaign.

Sustainable 5G

As 5G becomes more pervasive, the energy consumption demand on mobile networks will rise. Energy-saving measures built into the 5G new radio (NR) standard may be offset by rising data traffic, paradoxically resulting in higher levels of energy consumption and emissions. However, the energy strategies of operators take a holistic perspective that includes retiring legacy networks, increasing renewable consumption and buying power-efficient equipment.

The GSMA Intelligence report 5G energy efficiencies: green is the new black provides an overview of efficiency strategies. The benchmark analysis presented in the current report is complementary and will need to be updated over time to account for the mix effect in the mobile customer base that will gradually increase in favour of 5G.

Green finance and infrastructure investment

Green bonds represent a paradigm shift from traditional modes of financing by securing funding on the basis of achieving climate and environmental – rather than purely financial – targets. The telecoms sector is among the leaders in embracing this model of investment, with BT, Deutsche

Telekom, KPN, Verizon and Vodafone among those to have made similar issuances and the telecoms industry more broadly committing to net zero by 2050. To meet this goal, the sector is at the forefront of reappraising how business operations are run so as to reduce energy usage and ultimately carbon emissions. The fact that institutional investors are increasingly gearing capital allocations with climate covenants is a clear signal that sustainability is part of a new normal in the corporate world.

Operators have been selling their tower businesses or taking them public for several years now. Debt reduction is an important reason behind these deals. Operators can also expect potential cost savings from having to pay reduced fees for their tower use as the tower companies maximise revenue per tower by onboarding more tenants. Tower companies can improve energy efficiency as co-location and the sharing of passive or even active infrastructure improve the use of equipment. However, gaps remain in aligning consumption reduction targets between operators and tower companies. We expect future lease and leaseback agreements to incorporate energy-saving measures either as part of service-level agreements or, at least, best-efforts delivery.

Meanwhile, the Next G Alliance has started working groups on the 6G roadmap, and 'Green G' will have a heavy focus on achieving energy efficiency.

Renewables transition

The rising share of renewables in overall electricity consumption for mobile operators is the single most important driver of CO_2 reductions so far. BT, for example, already uses 100% renewables in its UK network operations. Telefónica, Verizon and Vodafone – among others – have renewable targets in place on ambitious timelines. This has been helped by increased liquidity in renewables trading and the presence of longer term purchase contracts. Operators are also investing in solar capacity on premises connected to RAN and via solar farms.

The challenges generally lie in countries whose economies are more reliant on petroleum production, including the Gulf states, Russia and even the US in light of its fracking revolution – though with an impending change in political direction likely to favour energy diversification. Lack of connectivity to the central electricity grid can similarly result in the need to use fuel-based backup solutions, emitting significant CO_2. Off-grid implies telecoms towers are either completely disconnected from the grid or receive no electricity from the grid. Towers that face more than six hours of power outage per day, on average, are classified as bad grid and need to find an alternative source of energy. In hard-to-reach areas such as high mountain environments, deserts or islands, an alternative source of energy is essential to provide reliable telecommunication service. In these circumstances, public subsidies or other interventions may be required to create renewables capacity.

5. How to get involved

Decarbonisation and sustainability will continue to be a key strategic priority area for the telecoms sector over the next decade as operators play their part in the global response to climate change. A sustainable approach also helps to foster innovation and engender enthusiasm and loyalty from employees, customers and suppliers. Mobile operators are increasingly placing a green agenda at the heart of their business strategies, driving the wider industry's contribution to the Sustainable Development Goals (SDGs). To support these aspirations, GSMA Intelligence will continue to run an extended version of a similar energy efficiency benchmarking activity at the beginning of 2022, based on new 2021 data.

However, to make the results as representative and impactful as possible across all regions, we would like to increase the range of participating operators. In addition to public-facing research and best practice, participating operators will receive customised reports on their own network energy efficiency compared to industry averages on an anonymised basis.

