GSMA Intelligence

The carbon-neutral mobile network

Tackling the holistic energy challenge

February 2022

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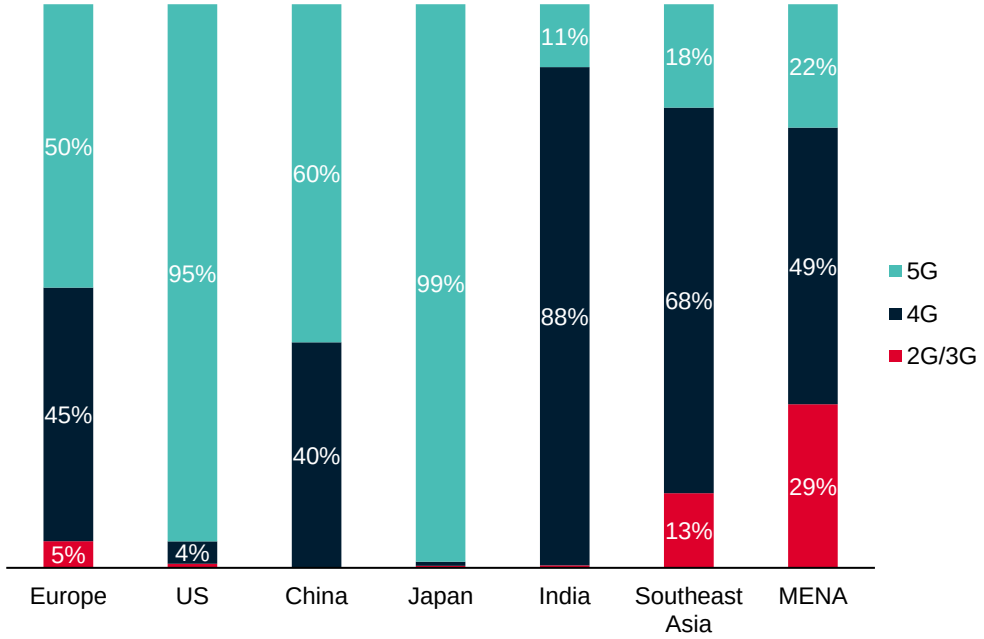
Moving to a 5G world, with regional variation

- Following initial commercial launches in 2019, 5G now accounts for around 8% of the global mobile subscriber base. By 2025 this will have risen to 25%.
- Early take-up has been concentrated in a small number of vanguard countries – principally, the US, South Korea and Japan. Europe and others are further behind.
- For India, Africa and most of Southeast Asia, 4G smartphone upgrades (driven by declining mobile data prices) are still the main trend, with 5G some way off.
- These structural differences mean that the telecoms market will have three broad tiers by 2025: 5G vanguards (US/CJK*), 5G transitions (Europe) and 4G mainstays (everywhere else).
- The onus to operate more energy-efficient networks is common regardless of the subscriber profile. 2G/3G customers may use less data, but the underlying networks are far less efficient than 4G/5G networks.

*China, Japan and South Korea

Smartphone customer base in 2026
Breakdown of smartphone connections

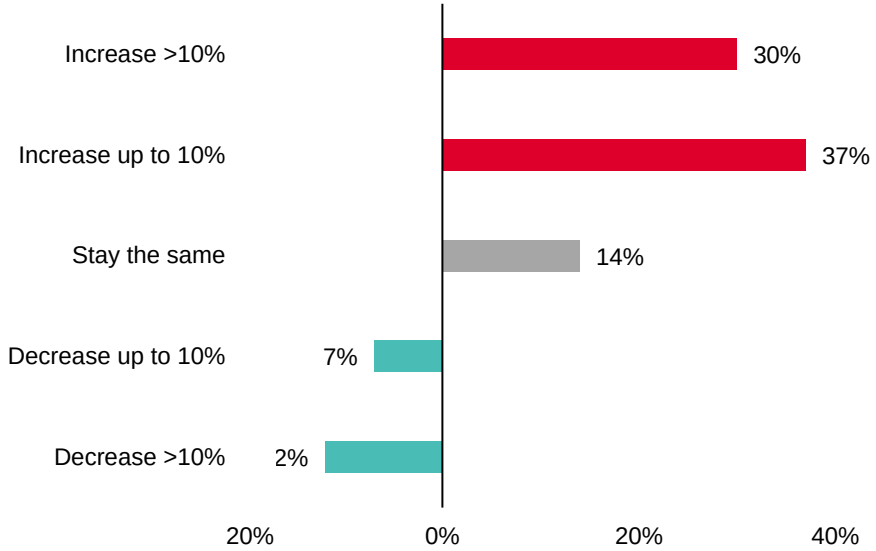


Source: GSMA Intelligence

Even with spectral efficiency gains, costs are expected to rise

- One of the engineering feats of the 5G new radio (NR) standard is that it is far more spectrally efficient than 4G (and even more so than 3G). While estimates vary, a reasonable barometer is a 1.5× improvement.
- In practical terms, this gives operators the ability to transmit more cellular data for a certain amount of spectrum and power – something welcome in an era of rising costs and pressure to reduce consumption.
- Efficiency gains must be weighed against the sizeable increase in overall data traffic as a result of higher monthly usage (video streaming, AR/VR and others).
- There is also the issue of variable energy prices, which have spiked sharply in recent months following supply shortages and excess demand from the economic recovery from the pandemic.
- Nearly 70% of operators expect their energy costs to rise over the next three years.

