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Content

Executive Summary

5G and FTTH: more local progress, but we risk falling short of the gigabit objectives

- FTTH population coverage reached 55.6% in Europe in 2022, up from 50% in 2021. However, current evidence suggests that European coverage is currently expected to reach roughly 90% by 2030, and will therefore risk falling short of the EU Digital Decade target on 'gigabit for everyone'. This might concern tens of millions Europeans.
- 5G population coverage in Europe reached 73% in 2022, up from 62% in 2021. This means that Europe lags behind all of its global peers: coverage is approaching 96% in the USA, 95% in South Korea, 90% in Japan and 86% in China.
- The Asia–Pacific block leads in terms of the number of 5G standalone services with 15 active services. Europe has 4 and North America has 3.

Telecoms investment is at its highest level yet, but that in Europe is lower than that elsewhere

- Telecoms investment in Europe reached its highest level since 2016: in 2021, total telecoms CapEx (fixed, mobile and others) reached €56.3 billion. ETNO members solidly remain Europe's telecoms investment leaders, and represent over 68% of the total telecoms investment in the bloc.
- When considering fibre investment (FTTH and FTTx) specifically, ETNO members continue to lead. They have invested €194 per capita compared to €139 for non-ETNO members.
- Nonetheless, Europe continues to trail its peers worldwide in terms of telecoms investment. Investment per capita adjusted to GDP was €104 in Europe in 2021 compared with €260 in Japan, €150 in the USA and €110 in China.

Edge computing, Open RAN and IoT: can telecoms innovation take off?

- Networks are, and will remain, the focus of telecoms investments. However, indicators show that operators are making major efforts to embrace innovation at both the network and service level.
- When it comes to Open RAN, Europe scored 6 trials in 2022, the same as China, followed by the US and South Korea with 3 trials, and Japan with 2. However, Europe still lags behind with respect to the number of real-world Open RAN deployments, despite many trials having been established. The most significant deployments are in Japan (Rakuten Mobile) and the USA (DISH Network).
- There were 204 million active IoT connections in Europe in 2021. We estimate that there will be about 370 million (that is, almost twice as many) in 2024 and 770 million in 2030. IoT is clearly an area of significant growth.
- Cyber security services are another area of growth. Retail revenue in Europe was €4.1 billion in 2022 and it is expected to grow to €5.2 billion by 2025.
- 18 edge cloud offers were announced in Europe in 2022, 10 of which came from ETNO members. The only region in which more offers were announced was Asia–Pacific (19 offers in 2022); North America had just 5.
- European operators are under pressure to create short-term shareholder value in the face of stagnating average revenue per user (ARPU), despite the significant potential for innovation in the telecoms sector. More investment capacity is needed to accelerate innovation, but the established current trends place additional pressure on many operators to sell or separate service and innovation-related assets.

Telecoms operators and tech companies: who invests and who monetises?

- Telecoms operators and tech companies (also known as content and applications providers (CAPs)) contribute to the European digital economy in different ways. There is an acute discrepancy between the returns on investment in European telecoms infrastructure and the returns on investment of the largest services that run over this infrastructure. When it comes to internet access, it is telecoms operators that shoulder the investment burden, while in terms of new value creation it is tech companies that benefit the most.
- New data shows that European telecoms operators invested €56.3 billion in digital infrastructure (mostly access networks) in 2021, while CAPs invested roughly €1 billion in infrastructure such as large international/undersea routes, peering, transit and caching. The remainder of CAPs' digital infrastructure investment (around €16 billion) was devoted to data centres.
- The revenue per employee of ETNO members was €0.46 million in 2021, compared to €2.33 million for Netflix, €1.46 million for Alphabet and €2.33 million for Meta.

Sustainability: 'greening of' and 'greening by' the networks

- An essential action that operators can take when it comes to the greening of telecoms networks is to transition to next-generation networks, which are more energy-efficient than current networks. Five decommissioning dates per year were announced for legacy networks (PSTN) in 2017. This is due to increase to 10 in 2023 and 2024 and 11 in 2025–2030.
- Europe's telecoms sector is also speeding up its transition to renewable energy sources. 83% of the total energy used by the sector came from renewables in 2021, up from 71% in 2018.
- The use of renewables and the improved network efficiency means that European operators' scope 1 and 2 greenhouse gas (GHG) emissions per unit of revenue went down from 4.42 CO2e in 2018 to 2.18 CO2e in 2021.
- This report also describes some key use cases in which other sectors are "greened by" telecoms networks. These include smart utilities and green digitalisation, whereby the adoption of ICT tools decreases the emissions of industrial sectors.

Fundamentals of the sector: why they matter to Europe

- The fundamentals of the European telecoms sector remain weak, with significant uncertainties ahead. This is not desirable from a public policy viewpoint, especially in face of Europe's digital sovereignty plans and the EU Digital Decade targets.
- Europe's telecoms index has consistently underperformed a series of benchmarks on the stock market since 2018. The Stoxx Europe 600 index for telecoms is lower than the Stoxx Global 1800 for telecoms, and is also lower than selected stocks such as Alphabet, Meta, Amazon and Microsoft.
- The need to increase investment to achieve 5G and FTTH objectives also means that European telecoms companies have reached their highest investment intensity for many years (nearing 20% in home markets in 2021). This has practical consequences; the net debt/EBITDA ratio of ETNO members is now 2.53, its highest since 2014. Similarly, the average EV/EBITDA multiple (the measure of a company's total value in relation to its profits) for ETNO members was 5.7 in November 2022, as opposed to 17.4 for Microsoft, 12.5 for Alphabet and 20.3 for Amazon. This shows that the European telecoms sector is considered to be a low-growth industry.

Introduction: the 'long COVID' of the telecoms industry

This time last year, it was reasonable to expect that we would be in a post-COVID-19 world where we enjoyed the benefits of accelerated digital transformation, and where digital services and robust connectivity would be cemented into peoples' lives. Certainly, some of the changes introduced by the pandemic are here to stay. Indeed, many have observed that it took 24 hours to get workers to work from home, but it will take 5 years (or more) to get them back to the office.

The silver lining to the COVID-19 pandemic was that the disruption it brought about also created the opportunity to rebuild economic activity, and even personal lives, on a greener, more sustainable basis. The broad digital/ICT sector is pivotal to the ability of economies to recover, and it can help to deliver on the promise of decarbonising the rest of the economy, even as it reduces its own carbon footprint. These sustainability initiatives are well-progressed, but new external shocks create further problems.

- The removal of most COVID-19-related restrictions created a general demand boom that put pressure on supply and triggered inflationary rises in some input costs. For example, energy prices started to rise steeply in 2H 2021.
- The Russian invasion of Ukraine further contributed to the spike in energy costs, which in turn affected other costs, thereby creating a 'cost of living' crisis for consumers that also extended to labour costs.
- The general trend towards the decoupling of China from the 'Global North' has had an effect on supply chains and has created pressure to remove Chinese equipment from telecoms networks. This has also created competing industry standards. This trend has been evident for several years now, and has resulted in disruption and increased input costs for operators.

How the telecoms sector traverses this period of higher inflation is now a critical concern. The following considerations are of particular importance:

- Will operators be able to match opex (cost) increases with improved revenue, and capex (investment) increases with improved returns on investments?
- Will operators see price rises by competitors as opportunities to follow suit or will they compete for churners?
- Can operators break out of the pattern of flat ARPU, which has hampered the financial strength of the telecoms sector for a long time, in inflationary times?
- How will inflation, opex, price and competitive dynamics affect the telecoms sector's ability to invest rapidly?

There is no escaping that Europe lags behind other comparable countries and regions on several supply-side indices, as noted last year. 5G coverage is lower, and the availability of 5G standalone underwent limited progression in 2022. The path towards the full achievement of the gigabit connectivity target by 2030 remains unclear. Europe does not have a major public cloud provider and has few major customer-facing content and applications providers (the vast majority are headquartered in the USA or China). Nonetheless, the roll-out of gigabit networks continues at a good pace and FTTH has clearly become the technology of choice. 5G spectrum assignment has accelerated compared to that in previous years, thereby providing hope that Europe can start to catch up on its '5G gap'.

Data traffic growth slowed in 2021 after the disruptions of the pandemic, but is expected to revert to 20–25% per year once the extraordinary pace of growth experienced during COVID-19 times has been fully reabsorbed. This load is being augmented by the shift of the delivery of broadcast TV to the internet, and significant new demands will be placed on digital infrastructure by metaverses, as well as by other technological and service innovations such as Web3.0. One recent study suggested that Virtual Reality (VR) users in the metaverse will require more than five times as much data than would be needed to stream traditional HD video.[1]

[1] Arthur D Little (2022), *The metaverse: what's in it for telcos?*

The capex intensity of the European telecoms sector continued to increase in 2021, following a trend that has been in place for 6 years. Capex intensity in Europe is higher than that in much of the rest of the world, partly due to low ARPU and partly because of the timing of FTTH roll-outs. ETNO members' capex intensity (excluding spectrum licences) reached a record high of 19.4% of revenue in 2021. Investments by other players (non-ETNO operators, third-party infrastructure funds and entities that come from the digital infrastructure/cloud side) are also at record levels. The fiberisation of the fixed local loop remains the largest single element in operator capex; this resembles a once-in-a-lifetime investment rather than a generational upgrade. Steady investment in mobile infrastructure, plus spiky payments for spectrum licences, add to this rising capex.

Barely 6 months after the end of the last COVID-19-related lockdowns, European telecoms operators are not in a position of robust financial stability and may still have financial worries. The pandemic showed the importance of fast, reliable and secure connectivity, but there has been no appreciable revenue upside. The pandemic accelerated the digitalisation and automation of service provision, but these opex benefits have been offset by the headwinds of inflation. The improvement in profitability (EBITDA) sustained over the past 5 years has stalled and reversed. Growth in core revenue is hampered by (sometimes artificial) competition, and it has proven to be difficult to grow revenue from adjacent services rapidly, or in a way that does not dilute profitability. The telecoms industry remains highly leveraged. Return on capital employed (ROCE), which measures profitability in relation to all of a company's capital, has fallen over the past 4 years to a level that is barely higher than (and in some cases lower than) the weighted average cost of capital (WACC) of operators.

These factors throw into question the long-term profitability of the sector and the sustainability of investments. Current macroeconomic uncertainties, particularly regarding the direction of interest levels, compound these problems, and could serve to undermine the efficient roll-out of infrastructure.

In this context, policy has to continue to address the gap between areas of investment where a return can be made and broader economic and social goals. There are many ways in which this can be achieved, and all participants in the end-to-end digital communications' value chain have a role to play. The financial health of the sector and the companies that play the largest role in delivering on those European economic and social goals should not be ignored.

This report has been commissioned by ETNO to provide market context and a quantitative and qualitive assessment of digital communications providers within Europe and beyond. The report investigates five key areas.

The first section of this report examines the direct and indirect impact of the telecoms sector on Europeans' lives.

The second examines the demand for telecoms and digital services from both consumers and businesses.

The third section looks to the future and considers how operators can meet the challenges of sustainability, innovation and deploying fit-for-purpose networks.

The fourth section details telecoms innovations and Europe's contribution to their development and deployment.

The fifth and final section reviews the financial performance of the telecoms industry, and highlights Europe-specific problems in relation to the global trends in the telecoms market.

This report includes China as a comparator country for the first time this year. This comparison is unavoidable because China is the world's second-largest economy and is, especially in terms of supply-side metrics, ahead of markets such as the USA, Japan and Europe. However, readers need to be aware that the characteristics of the Chinese market (that it is a managed economy, has infrastructure targets that are set and funded by state-owned institutions and has state-influenced prices, for example) compared with those of the other markets included in this report mean that the comparability of data presents some major methodological limitations.