For more information on the Energy Efficiency Benchmarking 2022 project, or to be involved directly, please contact:

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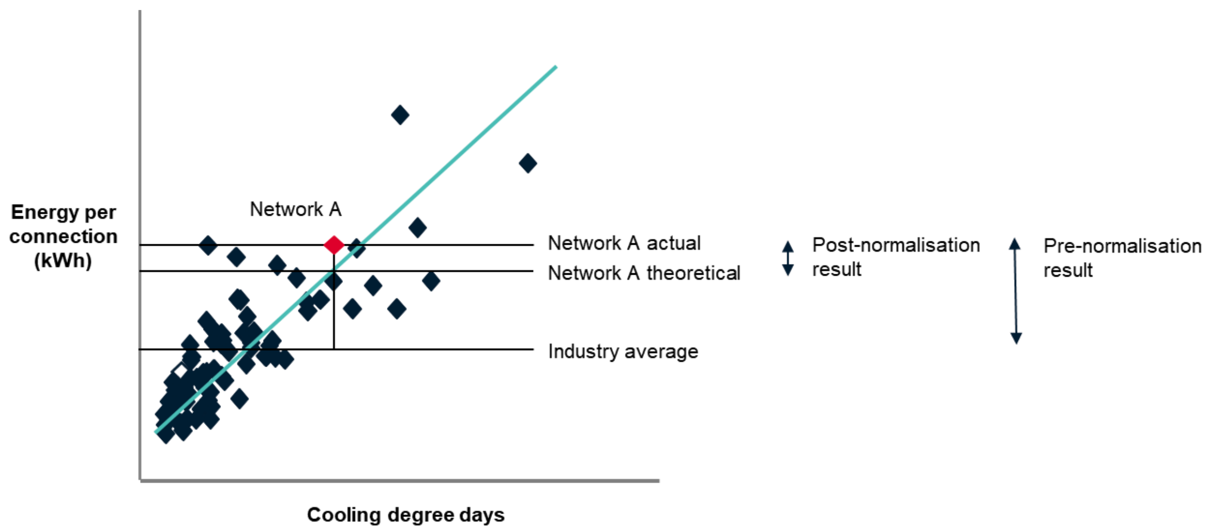
Appendix

Normalisation

Regression analysis produces a set of results that enable a mathematic equation to be written to explain a relationship. With this equation, we can calculate the theoretical energy per connection for a network, using the network's values for each of the independent variables. Subtracting the network's actual value from the theoretical value gives a measure of whether the network is over- or under-performing. This approach can be extended to multiple networks.

Without the normalisation process, the efficiency ratios would be compared to an industry average. This could be misleading since many other impacts would be included that are not the responsibility of the mobile network operators. For example, just because a network is located in a warm climate with a consequent high demand for air conditioning does not necessarily translate to a poor energy efficiency reading.

Figure 4: Actual versus theoretical energy consumption



Source: GSMA Intelligence

Key factors influencing energy efficiency

After testing several potential explanatory variables, three non-network factors were identified to normalise the data. GSMA Intelligence aimed to extract those factors outside an operator's control from the original energy per unit of traffic value. These three variables enable us to normalise the result from three different angles:

- **Network traffic –** average monthly mobile data traffic per mobile subscriber during 2020.
- **Climate** – a cooling degree day (CDD) is a measurement designed to quantify the demand for energy needed to cool buildings.
- **Network density** – the number of connections per cell site. The average size of the area that the cell site covers has an impact on energy efficiency/consumption. This measure accounts for population density, market share and topology.

Thanks to the subtraction of these different variables, the real network-related attributes come to the forefront in the benchmarking.

The result of the benchmarking gives us a diverse picture: top performers can be found in different regions. Network efficiency does not directly correlate with how developed a market is, and there is a difference of 10× between the worst and best performers.

Glossary

AI – Artificial intelligence	MHz – Megahertz
BBU – Baseband unit	MW – Megawatts
CDD – Cooling degree day	MWh – Megawatt hour
FWA – Fixed wireless access	NR – New radio
GB – Gigabyte	OSS/BSS – Operation support system / business support system
Gbps – Gigabits per second	RAN – Radio access network
GHz – Gigahertz	RoI – Return on investment
kWh – Kilowatt hour	SDG – Sustainable Development Goal

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