Two thirds of telcos expect their energy costs to rise over the next three years
How do you expect your energy costs to change over the next three years?
Survey of network managers (N=100), July to August 2021

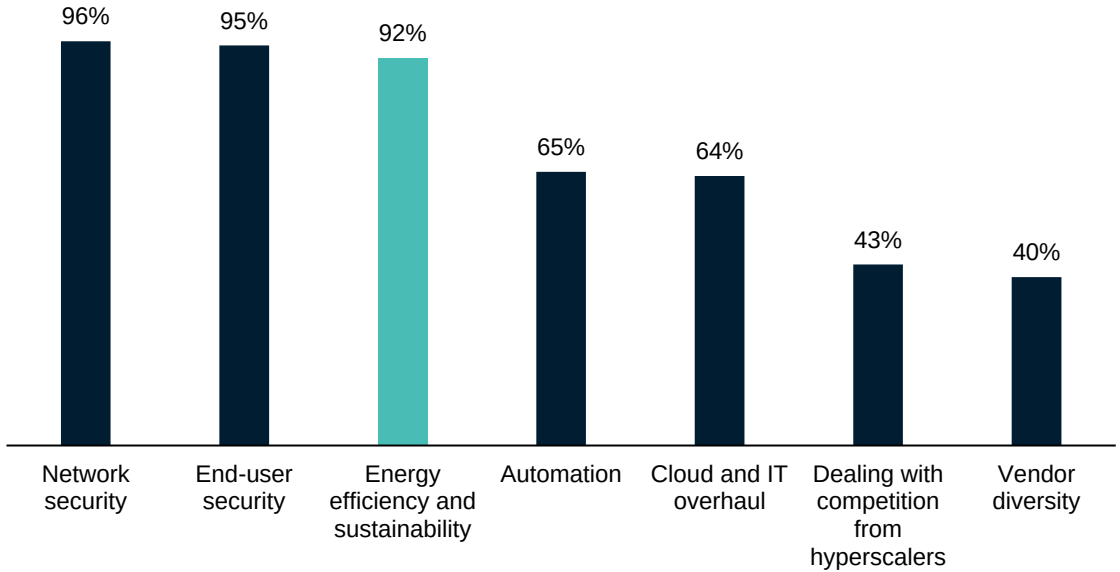


Source: GSMA Intelligence

The green agenda is now a top priority – and a competitive differentiator

- Though climate change has been an issue of public profile for over 20 years, the strategic imperative for ‘going green’ in the private sector has risen to prominence over a short period.
- For telcos, part of this comes from the urgency to fight climate change, while part comes from the cost pressures associated with network investment outlays set against persistently low revenue-growth environments.
- At a network level, this means a mix of redesign and built by design. The GSMA Intelligence Network Transformation Survey indicates that more than 90% of operators rate energy efficiency and sustainability as a priority. This puts it in line with other must-haves such as security, and well above other upgrades.
- For telecoms vendors, energy efficiency will be a key competitive differentiator in the 5G era, at all levels of the stack.

How important are the following priorities as a part of your network transformation strategy?
Operator survey data, 2021. Answers on a 1–5 scale where 1 = not at all important and 5 = extremely important. Data shows those rated very or extremely important.