SECTION 1

Supporting the growing digital society in Europe

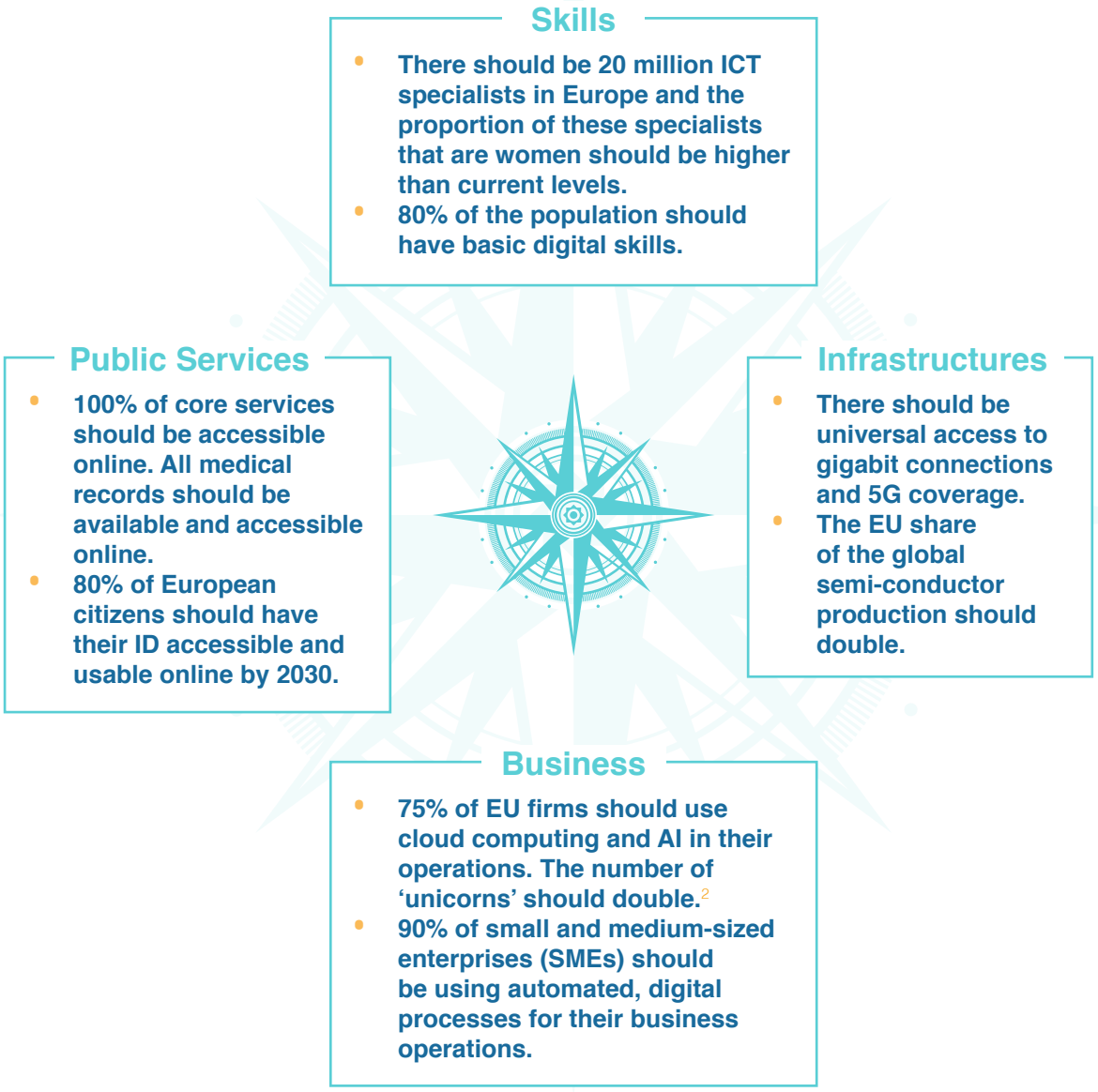
In this section, we review the impact of telecoms and digital services on society. We cover both the direct and indirect impact on the economy, provide insights into employment and compare trends in Europe to those in other markets around the world.

1-1 DIRECT IMPACT FOR EUROPEANS

Telecoms operators' core business is to provide consistent, fast connectivity by investing in cutting-edge networks for both fixed and mobile access. It is vital that operators continue to provide reliable and effective connections as businesses and services in Europe move online and become increasingly digital.

The European Commission (EC), in 2021, set targets for its Digital Decade programme for 2030 aimed at empowering and digitally transforming European citizens and businesses. The Digital Decade targets cover four key areas (skills, government, infrastructure and business), which are illustrated as Europe's digital compass.

FIG 1-1 : ***The European Commission's digital compass for 2030***



Source: European Commission, 2021

[2] Unicorns are private tech start-ups that are worth over $1 billion.

Europe's infrastructure targets from the Digital Decade programme and the Connectivity for a European Gigabit Society strategy prioritise gigabit connectivity and 5G coverage (**Figure 1.2**).

FIG 1-2 : ***Infrastructure targets of the Connectivity for European Gigabit Society strategy and the EC's Digital Decade agenda***

Connectivity for a European Gigabit Society (2025)	Digital Decade (2030)
• Access to download speeds of at least 100Mbit/s (using gigabit-upgradeable technology) for all European households • Uninterrupted 5G wireless broadband coverage for all urban areas and major roads and railways • Access to 1Gbit/s speeds for all schools, transport hubs, major providers of public services and digitally intensive enterprises	• Full 5G coverage of populated areas • All households covered by a gigabit-capable network • 10 000 climate-neutral, highly secure edge computing nodes to be deployed in the EU

Source: European Commission

The EC is supporting multi-country projects to encourage a combination of both private and public investment in critical infrastructure in order to help meeting the Digital Decade targets. EU funding encourages private investors to invest in complex, long-term projects that no single country could achieve by itself. Multi-country projects support the telecoms market with investments for pan-European deployments of 5G corridors, blockchain, processing and computing, cyber security and quantum computing infrastructure. However, these projects remain at an early stage and operators are currently relying on IPCEI for innovative projects such as Telco Cloud, for which funding is allocated through a complex and very lengthy screening process that is poorly aligned with the speed of innovation.

Europe has been continuing to put people at the centre of its digital transformation since the Digital Decade targets were first announced. The declaration on Digital Rights and Principles was released in January 2022 and is made up of six chapters including guidance on how to support solidarity and inclusion and how to ensure freedom of choice online. The declaration emphasises universal European access to high-speed connectivity and promotes the sustainability of next-generation networks and digital technologies that do not excessively contribute to climate change. In addition, the declaration stresses that all market actors have a duty to invest in the maintenance and expansion of the infrastructure required to bring the fruits of the digital transformation to as many people as possible.

Fixed broadband and FTTH coverage

Fixed networks underpin the digital ecosystem that delivers most data traffic. Options to deliver the European Commission's infrastructure targets for gigabit-capable networks include fibre-to-the-home (FTTH), fibre-to-the-building (FTTB) with LAN cabling and cable HFC with DOCSIS3.1. Variants of 5G fixed-wireless access (FWA) may also support gigabit connectivity, but few current FWA services offer such downlink speeds.

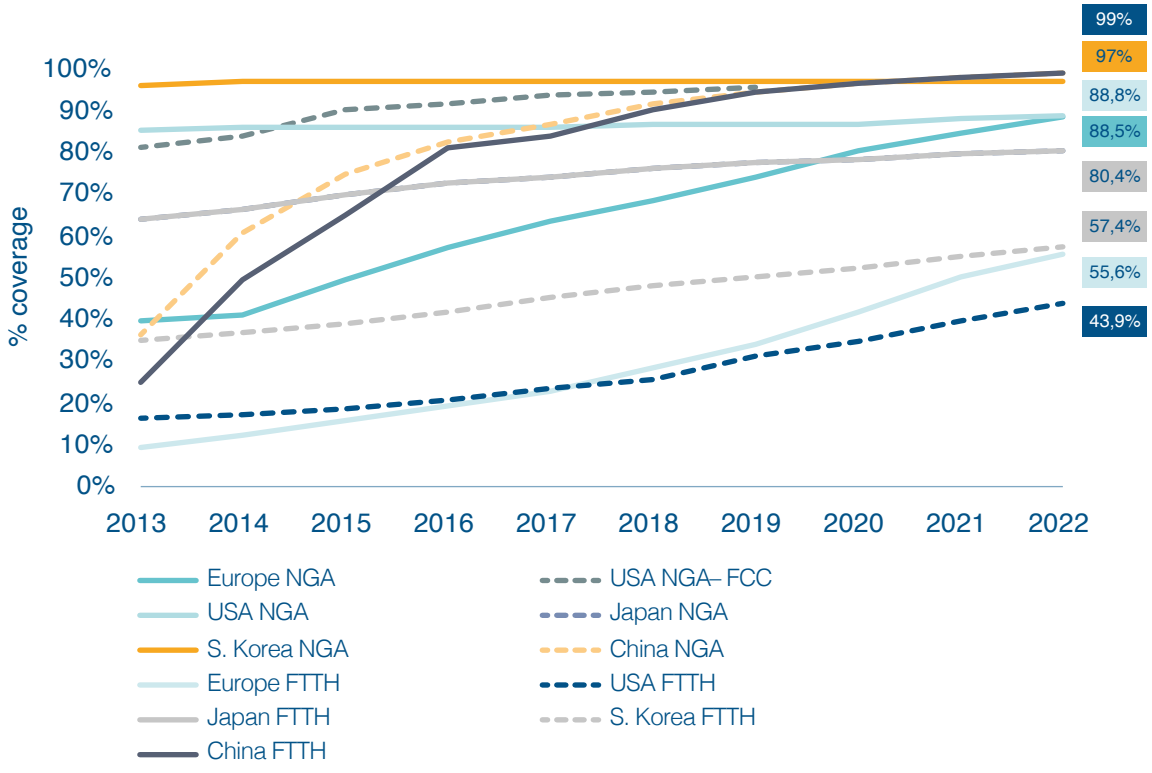
FTTH is the best networking technology for gigabit access because of its high speed, long asset lifespan, low opex and energy efficiency. It is also resistant to obsolescence, because the future roadmap of FTTH technologies will support speeds of up to 100Gbit/s. However, the initial capex required to roll out new FTTH networks is greater than that for other networks.

FTTH's strengths as a fixed network technology explain why the EU and national governments are prioritising, via both subsidies and policies, its deployment. For example, the Spanish government has championed FTTH connectivity for a long time, even in rural areas, by using its EU-allocated regional development funds to roll out FTTH network. Portuguese authorities will launch public tenders in 1Q 2023 to cover 'white areas' with public-funded gigabit networks.

FTTH network coverage has increased to 55.6% of the European population, up from 50% in 2021 (**Figure 1.3**). The increase in coverage in France and the UK between 2021 and 2022 was equivalent to 10% of the homes passed in these countries in 2021. The number of non-FTTH next-generation access (NGA) networks has also been growing. Indeed, 88.5% of Europeans have access to NGA connectivity (**Figure 1.3**), which reflects its broad availability across most of the continent.

Europe remains ahead of the USA in terms of FTTH availability, on a par with South Korea but far behind China (**Figure 1.3**). However, China implemented a powerful FTTH roll-out policy in 2013, in which all new builds were mandated to have FTTH access. This, coupled with a high rate of house building in China, means that near-universal coverage has been achieved in under 10 years.

FIG 1.3 : *NGA and FTTH population coverage, China, Europe, Japan, South Korea and the USA, 2013–2022*

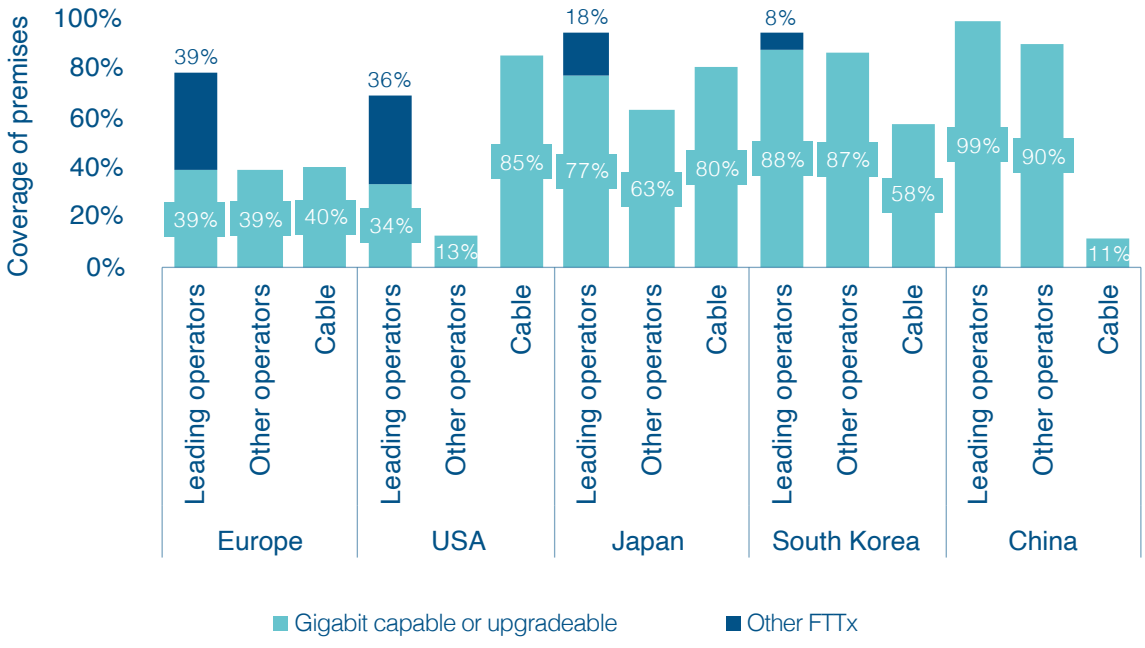


Analysys Mason, 2022

Alternative operators have received substantial financial backing from infrastructure-focused private equity funds. As a consequence, the coverage of these other operators is growing rapidly across Europe and reached 39% in 2022, up from 27% in 2021. As such, it now almost matches the coverage of the leading operators (**Figure 1.4**).

> "FTTH is now available to 55.6% of Europeans, up from 50% in 2021."