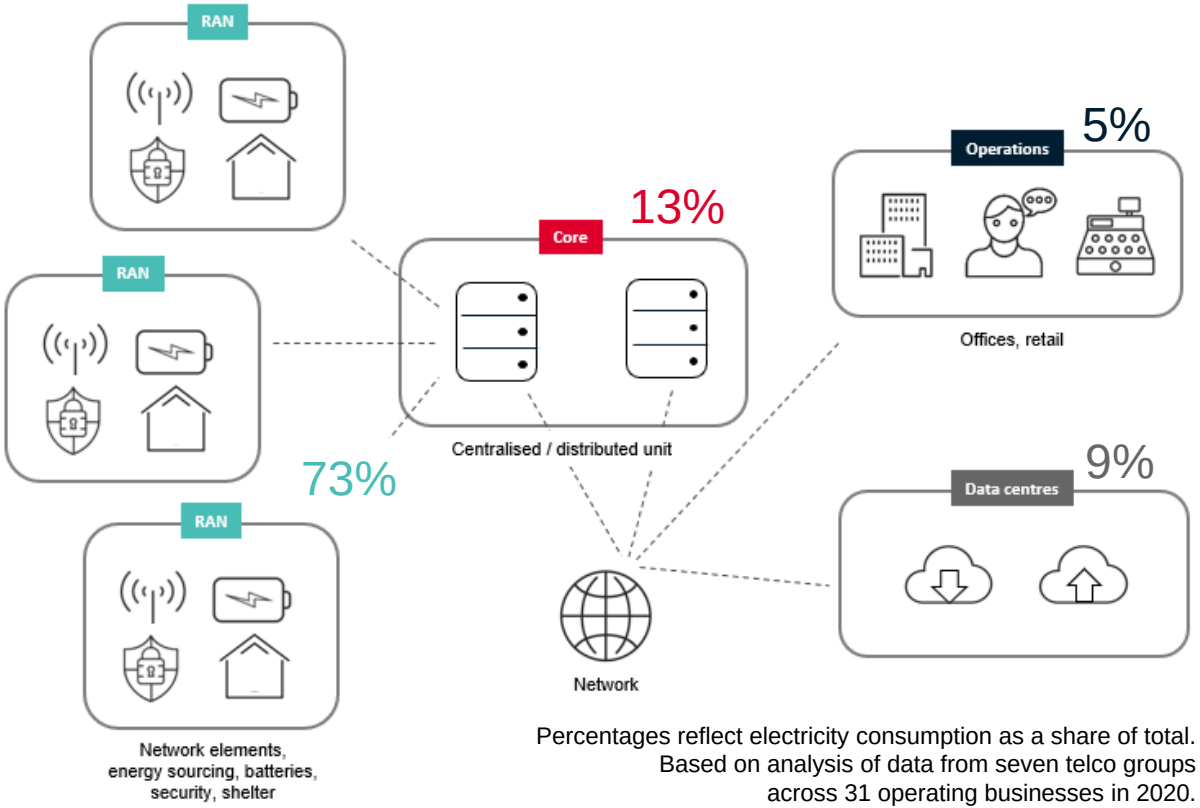


Source: GSMA Intelligence

Where is energy consumed in the mobile network?

- Telecom networks are a series of interconnected parts, each serving distinct functions. Understanding how energy is distributed across these network elements is important for accurately targeting remedies to improve efficiencies.
- Radio networks serve as the primary means of delivering cellular connectivity. These are linked together through the core, and to the internet via datacentres.
- Our benchmarking of real-world data from mobile networks in 31 countries suggests the RAN occupies almost 75% of energy usage, with around 10% each for the core and owned data centres.

Distribution of electricity usage across a mobile network



Percentages reflect electricity consumption as a share of total. Based on analysis of data from seven telco groups across 31 operating businesses in 2020.
Source: GSMA Intelligence

Energy toolkit: AI-driven energy management

AI has emerged as an effective means of optimising power consumption in mobile networks. Operators and their vendors are incorporating AI into multiple levels of the stack. This can result in a system-level change in which energy is used in a more precise and scrupulous fashion where required.

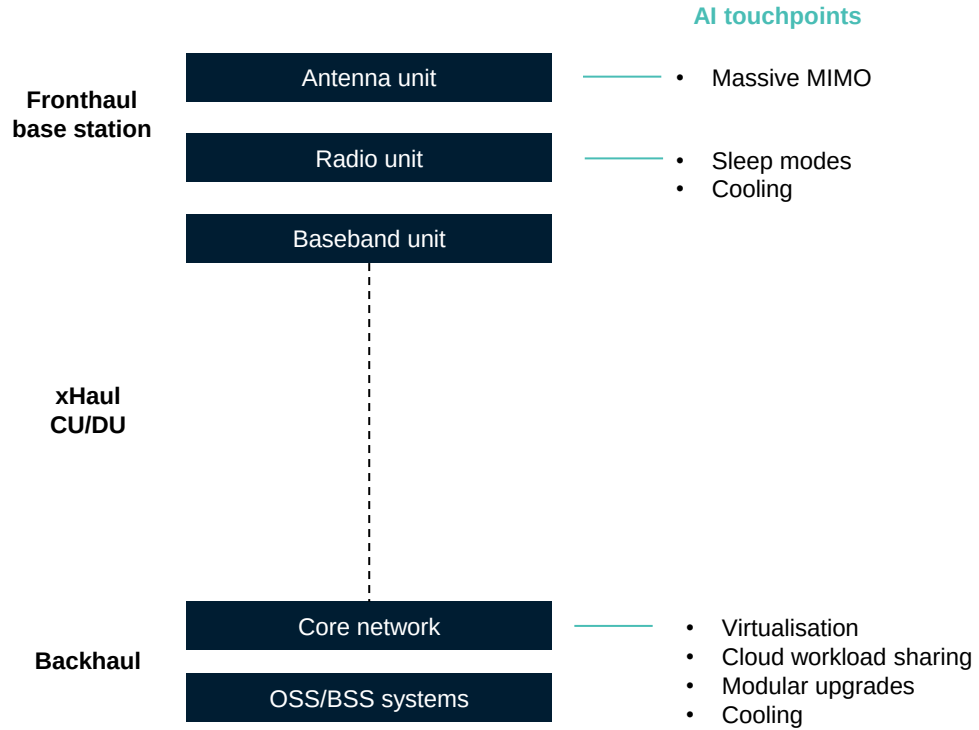
RAN

- **Massive MIMO** – Adjusts signal beams depending on customer density and location.
- **Sleep modes** – Built into the NR standard to allow networks brief respite periods, as opposed to the 'always-on' mode of 4G and prior generations.
- **Cooling** – Dynamic adjustments of air-conditioning intensity.

Core

- **Workload sharing** – AI can help adjust the number of workloads handled on a single server to increase productivity.
- **Modular upgrades** – Software-driven updates of signalling algorithms.

AI helping to optimise power consumption in mobile networks

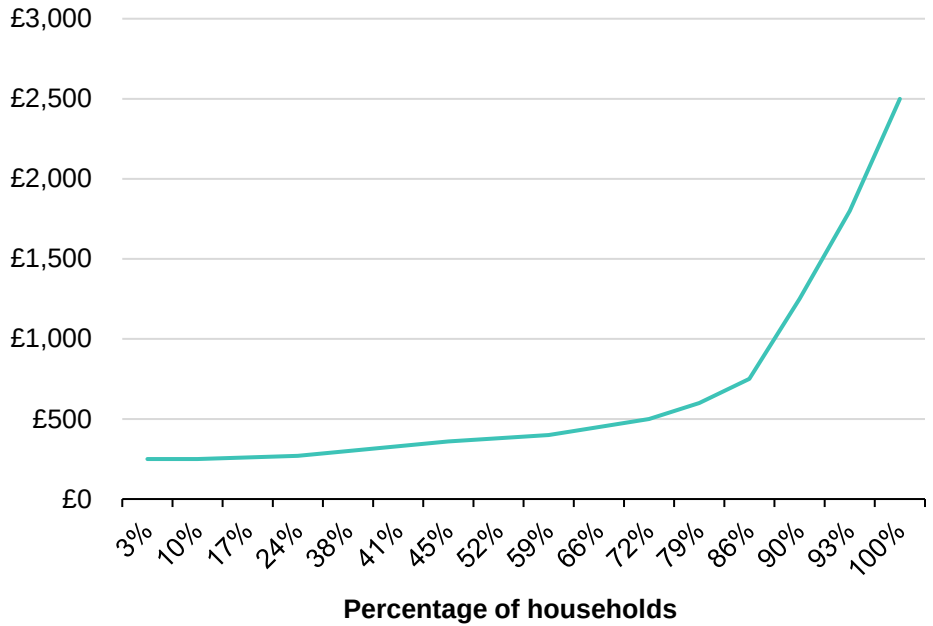


Source: GSMA Intelligence

Energy toolkit: AI-driven energy management (continued)

- AI is also being used in other network energy-saving contexts, including predictive analysis to inform base station locations. This is particularly the case in rural or remote areas, where the economics become extremely challenging when reaching/passing the final 10% of household premises because of the low population density and lack of electricity grid access.
- Vendor solutions are increasingly incorporating renewable energy sources to power these kinds of remote base station. ZTE, for example, has deployed its PowerPilot radio access kit into 30 mobile networks covering 900,000 sites, which it claims can save more than 800 million kWh of electricity annually and reduce carbon emissions by 400,000 tonnes. Nokia, Ericsson and Huawei have engineered similar products and promoted them heavily as a competitive differentiator.

Passing homes with fibre (or mobile backhaul) in the final 10% costs 5–10× the rest
Cost per premises passed, UK



Source: GSMA Intelligence, National Infrastructure Commission

Energy toolkit: lithium batteries

- Battery innovations are also taking shape. The main switch is from lead acid to lithium ion, which offers significant emissions savings.
- At a network level, this allows energy to be retained/stored and distributed in a staggered fashion as opposed to the linear cascade through the RAN and core that can otherwise lead to leakages.
- Other benefits include:
  - a longer life (up to three years)
  - a smaller and lighter form factor, requiring less space in equipment housing
  - voltage boosting, which reduces energy leakage and therefore wasted emissions – something not generally possible with lead batteries.
- Proof points have been somewhat lacking but are starting to emerge. For example, ZTE claims deployment of a lithium battery (SmartLi) with CMPak in Pakistan has led to an 8-tonne reduction in CO_2 per site, per year (according to 2020 base station operation data).