FIG 1.4 : *Coverage of gigabit-capable or gigabit-upgradeable networks and other FTTx networks by leading, alternative and cable operators, China, Europe, Japan, South Korea and the USA, 2022f* [3]

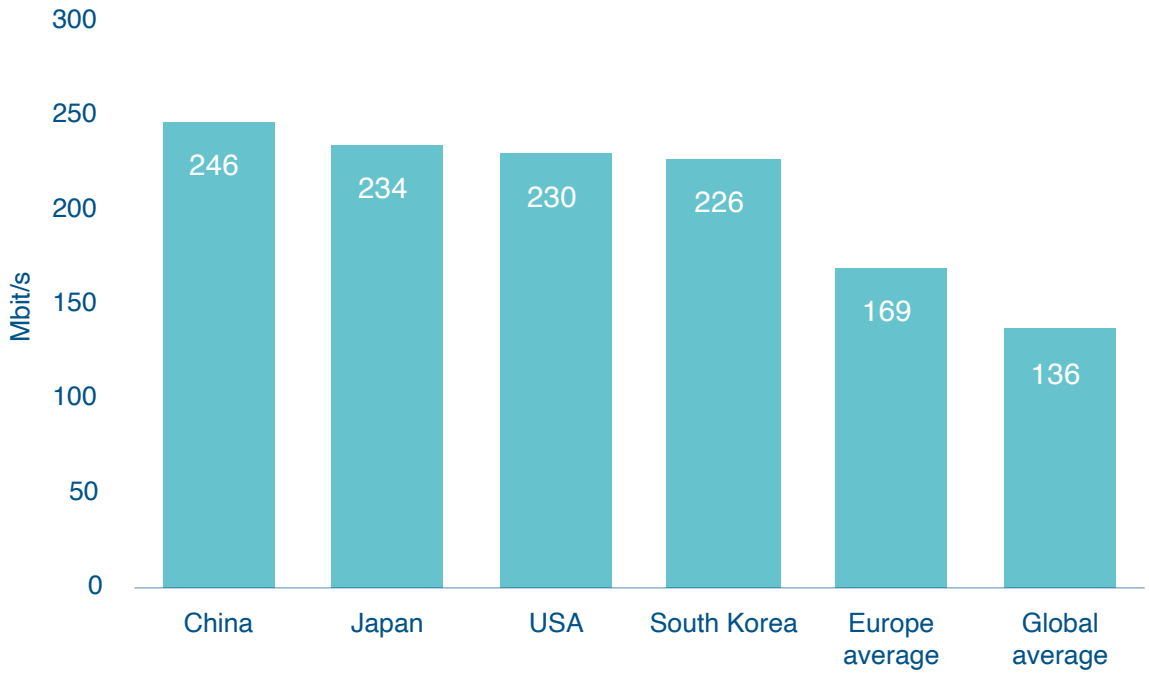


Source: Analysys Mason, 2022

[3] Leading operators are historical incumbents who have traditionally been the largest players in their countries.

The average fixed downlink speed in Europe increased from 143Mbit/s in 2021 to 169Mbit/s in 2022; this is an increase of 18%. However, it remains significantly lower than that in other developed regions and nations (**Figure 1.5**). Europe has lower legacy cable/HFC coverage than the USA, Japan and South Korea, so many premises will be dependent on copper-based infrastructure and technologies whose maximum speed is limited until FTTH or any other gigabit-capable infrastructure is built out to areas outside the legacy HFC footprint. This build-out is happening quite rapidly (see **section 3-1**), but average fixed broadband speeds will be held back until this has been completed. New FTTH networks often support multi-gigabit access, at prices that are affordable by consumers, so changes in individual areas can be dramatic.

FIG 1.5 : ***Average fixed downlink speeds, China, Europe, Japan, South Korea and the USA, 2022***



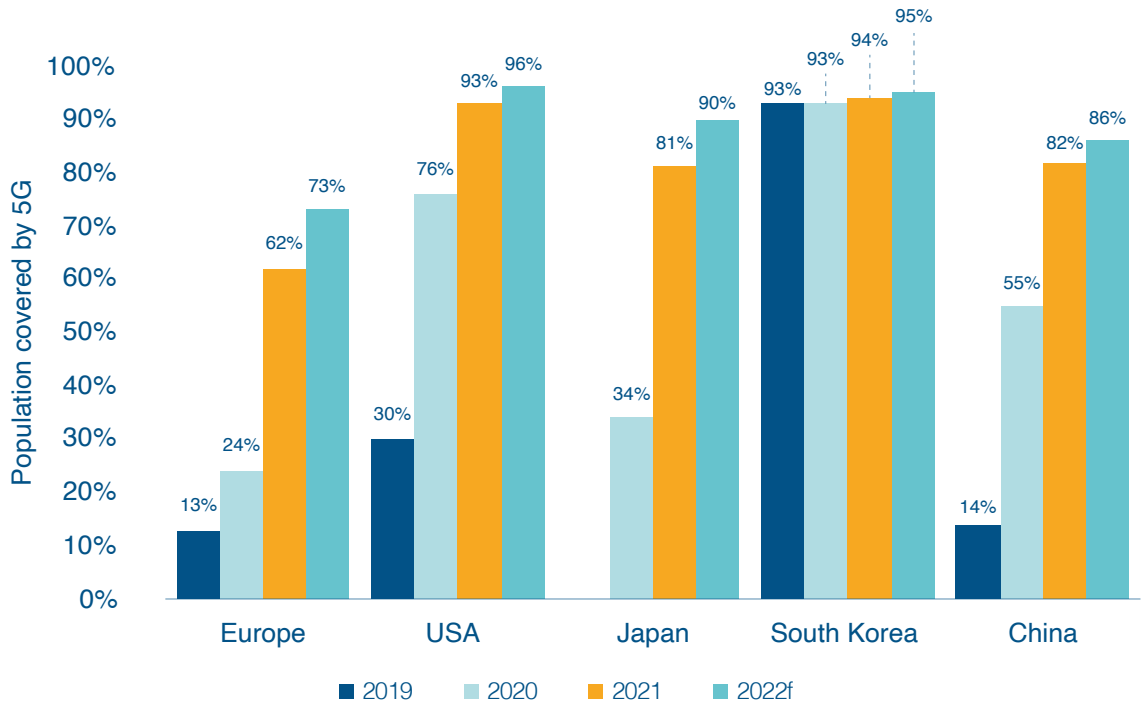
Source: Ookla, 2022

Mobile and 5G availability

4G mobile networks in Europe cover more than 99.5% of the population.[4] The first 5G networks in Europe were launched in 2019, and there are 105 public, operational 5G networks in Europe as of September 2022 (compared to 93 in 2021). Only a small number of new deployments have been announced over the past year.

73% of the European population are currently covered by 5G networks, up from 62% in 2021 (**Figure 1.6**). Europe's coverage remains lower than that of China, Japan, South Korea and the USA, but 5G coverage statistics are not always exactly comparable. There are two technologies that serve to boost 5G coverage figures without adding much to the user experience compared to 4G. Low-band 5G (700MHz in most regions, but 600MHz in North America) provides broad coverage and better indoor coverage than 4G, but does not permit meaningfully faster speeds than those available via 4G. Similarly, dynamic spectrum sharing (DSS), which allows 4G and 5G services to be provided simultaneously from the same infrastructure, also increases 5G coverage without necessarily offering faster connectivity. The European expansion of 5G networks in 2022 mainly focused on increasing 3.5GHz coverage, and the total coverage (that in some markets was increased using DSS and low-band spectrum) has not grown rapidly.

FIG 1.6 : ***Percentage of the population covered by at least one 5G mobile operator, China, Europe, Japan, South Korea and the USA, 2019–2022f***



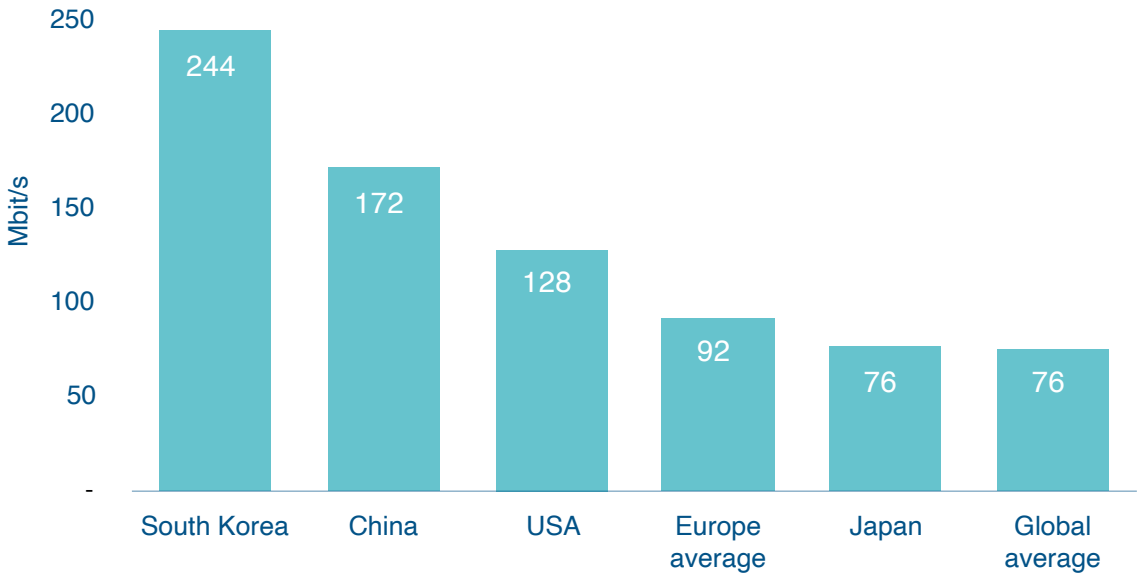
Source: ITU, 2022

[4] A member of the population is typically deemed to be covered if they have useable signal *outdoors* at their home location, or if they are within range of a useable signal. We take these definitions to be effectively the same, but it is important to note that there is nothing in either that guarantees indoor coverage. This depends on building materials as well as factors that are more in operators' control such as spectrum, power and equipment capability.

European mobile downlink speeds are higher than the global average, but they are significantly lower than those in South Korea, China and the USA (**Figure 1.7**). Indeed, the average European speed is now 92Mbit/s, which is less than half as fast as the fastest speed in the world (244Mbit/s in South Korea), despite growing from 69Mbit/s in 2021. Speeds in most countries have also grown, which has resulted in the global average increasing from 55Mbit/s in 2021 to 76Mbit/s in 2022. The speed gap between Europe and the USA has remained largely unchanged between 2021 and 2022; the average US mobile downlink speed was 96Mbit/s in 2021 and 128Mbit/s in 2022.

> 73% of the European population are currently covered by 5G networks, up from 62% in 2021.

FIG 1.7 : ***Average mobile downlink speeds, China, Europe, Japan, South Korea and the USA, 2022***



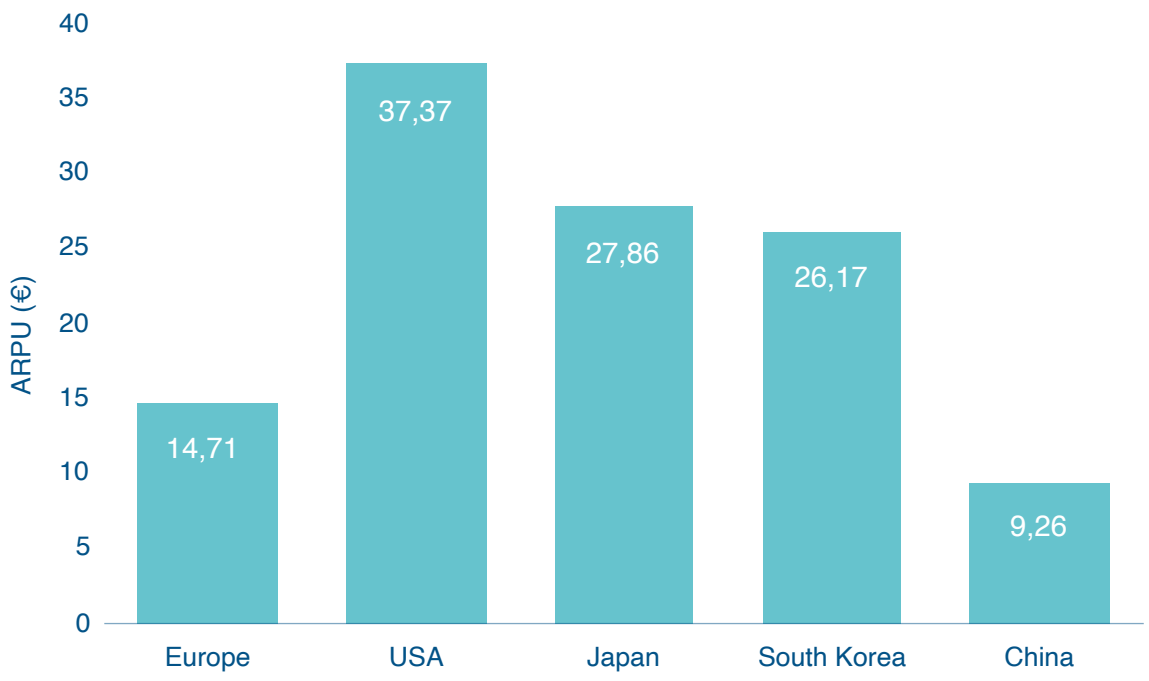
Source: Ookla, 2022

The prices that European consumers pay remain very low by global standards

European operators' average revenue per user (ARPU) for both fixed and mobile services remains lower than that in many comparable markets. ARPU is never an exact proxy for prices, but these are also low. These low prices are good for end users, but they limit the telecoms sector's ability to grow at a time in which capital intensity is rising. This modest revenue is primarily due to strong competition, which has been exacerbated by a tough regulatory environment leading to artificially low prices.