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1 The 5G energy story

2 Scenario analysis of energy consumption

3 Strategic considerations

Understanding 5G's impact on energy

To understand the outlook for energy consumption in mobile networks over the next 10 years, it is helpful to establish the various sources of upward or downward pressure on power usage.

Upward pressure

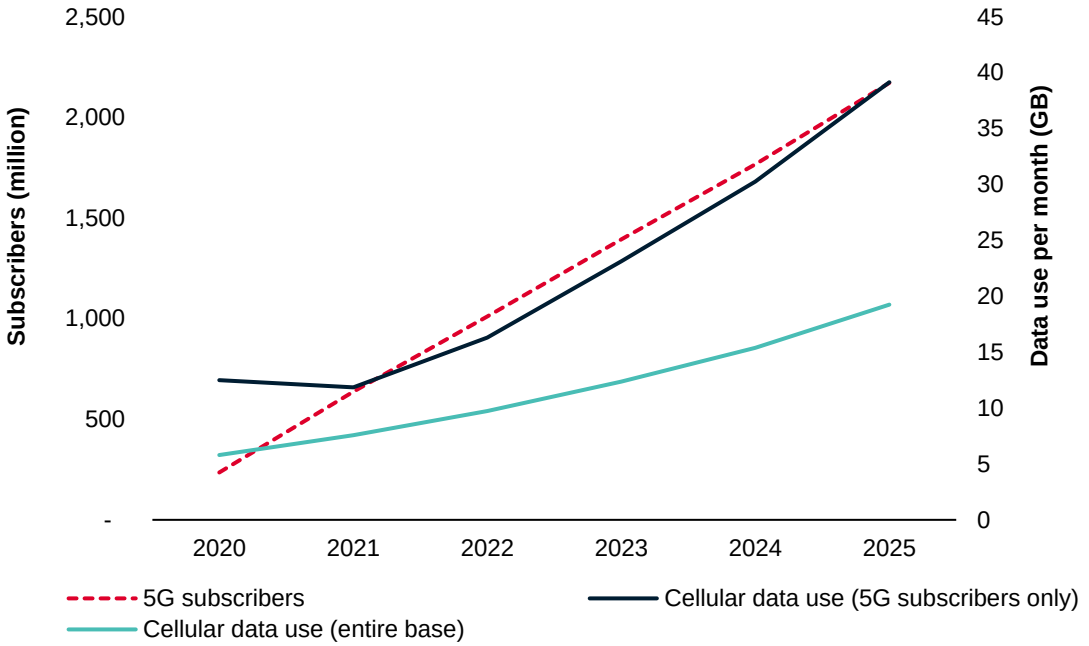
- 5G subscriber mix effect
- Rising average data usage
- Network densification (particularly in urban and suburban areas)

Downward pressure

- Retirement of 2G/3G networks
- Refarming of low-band spectrum
- Energy-efficient network equipment
- Renewables

5G subscriber growth and the consequent rise in data traffic are the most pressing factors. On current projections, the average customer on a mobile network will burn through 20 GB of data per month by 2025. However, because this is an overall average, it understates the true eventual load burden, which will rise as 5G becomes a larger share of the base.

The 5G mix effect will drive up average data usage fourfold (and that's before Wi-Fi)

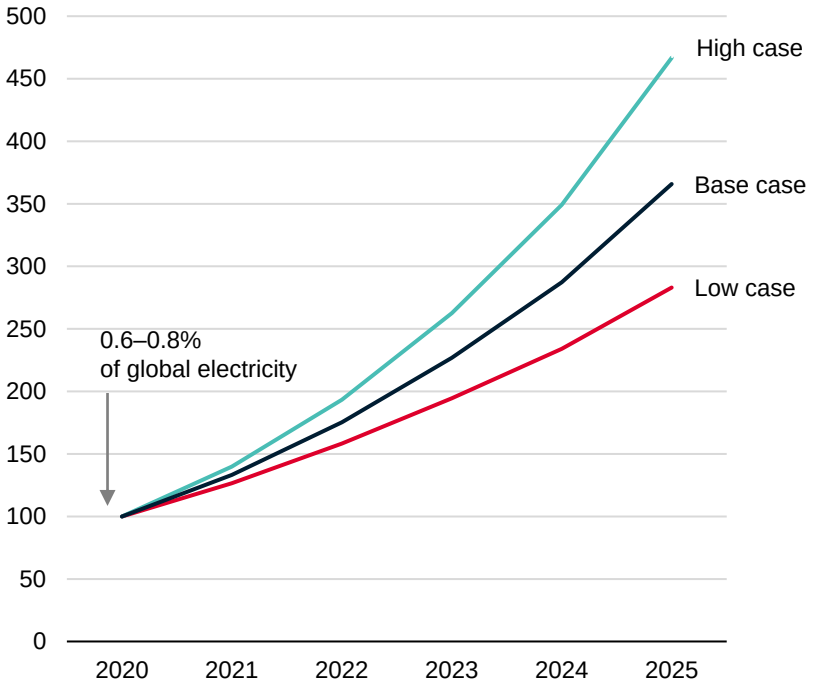


Source: GSMA Intelligence, Ericsson

Energy scenarios for the 5G era

- Taking the aforementioned influencing factors in the round, along with a set of assumptions, we can estimate a range of scenarios for overall energy consumption in mobile networks from the starting point of 0.6–0.8% of global electricity consumption in 2020.
- The scenarios use an assumed level of data traffic attributable to 5G versus all other mobile customers and flex the energy efficiency of transmitting that traffic, starting from a baseline of 0.24 kWh per GB in 2020.
- The projections result in increases in overall energy consumption that range from 3× in an ideal (low) case (where efficiencies accrue at 5% per year) to 5× in a high case.
- These are high-level scenarios designed to show the direction of travel rather than provide detailed forecasting. The eventual change in CO_2 emissions and path to carbon neutrality depends partly on these scenarios but also (and crucially) on the share of renewables.

What energy usage could look like in the 5G era
Indexed value of electricity consumption per year for mobile networks (2020 = 100)



Source: GSMA Intelligence

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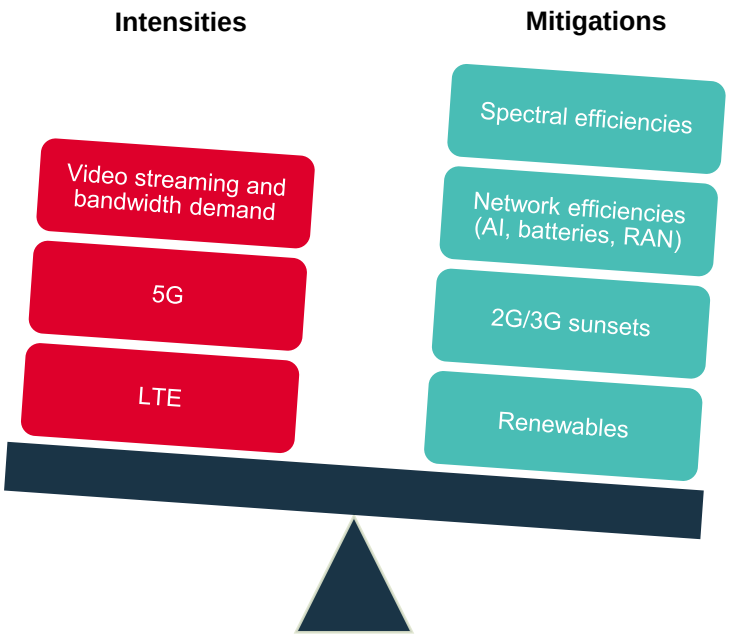
Lowering overall energy is a holistic challenge

- As much as 5G networks will inevitably carry more data traffic than prior generations, the energy challenge for telecoms operators in reducing their carbon footprint is holistic across all facets of the business. This implies the need for a cross-cutting energy strategy.
- Notions of ‘green 5G’ or ‘sustainable 5G’, while attractive, do not speak to the full range of actions underway. For example, more energy-efficient network kit is as applicable to 4G as 5G networks. Similarly, sunsetting 2G and 3G networks – which are far less efficient – will help. Renewables are perhaps the most potent underlying change driver, specifically solar and wind to complement hydro.