Mobile ARPU in Europe is €14.7; this is substantially lower than that in the USA, Japan and South Korea (**Figure 1.8**). A high level of retail competition, the prevalence of fixed–mobile convergence (FMC) in Europe and the limited number of operators selling 5G at a premium has led to the erosion of mobile prices in recent years, though prices in 2021 were similar to those in 2020. Conversely, prices in most of the other markets included in this report have risen (+4% in China, +5% in South Korea and +1.5% in the USA) over the past year. Prices fell by 1% in Japan, but this was largely because of a new entrant. These changes in ARPU are recorded in local currency and do not take inflation into account. Operators in both South Korea and China have managed to sell 5G at a premium.

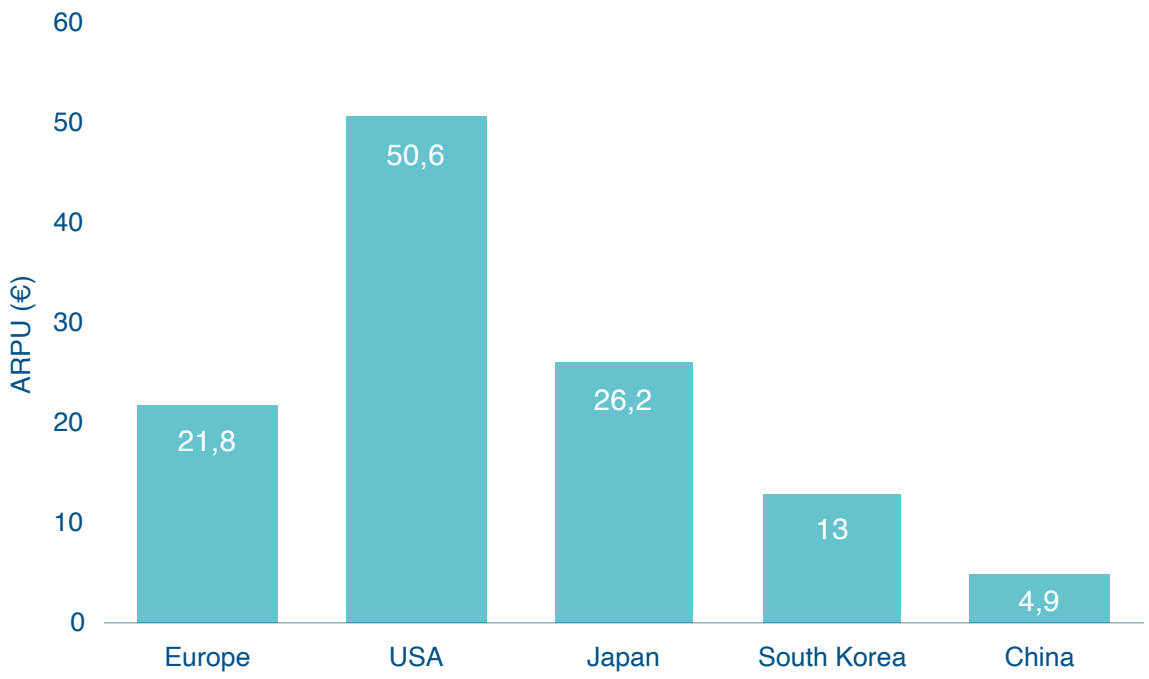
FIG 1.8 : ***Mobile ARPU (excluding from IoT SIMs), China, Europe, Japan, South Korea and the USA, 2021***



Source: Analysys Mason, 2022

European fixed broadband ARPU has held up against price erosion better than that for mobile services; it grew by about 1% between 2020 and 2021. Low fixed ARPU in South Korea and in China is a result of FMC, in which broadband services tend to get subsidised by mobile services. Fixed ARPU in these countries and in Japan remained largely unchanged between 2020 and 2021. The US fixed broadband market has, until recently, been dominated by cable operators, with limited competition, thereby resulting in very high ARPU levels compared to those in the rest of the world (**Figure 1.9**).

FIG 1.9 : *Fixed broadband ARPU, China, Europe, Japan, South Korea and the USA, 2021*



Source: Analysys Mason, 2022

ARPU for mobile and fixed services in China is significantly lower than that in Europe, even though China is highly advanced in terms of mobile and fixed infrastructure and service take-up. We must take the following factors into consideration when comparing Europe to China.

- Chinese operators are majority state-owned. The Chinese government stopped setting retail telecoms prices in 2014, but it continues to provide 'guidance' for operators on setting prices as part of its broader policy targets. The fundamental purpose of this guidance is to improve connectivity speeds while reducing prices. The government does sometimes request that prices should fall.
- Chinese national operators are federations of regional operating companies that can set prices in relation to regional economic conditions.
- Average national income levels and labour costs remain significantly lower than in the other comparator countries.

European operators have increasingly turned to FMC as a consumer strategy. FMC subscriptions involve offering a single contract for both fixed broadband and mobile services. This allows operators to upsell (that is, increase the average spend per customer), increase customer loyalty and reduce churn. However, not every operator can win at FMC because they cannot all upsell services. Nonetheless, the strategy tends to erode single-service ARPU because the bundled services are sold at a discount compared to selling both services individually. Mobile contracts in Europe tend to get sold using FMC strategies to retain or

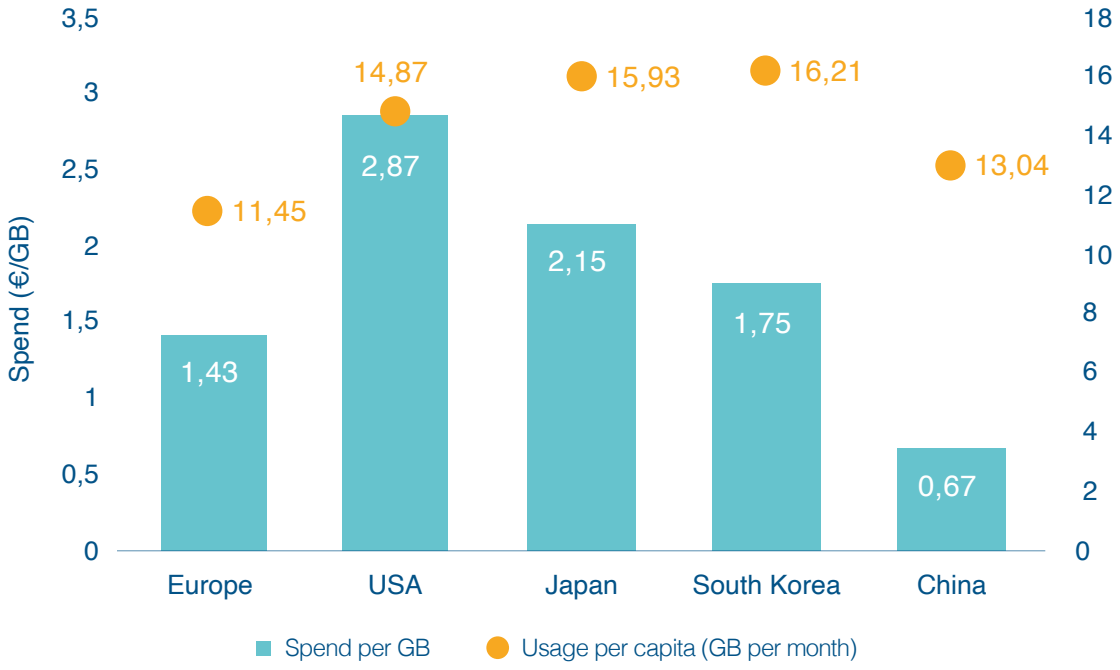
acquire home broadband subscribers (especially for FTTH). This tends to drag down the price of mobile-only subscriptions.

The effect of FMC can be seen when comparing Europe to the USA; the USA has a higher ARPU and a lower penetration of FMC plans. However, there is significant national diversity when it comes to FMC penetration, even within Europe. Broadly speaking, MNOs in countries with lower rates of FMC adoption, such as the UK and Italy, are less active in the fixed market, which reduces the attractiveness of offering FMC bundles because they would have to acquire wholesale access to existing fixed infrastructure. Conversely, mobile contracts are added on top of FTTH subscriptions in the European nations with the highest FMC penetration, such as Spain, France and Portugal, and FMC now accounts for over 45% of broadband connections (an extraordinary 73% in Spain).

FMC is also very common in China, and accounts for approximately 75% of broadband contracts. Chinese operators do not typically report whether revenue originated from fixed or mobile contracts, but they most commonly market data-heavy mobile contracts that come with discounted FTTH subscriptions, meaning that mobile services are driving FMC take-up, unlike what is typical in Europe.

Differences in actual mobile usage between countries are not as significant as ARPU differences. South Korea has the highest mobile data usage (16.21GB per capita per month), while Europe has the lowest (11.45GB per capita per month) (**Figure 1.10**). This does not mean that Europeans use mobiles less intensively than users in other regions; it means only that European attach their devices to mobile networks less than in other regions. This is driven by many factors, but the main cause is the smaller number of mobile-only households, which itself the result of low broadband prices.

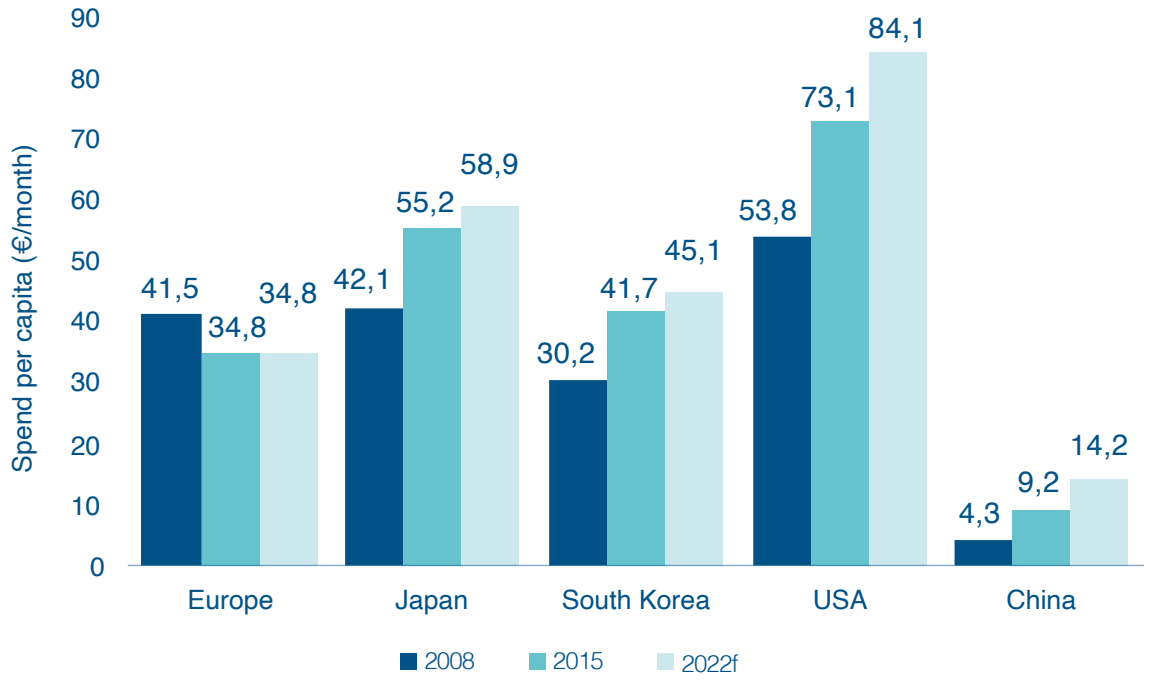
FIG 1.10 : ***Average spend per gigabyte of mobile data used and average mobile data usage per capita, China, Europe, Japan, South Korea and the USA, 2021***