Weighing energy intensities and mitigations

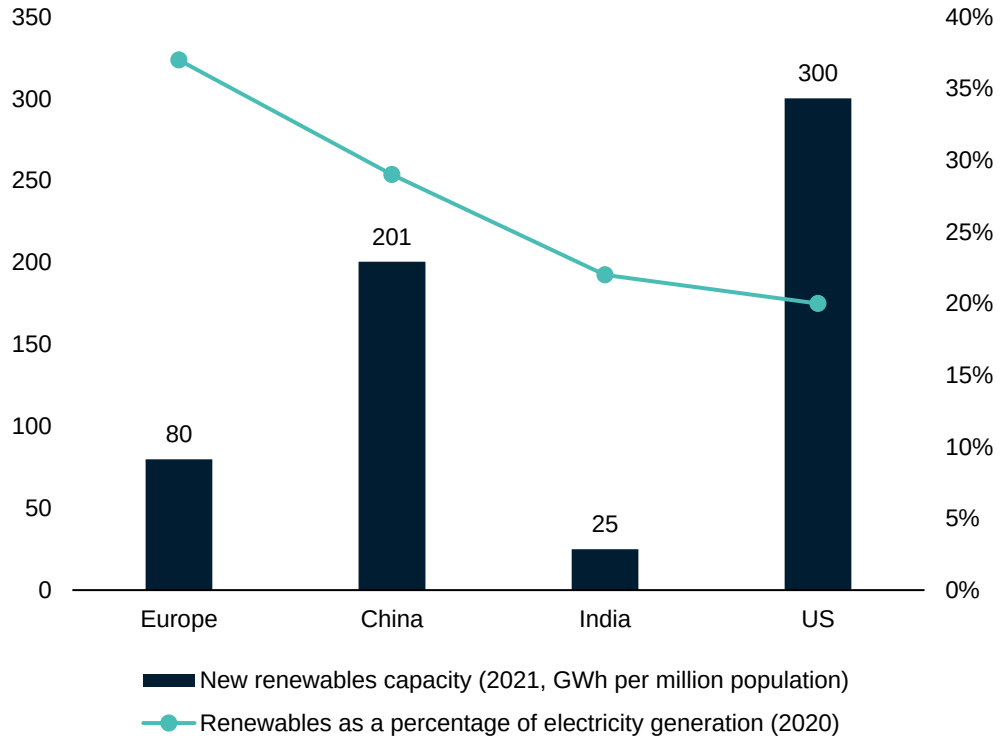


Source: GSMA Intelligence

Renewables, renewables, renewables

- European operators are furthest along in the use of renewable energy. For example, Vodafone, BT and Telefónica are all at or near 100% renewables for their European operations. The same is true of several Nordic groups.
- This has been helped by expanded grid capacity and the use of power purchase agreements, enabling companies to lock in supply and rates on a forward basis to offset future market volatility.
- Indicators suggest the highest impending rises in renewable production relative to population will come from the US and China. These two superpowers account for around 50% of global capacity, providing a strong supply line relative to their 20% of global population.
- India is a giant in waiting. The country committed to an aggressive target at COP26 of 50% domestic energy supply from renewables by 2030, implying a sharp rise still to come in new capacity on current levels.

Renewables capacity and share of electricity generation

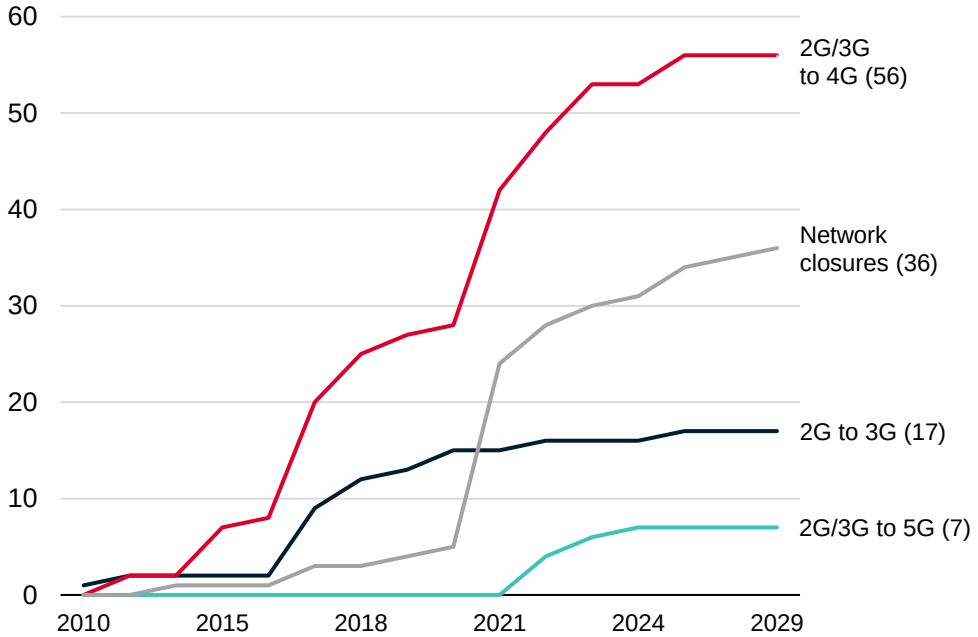


Source: IEA, ourworldindata.org, GSMA Intelligence

Retiring power-hungry 2G and 3G networks…

- 2G and 3G networks are more power hungry (i.e. less efficient) than 4G and 5G. While this has always been the case, the realised impact has grown in recent years with cost pressures and overall urgency to reduce emissions.
- Partly for this reason, many operators have retired, or plan to retire, legacy networks and move customers up to higher speed service. By 2025, 2G and 3G customers will account for only 7% of the global base, compared to 20% now.
- The most common way of doing this appears to be shifting 2G/3G up to 4G, which accounts for around half of migrations. This is pragmatic; most of the shifts come from operators in emerging markets where 5G rollouts are nascent or non-existent.
- The energy savings will therefore be less than with 5G but nevertheless significant, particularly where operators are also upgrading their 4G networks with energy-efficient equipment.