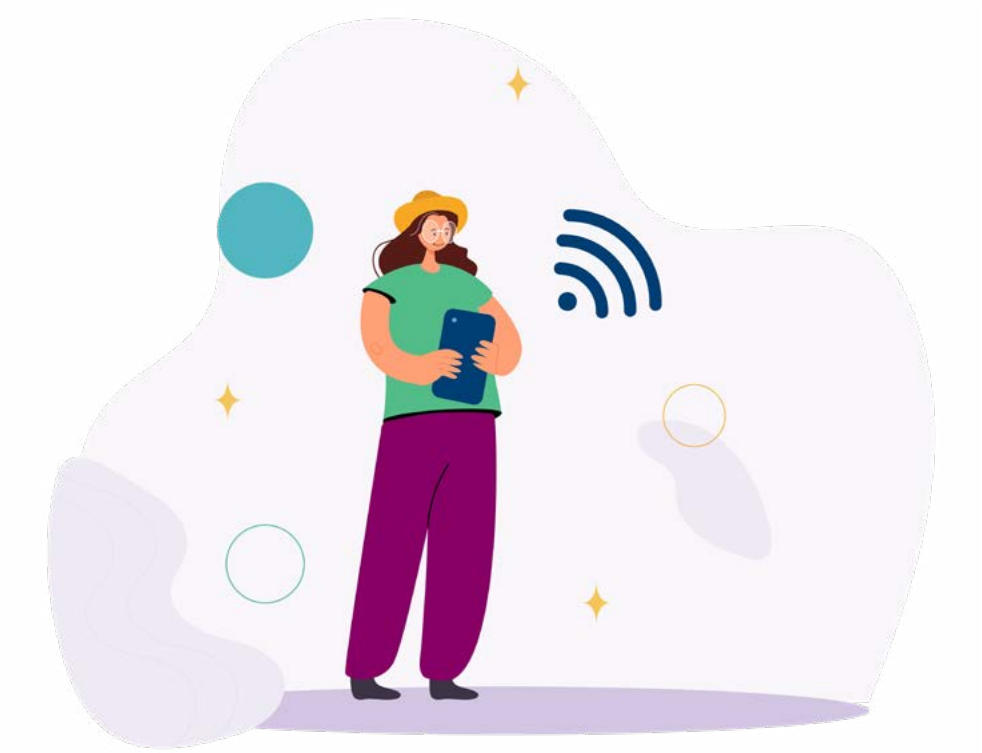
Source: Analysys Mason, 2022

The overall spend on telecoms per capita in Europe remains lower than that in Japan, South Korea and the USA (**Figure 1.11**).

FIG 1.11 : *Average spend per capita on mainstream telecoms, China, Europe, Japan, South Korea and the USA, 2008, 2015 and 2022f*

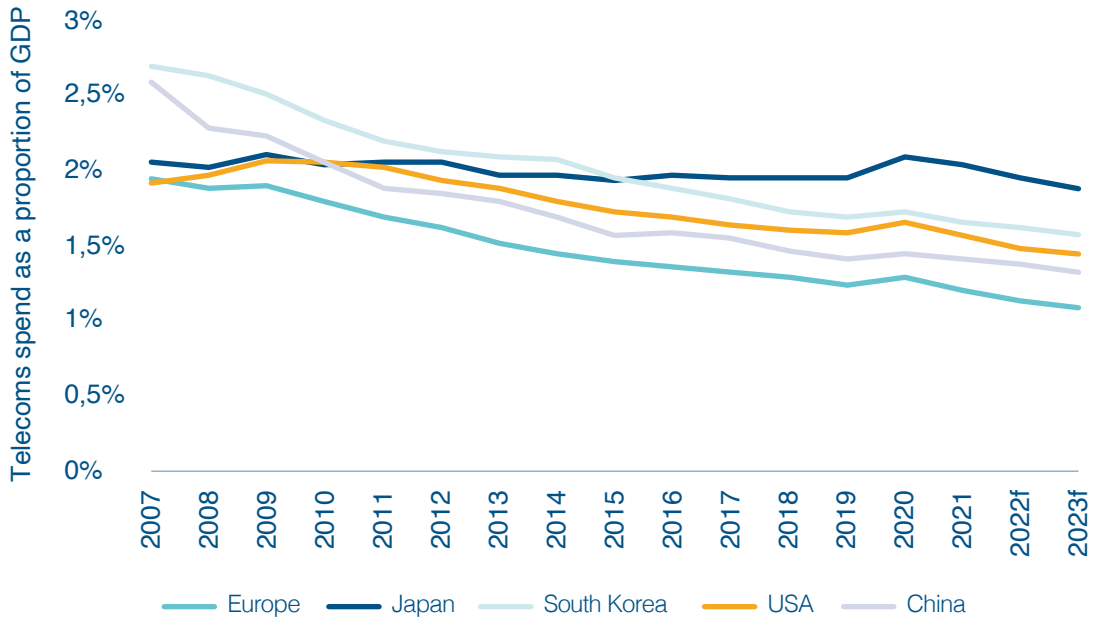


Source: Analysys Mason, 2022



Europe has had the lowest telecoms spend as a proportion of GDP for 15 years. Telecoms spending as a proportion of GDP is declining in all of the markets in this report (**Figure 1.12**). However, the decline in GDP (with no sudden uplift in spending) caused an increase in telecoms spend as a proportion of GDP in 2020 in all regions, though the underlying trend resumed in 2021. Japan appears to be an outlier; it has a particularly resilient telecoms spend that remains at about 2% of GDP, largely because GDP has flatlined. This stands in contrast to Western Europe, where telecoms spend has declined while GDP has significantly increased, thereby leading to a strong decrease in the proportional telecoms spend.

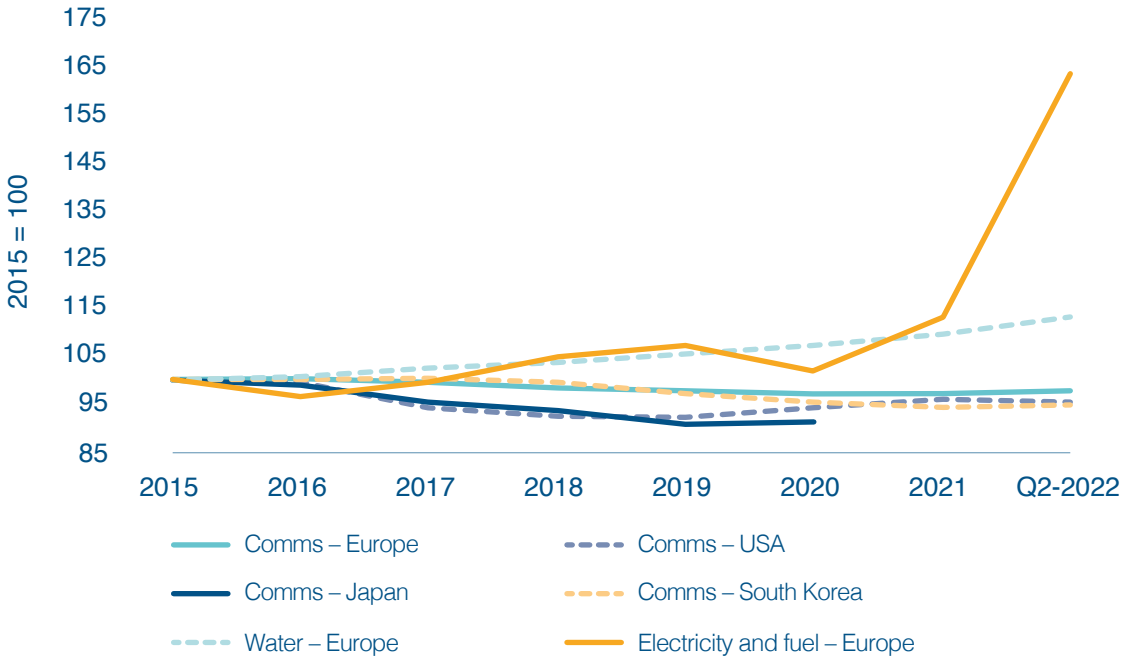
FIG 1.12 : ***Telecoms spend as a proportion of GDP, China, Europe, Japan, South Korea and the USA, 2007–2023f***



Source: Analysys Mason, 2022

Operators have faced considerable increases in input costs due to the current inflationary environment, but telecoms prices for consumers have undershot those for other capital-intensive utilities such as energy and water (**Figure 1.13**). This appears to be true across most regions and OECD countries, but it is worth nothing that energy costs have risen the most in Europe and yet telecoms prices remain low.

FIG 1.13 : *Europe Harmonised Index of Consumer Prices (HICP) and Japan, South Korea and USA Consumer Price Index (CPI) for infrastructure-based services, 2015–2Q 2022*[5]



Source: Source: OECD, 2022

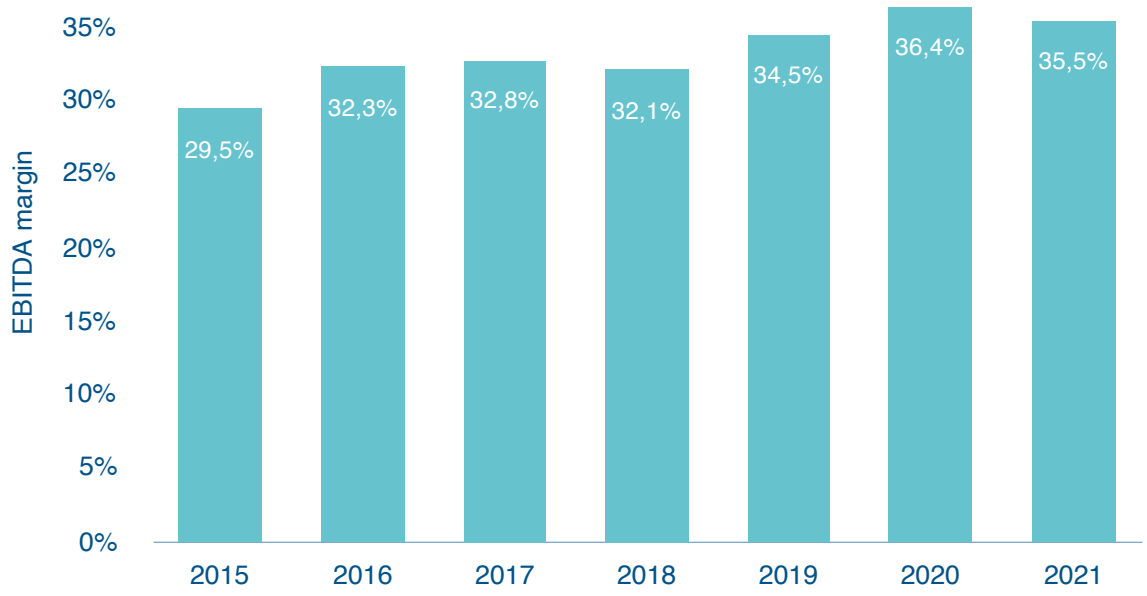
[5] The HICP and CPI published by the OECD and EC use a 'basket of goods and services' to measure inflation as the average change over time that people pay. This basket of goods and services uses a standardised set of products, albeit one that is updated annually to match changes in demand and usage. For communications, this includes wired and wireless, telephone and telefax equipment and services, including services bundled with pay-TV. The CPI for communications in Japan has not been reported by the OECD since 2020.

Inflation is beginning to affect costs, but its impact on telecoms prices is less clear

The impact of inflation is already being felt by telecoms operators, some of which have issued profit warnings because of energy costs. Energy prices started to rise sharply in 2H 2021 because of a return of demand after the pandemic, and the Russian invasion of Ukraine accelerated this increase. 5G is more-efficient than previous generations of mobile networks in terms of watt-hours per gigabyte, but it also requires additional energy to operate. The same is true for fixed telecoms; energy (cost) savings will not be realised unless legacy networks are retired.

Energy accounts for a fairly small percentage of operators' overall costs (3–3.5% for integrated fixed–mobile players before the energy crisis). Energy price rises represent an increase in direct input costs for operators so will reduce profits, but they are also a catalyst for other rising input costs. Operators face strong upward pressure on labour, equipment and raw material costs. This has been reflected in the EBITDA margins for ETNO operators (**Figure 1.14**). Indeed, aggregate EBITDA margins fell in 2021 (prior to the invasion of Ukraine) after several years of efficiency gains and several European operators indicated lower-than-anticipated EBITDA margins in 2022 because of energy-related pressures.

FIG 1.14 : *Aggregate EBITDA margin, ETNO members at the group level, 2015–2021*



Source: Analysys Mason, 2022

> ETNO members have played a key role in supporting Ukraine since Russia's invasion: temporary reductions of inter-operator roaming rates, free prepaid SIM cards, financial donations, adapted termination on mobile calls from Ukrainian operators, free Wi-fi at gathering points for refugees.

Telecom ARPU, particularly for mobile services, typically remains fairly flat during periods of low inflation, and increases in usage (reflected in the data plans that consumers buy) tend to reflect decreases in unit prices. This could pose a problem in inflationary times because it suggests that willingness to spend is elastic, and that telecoms will become the networked utility that inflation forgets. The danger is that spend will remain static while input costs for operators increase, and that consumers that face price rises for essentials will see telecoms as a more controllable element of their spending. At the time of writing, it is rather too early to see whether this was already happening in 2H 2022.

However, some telecoms service contracts allow the operator to raise prices by CPI + a fixed percentage in the middle of a contract. It is more likely that operators will use this facility in inflationary times, and it is also more likely than not that operators will follow, rather than compete against, any larger operator that does increase prices in line with inflation, though there are examples where the opposite has happened. The rush to maximise the conversion of homes passed by new FTTH networks into subscribers exerts some downwards pressure on prices, and many new players may resist price rises for this reason.

No consumer welcomes price rises, but operators' ability to invest in modern, fit-for-purpose networks is at stake. The operating profit (EBIT) margin of European telecoms has declined quite rapidly in the past 3 years (see **section 1-3**) and the future well-being of the European consumer or business may suffer as a result.

Networks keep us connected in times of emergency

The importance of telecoms networks was made apparent nearly 3 years ago when lockdowns were implemented because of the COVID-19 pandemic. European operators reacted to the crisis by offering additional data on mobile plans and lower-cost broadband in order to help those, especially the most vulnerable, to stay connected when physically isolated. Another immediate crisis occurred on the edge of Europe in 2022: Russia invaded Ukraine, thereby triggering the largest displacement of population in Europe since World War II.

ETNO members have played a key role in supporting Ukraine since Russia's invasion. Telecoms networks are essential for communication and co-ordination among both refugees and those trying to help them, and operators have provided free services and technical support. For example, they have introduced significant temporary reductions of inter-operator roaming rates, thereby allowing customers from Ukraine that are staying in the EU and those EU citizens with relatives in Ukraine to call and text for free or reduced prices. They have also provided free prepaid SIM cards and have directly donated money to charitable and governmental organisations working to support displaced Ukrainians. Operators have also adapted termination on mobile calls from Ukrainian operators.[6]

Operators have used their technology and resources in other ways to help refugees. All operators with a significant mobile presence close to the Ukrainian border, primarily in Poland, Romania, Moldova, Poland and Slovakia, have increased their capacity and provided free Wi-Fi at gathering points for refugees.

ETNO members had provided free services worth over €11 million to Ukrainian refugees and people trying to reach those still in Ukraine by the end of March 2022. This was made up of a combination of free calling and the provision of data roaming services at no or reduced charge.

Network infrastructure resilience is vital during times of emergency to help societies to cope with crises and start to recover. It is more important than ever that reliable and fast access to the internet is maintained during crisis situations as more and more services move online and citizens' interactions with governments become digitised, in line with Digital Decade targets.

[6] European Commission (2022), *Joint Statement by EU and Ukrainian operators to help refugees from Ukraine stay connected*

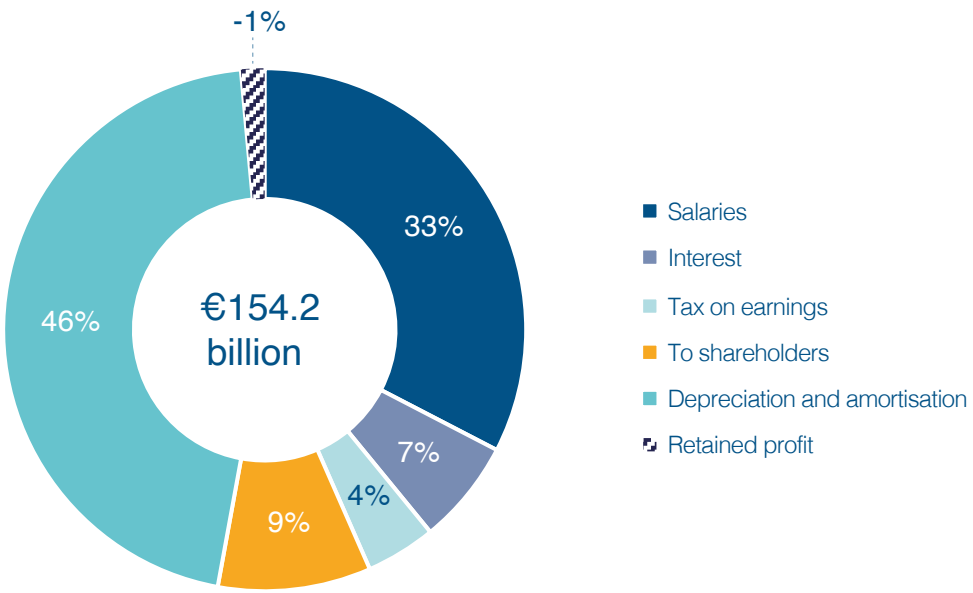
1-2 INDIRECT IMPACT FOR EUROPEANS

ETNO members contribute indirectly to European society well-being in several ways: through taxation, through investing in skills and rewarding employment and through sustained capital investment.

Distribution of value added

ETNO members are deeply embedded in European economic and social life, not simply because of the communications-based services that they offer. ETNO members generated €288.4 billion in revenue in 2021, €187.6 billion of which was generated in Europe. Value added (essentially revenue minus the direct cost of goods and services) was €154.2 billion. The distribution of this value has substantial indirect benefits for the European economy, for employees, for suppliers and for shareholders, a very high proportion of which are institutional investors (**Figure 2.1**).

FIG 2.1 : *Distribution of value added, ETNO members at the group level, 2021*

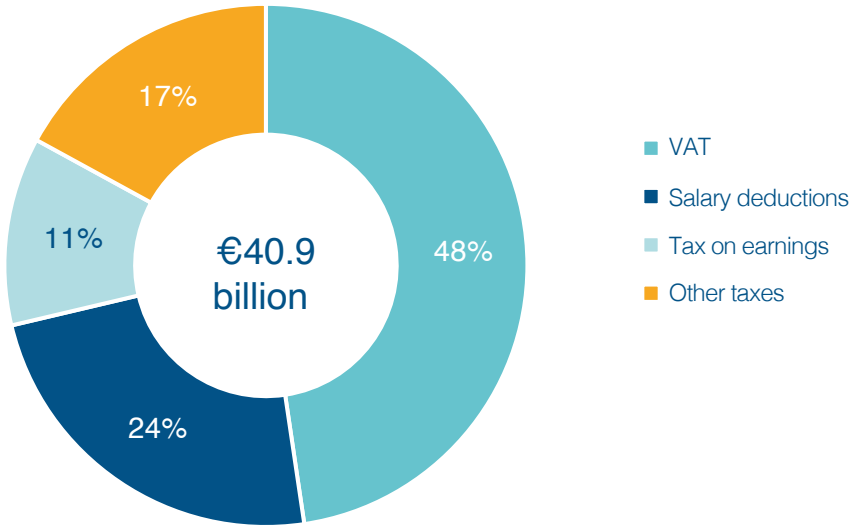


Source: Analysys Mason, 2022

Operator shareholders are often institutional investors such as pension funds, so the steady profitability of major European telecoms operators has important social benefits. ETNO members regularly distribute an important share of their net profit to shareholders. Indeed, dividend payments in 2021 were equivalent to about 64% of net profit from 2020. This distribution level is in line with the market average, but is lower than that for utilities such as energy. Net profits for ETNO members (excluding the impact of one-off asset sales but including impairment charges) declined by 46% between 2020 and 2021, and dividend pay-outs as a proportion of 2021 net profits exceeded 100% hence the negative value in the distribution of value added in **Figure 2.1**.

ETNO members paid around €40.9 billion in direct taxes (tax on earnings and other direct taxes) and indirect taxes (VAT and salary deductions) for their European operations in 2021; this is equivalent to about 22% of their revenue base (**Figure 2.2**).

Figure 2.2 : *Total direct and indirect tax, ETNO members (Europe only), 2021*



Source: Analysys Mason, 2022

The 'other taxes' category includes property taxes and telecoms-specific charges such as recurring spectrum licence fees (but not the prices paid at auction), fees for using numbering resources, specific taxes on telecoms assets (such as pylons and copper), universal service costs, the cost of financing national regulatory authorities and obligations to finance other sectors (such as public TV). The prices paid at auction for spectrum licences are not strictly a tax, but they have a similar function. European operators have paid €29.3 billion on spectrum licences since 2018.

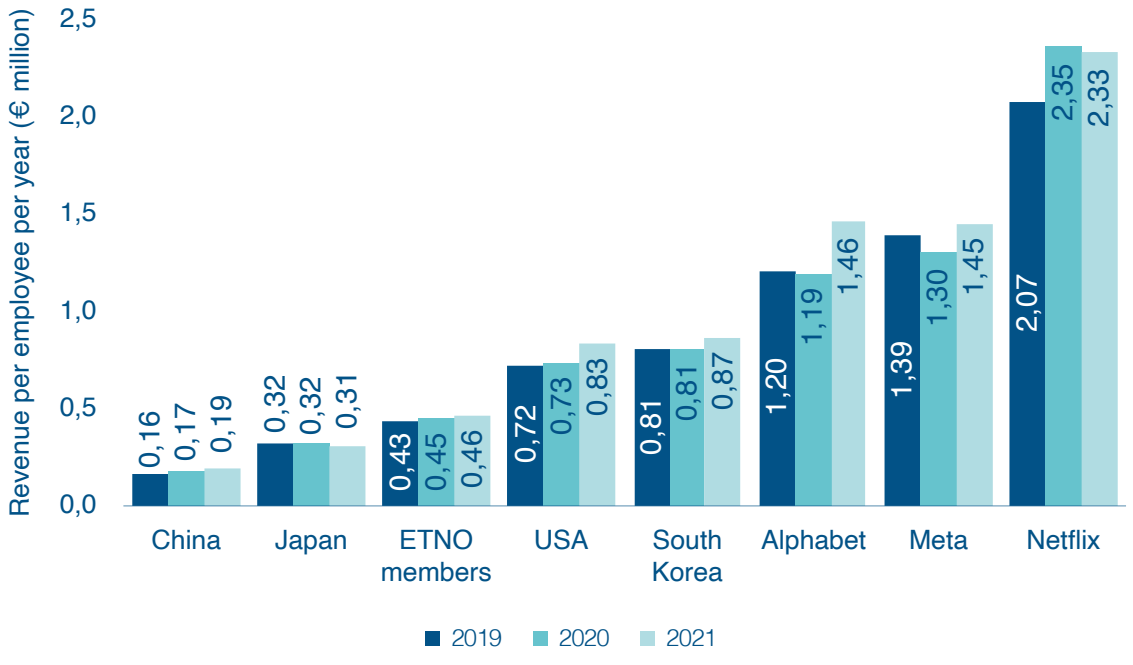
High-quality, productive and fair employment

The skill sets required by the telecoms industry are evolving, thereby driving the demand for skilled employees from both operators and vendors (Europe is home to two of the three top telecoms equipment vendors worldwide). The automation of customer- and network- facing functions has shifted the demand from lower- to higher-skilled posts; employees with software skills are particularly in demand. The total workforce of ETNO members in Europe declined by 4.0% in 2021, but employment costs rose by 2.1%, which equates to a rise in the average salary of about 6.3%.

Europe suffers from an ICT skills shortage (as do other regions); this has been compounded by high employment levels in some countries, thereby making it harder to recruit due to the smaller pool of potential applicants. Internal upskilling programmes have therefore become essential for operators.

Figure 2.3 shows the revenue per employee for ETNO members and comparable operators in China, Japan, South Korea and the USA. As the labour force evolves, so should productivity. Indeed, ETNO members have seen modest increases in productivity in recent years, and the gap between ETNO members and US operators can be explained by economies of scale and the very great difference in ARPU. CAPs such as Alphabet, Meta and Netflix enjoy higher productivity than ETNO members, but the skill sets that they require are more software-centric and therefore command substantially higher remuneration. It is nonetheless noteworthy that continuous growth in productivity (termed the platform effect) is no longer guaranteed, and consequently neither is job security. For example, Meta shed 11 000 staff (13% of its entire workforce) in October 2022.