2G and 3G networks retired or scheduled for retirement
Cumulative migrations or closures



Source: GSMA Intelligence

…yielding spectrum for 4G/5G capacity

- Aside from energy savings, decommissioning 2G and 3G networks has the benefit of releasing spectrum that can be re-harvested for newer networks.

- Looking at a selection of operators (mostly in Europe), sub-1 GHz and 2.1 GHz are the most common frequencies to be reassigned, providing capacity for 4G and 5G at far better spectral efficiencies.

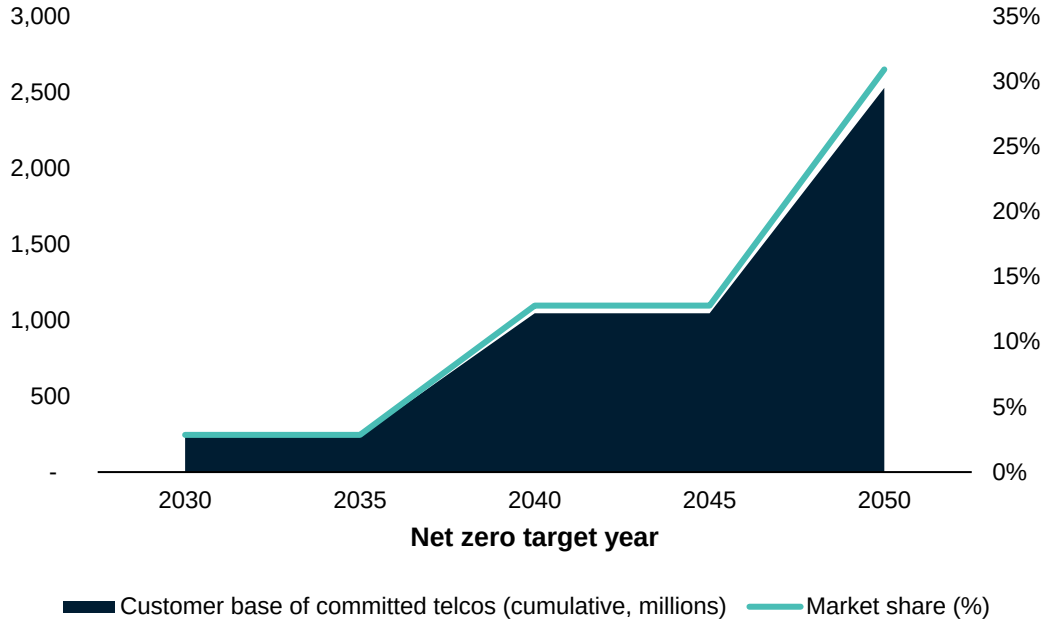
Operator	Country	Frequency	Previous technology	Current technology	Status
Optus (Singtel)	Australia	2100 MHz	3G	4G/5G	Planned
TIM (Telecom Italia)	Brazil	2100 MHz	3G	4G	In progress
T-Mobile (Deutsche Telekom)	Czechia	2100 MHz	3G	4G/5G	Planned
Telekom (Deutsche Telekom)	Germany	2100 MHz	3G	4G/5G	In progress
Vodafone	Germany	2100 MHz	3G	4G/5G	In progress
BSNL	India	2100 MHz	3G	4G	In progress
Vi	India	2100 MHz	3G	4G	In progress
Ncell Axiata	Nepal	900 MHz	2G	4G/5G	Planned
Nepal Telecom	Nepal	900 MHz	2G	4G/5G	Planned
Smart Cell (Smart Telecom)	Nepal	900 MHz	2G	4G/5G	Planned
Liberty	Puerto Rico	850/1900 MHz	3G	5G	Planned
Beeline (Veon)	Russian Federation	1800 MHz	2G	4G	In progress
O2 (PPF)	Slovakia	2100 MHz	3G	4G/5G	Planned
Orange	Slovakia	2100 MHz	3G	4G/5G	Planned
Slovak Telekom (Deutsche Telekom)	Slovakia	2100 MHz	3G	4G/5G	Planned

Source: GSMA Intelligence

Putting your money where your mouth is

- Any net-zero strategy requires a commitment, an action plan and progress reporting. While this sounds simple, in practice it is not.
- The Paris Agreement of 2015 achieved widespread global support, with ratification of nearly 200 nations. However, as of October 2021, only 12% had actually legislated carbon reduction targets into law – the strongest form of commitment.
- While there are several reasons for the languishing pace among governments, private sector commitments are materialising faster in several industries.
- Operators comprising a third of telecoms sector share have publicly committed to net zero. Most are on a 2050 target year in line with COP21 and COP26, though some have laid down more ambitious timelines between 2030 and 2040.
- Geographic representation will expand south (to Africa and Latin America) and east (to Asia), with the next decade being crucial for action.

A third of telcos have committed to net zero



Source: GSMA Intelligence, company reports

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