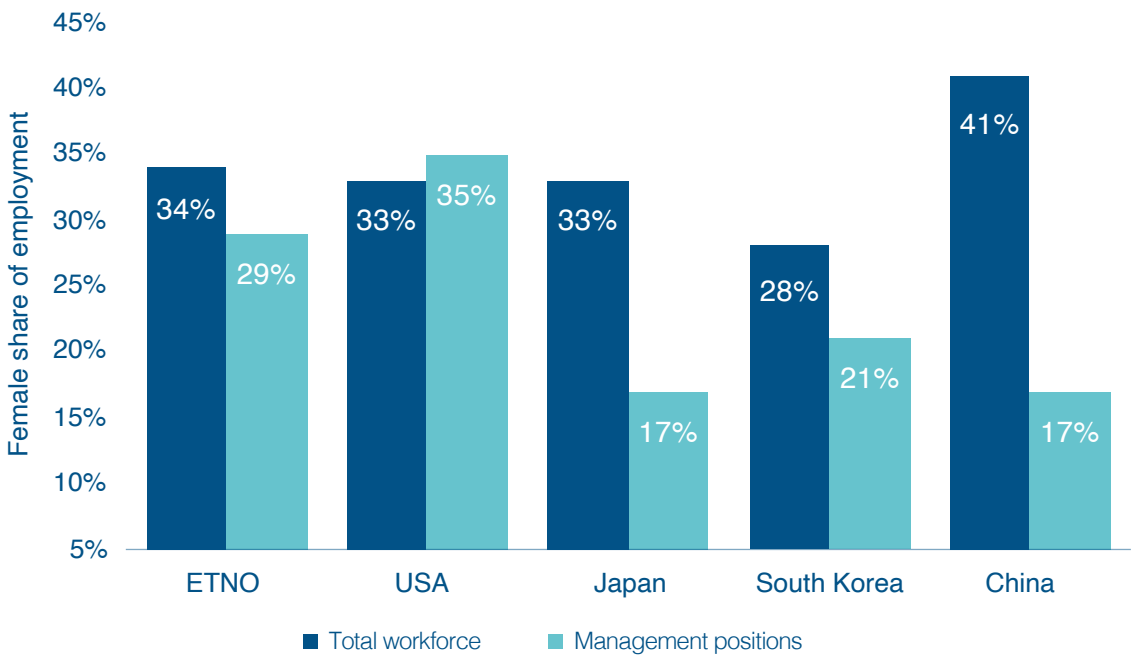
FIG 2.3 : ***Revenue per employee for ETNO members, operators in China, Japan, South Korea and the USA and selected CAPS, 2018–2021***



Source: Analysys Mason, 2022

The overall female share of the workforce has remained roughly stable among European operators, though the proportion of managers who are women has grown. Many ETNO members have established pipelines for female talent development and are aiming to increase the conversion of female employees into managers over the course of their careers. This is important because there is no automatic link between a high proportion of female staff and large number of female managers. Indeed, Japan and China are particularly stark examples of this (**Figure 2.4**).

FIG 2.4 : *Estimate average share of women in the workforce among ETNO members and operators in China, Japan, South Korea and the USA, 2021*



Source: Analysys Mason, 2022

In some markets women occupy a similar proportion of management roles to the proportion in the total work force. 29% of managers in Europe are female, compared with 35% in the USA, 21% in South Korea and 17% in both China and Japan. The gap between the total proportion of female employees and the share of female managers is smaller among ETNO members and operators in the USA than among operators in Asia. Indeed, China has the highest rate of women in the workforce (41%), but joint lowest proportion of female managers (17%). Different companies define management positions differently, but most include middle manager roles and above, though some may only include more senior management. It is worth noting that this overall management figure does not reflect the presence of women at the highest levels of European operators.

Many ETNO members have set specific targets for the proportion of women in management roles. For example, Orange plans to fill 35% of senior leadership roles with women by 2025. Altice Portugal has committed to reach the Portuguese national target of having 40% of senior management positions filled by women by 2030 and Telia intends to achieve a 50/50 gender balance in its extended leadership team by 2025. ETNO operators have also committed to initiatives aimed at growing the number of women in technical and digital roles. For example, Elisa has worked with Women4CyberFinland, an organisation that trains and mentors women that are aiming to work in the cyber security industry in Finland, which has traditionally been dominated by men. Swisscom is trying to encourage young women to take engineering roles by running Digital Days for Girls that showcase the diverse range of technical roles that women can take on in telecoms.

1-3 CAPITAL INVESTMENT: SUSTAINED INVESTMENT IN 5G AND INCREASED INVESTMENT IN FTTH

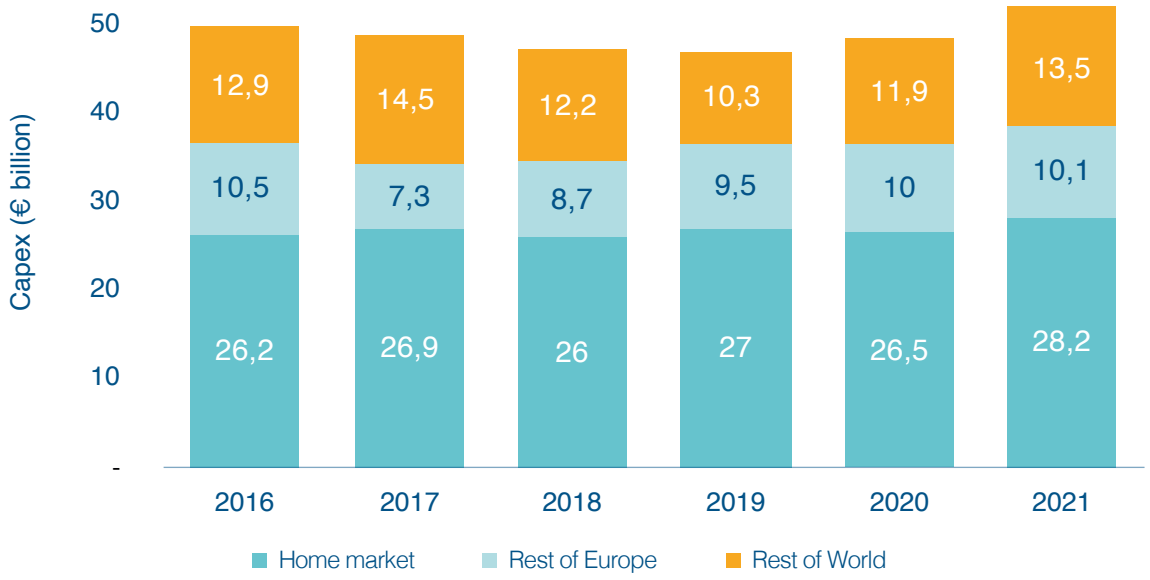
Telecoms operators are investing ever more heavily in upgrading their infrastructure. This, together with lower ARPU and revenue than their peers in other regions, is reflected in high capex intensity by global industry standards. This has both direct and indirect benefits for Europeans: it results in good-quality jobs and investment in a European supply chain (two of the top three telecoms equipment vendors worldwide are based in Europe).

There are two concurrent cycles of heavy investment: the upgrade to 5G and the upgrade of local fixed access networks to FTTH. The cadence of each of these two cycles is quite different. New generations of mobile technology tend to appear every 8–10 years, but in reality, capital investment in physical mobile networks is fairly steady and spread out over several years; it only looks spiky when spectrum acquisitions are considered. FTTH investments are longer-term, involve significant bulges in capex, but are one-off in nature. Moreover, the timing of FTTH investment is not dictated by the appearance of new technology generations or by the dates of spectrum auctions, and therefore has been different in different areas across Europe. Indeed, the process of fiberisation of the local loop is quite near completion in some countries, whereas there has been a significant capex uptick in the past year in others, including the two with the largest populations, Germany and the UK.

Capex from both ETNO members and other operators grew strongly in 2021 (**Figure 3.1**). Total capex by ETNO members, including investments outside Europe, was €51.8 billion in 2021; this represents 7% year-on-year growth. This figure was €38.3 billion when excluding investments outside Europe, up by 5.7% since 2020 (**Figure 3.2**). Capex in ETNO members' home markets was €28.2 billion in 2021, up by 7.7% year-on-year. These figures include capex for joint ventures in which ETNO members have operational control. FTTH is the largest driver of capex growth in both home and European markets.

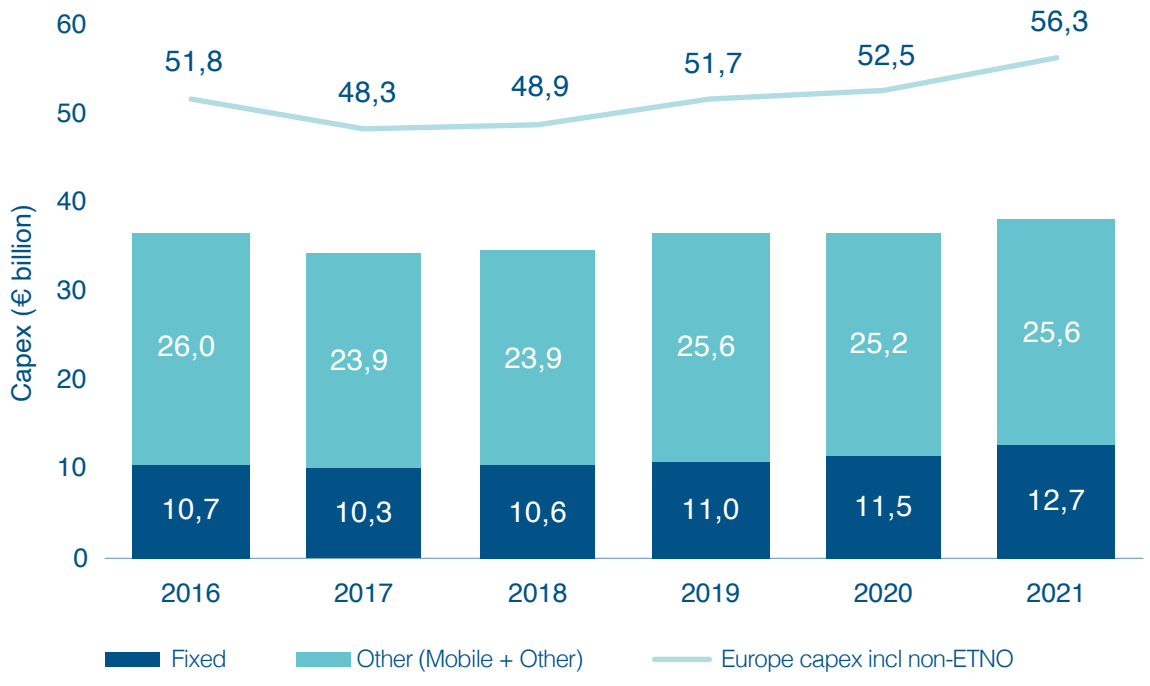
[7] Home markets are the countries in which the operator is the historical incumbent. The definition includes lines of business that serve multinational enterprises, but excludes mainstream operating businesses based in other countries. Comparator operators outside Europe have few mainstream operating businesses outside their home markets, and hence a comparison on the basis of 'home markets' is appropriate.

FIG 3.1 : *ETNO member capex (excluding spectrum costs), home markets, rest of Europe and rest of the world, 2016–2021*



Source: Analysys Mason, 2022

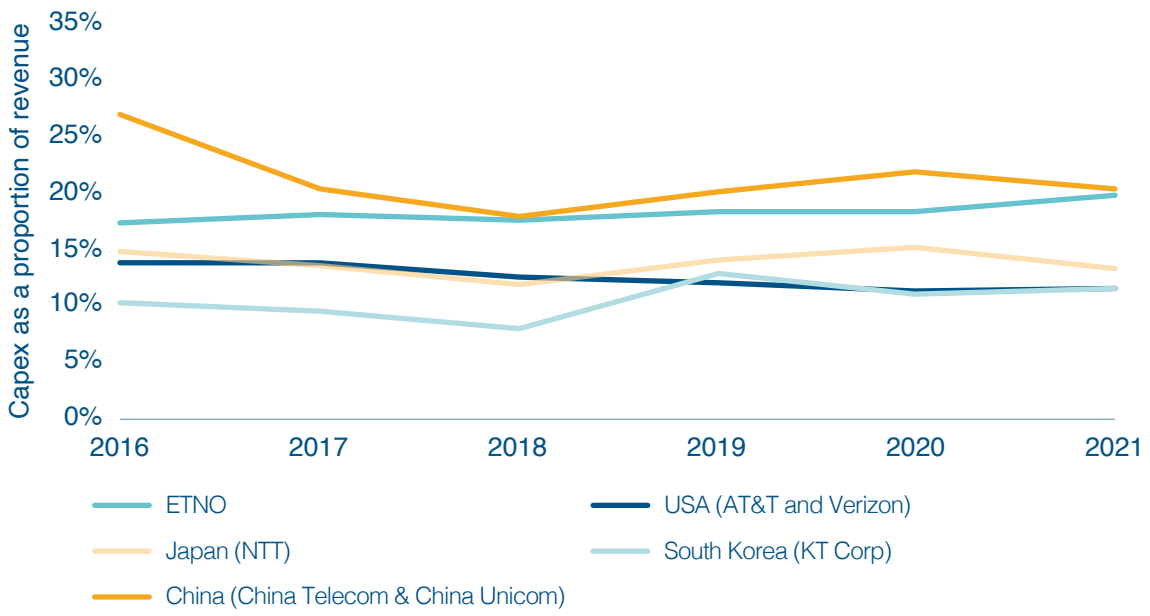
FIG 3.2 : *ETNO member capex in Europe only (excluding spectrum costs), plus total capex in Europe, 2016–2021*



Source: Analysys Mason, 2022

ETNO members' capital intensity continues to rise and is now nearing 20% in home markets. The figure in Europe is significantly higher than that in the USA, Japan and South Korea, and is only fractionally lower than that in China (20.3%) (**Figure 3.3**).

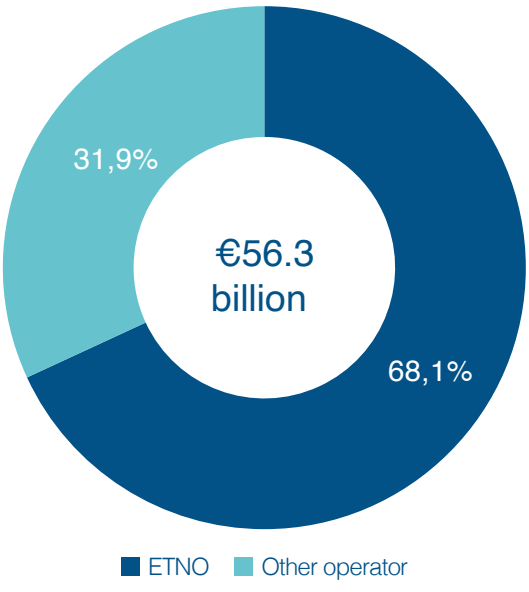
FIG 3.3 : *Capital intensity in home markets, ETNO members and comparable leading operators in China, Japan, South Korea and the USA, 2016–2021*



Source: Analysys Mason, 2022

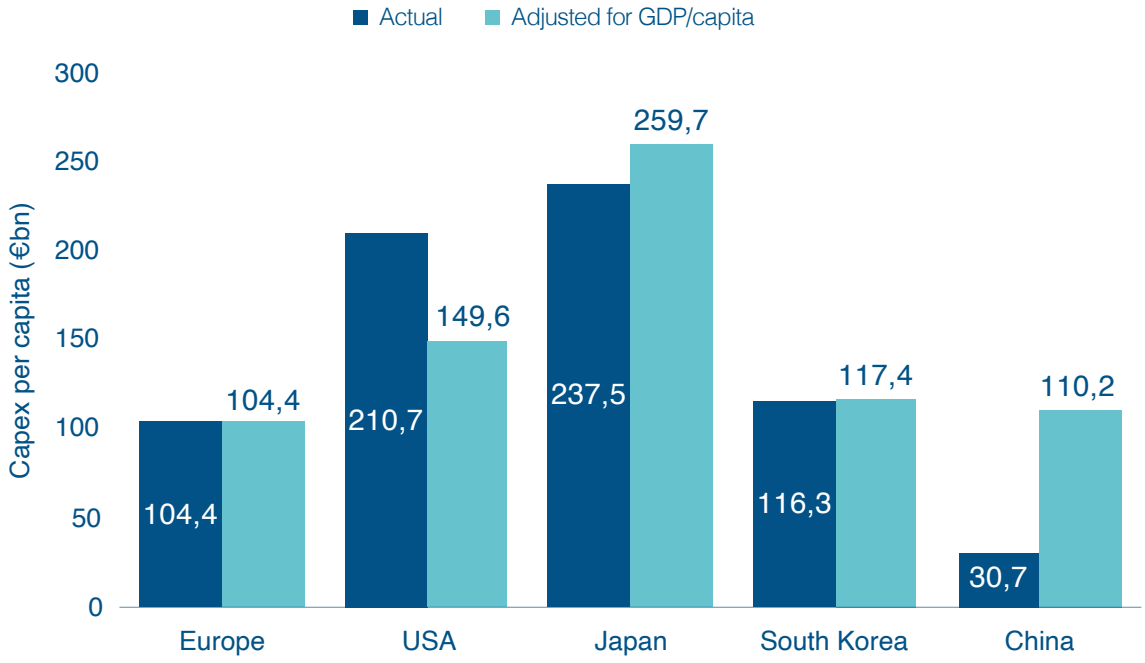
ETNO members have accounted for around 70% of telecoms investments in Europe in recent years. Indeed, ETNO members accounted for 68.1% of European telecoms operator capex in 2021, down slightly from 69.8% in 2020 (**Figure 3.4**). This decrease in ETNO members' share of capex disguises the fact that ETNO member capex actually grew in absolute terms. Established non-ETNO operators' capex increased at roughly the same rate as that of ETNO members, but new fibre infrastructure players boosted the non-ETNO share.

FIG 3.4 : *Split of capex between ETNO members and other operators, Europe, 2021*



ETNO members' high capital intensity must also be understood in terms of their proportionately lower ARPU and revenue. The actual investment per capita is lower than that in the other countries included in this report, even when adjusted for GDP per capita (**Figure 3.5**).

FIG 3.5 : *Capex per capita, China, Europe, Japan, South Korea and the USA, 2021*

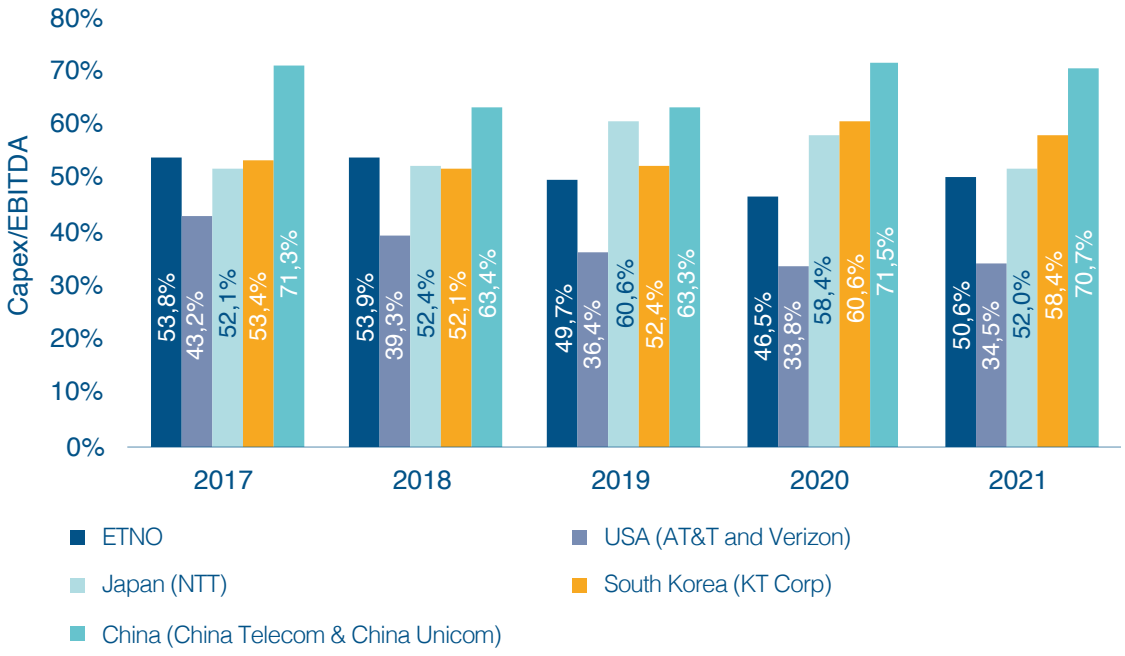


Source: Analysys Mason, 2022

> European telecom operators invested a record of €56.3 billion in 2021, the highest level since 2016.

Another way of looking at this is to consider the ratio of capex to EBITDA (**Figure 3.6**). This is quite high, especially when one considers the improvement in ETNO members' EBITDA and EBITDA margins between 2017 and 2020 due to increased operational efficiency (not revenue increases). In fact, ETNO members had the highest average EBITDA margins of all groups included in this report in 2021 (35.3%); they were fractionally higher than those of US operators (33.1%), higher than those of Chinese operators (28.7%) and substantially higher than those of Japanese and South Korean operators (26.7% and 20.8%, respectively). Nevertheless, it must be noted that the state's ownership and direction of Chinese operators makes their reinvestment level higher and, conversely, their cash conversion lower.

FIG 3.6 : ***Capex/EBITDA ratio, ETNO members and peers in China, Japan, South Korea and the USA, 2017–2021***

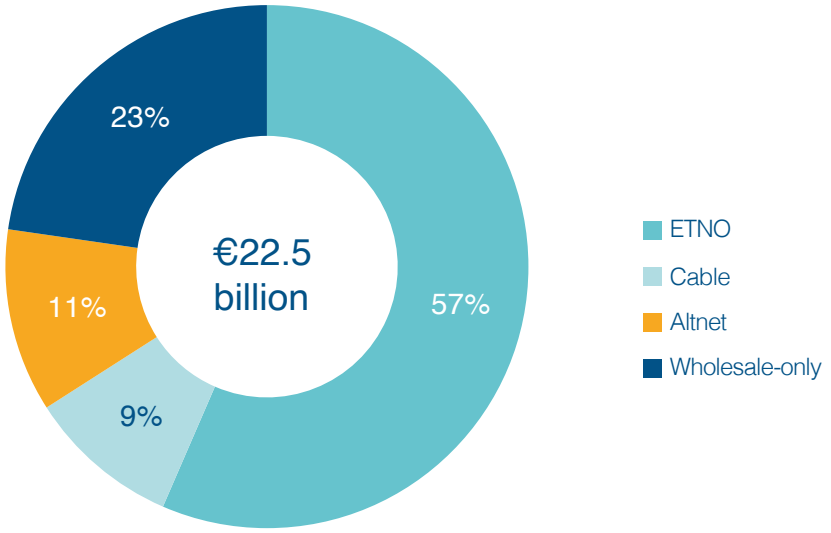


Source: Analysys Mason, 2022

Fixed/FTTH capex

Fixed access (dominated by new FTTH builds) accounts for most of the current growth in telecoms capex and ETNO members accounted for 57% of fixed access capex in 2021. Fixed network capex is distributed among a greater number of players than mobile capex; emerging regional infrastructure players and new local players compete with traditional telecoms operators (**Figure 3.7**). Moreover, the structure of the market, among ETNO members and altnets, is characterised by co-investment by infrastructure investors.[8]

FIG 3.7 : *Split of fixed capex between ETNO members and other operator types, Europe, 2021*



Source: Analysys Mason, 2022

Several new and growing wholesale-only players are active at a regional level, but only a few have national ambitions (OpenFiber in Italy and FastFiber in Portugal). In addition, there are a large number of new, mostly quite local, altnets with a vertically integrated business model (their number reaches the high double digits in the UK). The role of utilities and municipal infrastructure providers in using their existing construction knowledge to build new FTTH networks is also growing. They have played a prominent role in Nordic countries and Switzerland for a long time. Recent examples include Vattenfall's joint venture with Eurofiber to create an FTTH network in Berlin and NTE's investment in long-distance fibre networks.

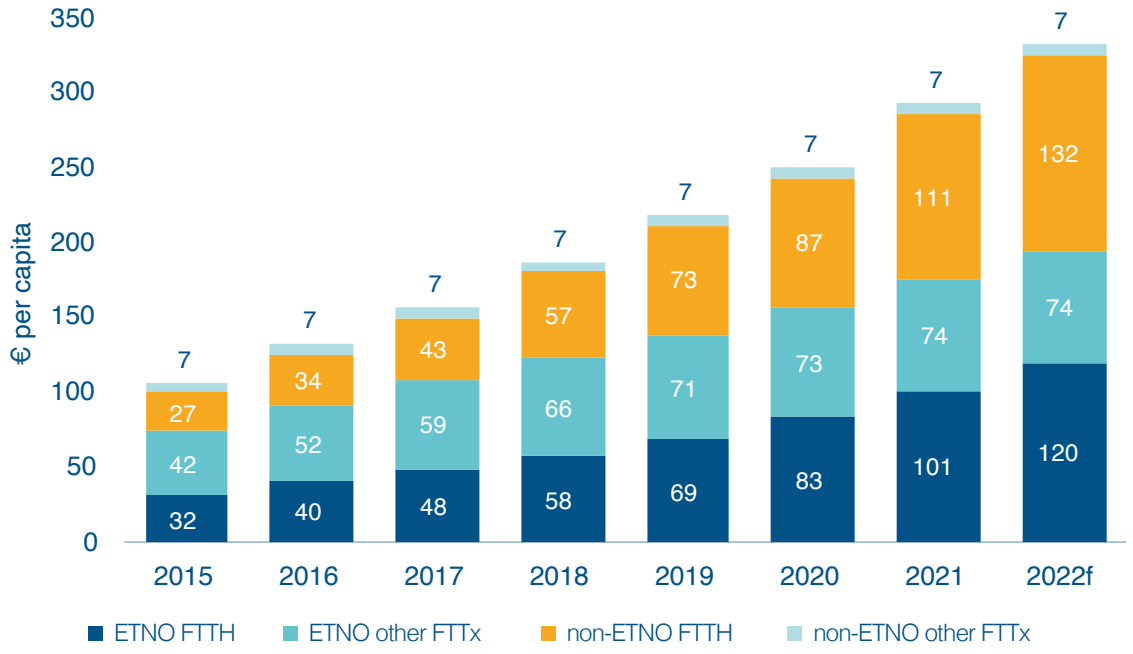
Further infrastructure-based competition in FTTH will come from cable operators, several of which (including Virgin Media O2, Virgin Media Ireland, SFR, Telenet and Vodafone Germany) have signalled, and in some cases embarked upon, upgrades to FTTH in part or all of their networks. Some of these have also suggested that they may enter into the wholesale market.

FTTH markets are beginning to show signs of consolidation and rationalisation. Several alliances, for example in Austria, Germany, Spain and the UK, were created in 2021 and 2022 between fibre infrastructure providers based on reciprocal access to each other's FTTH networks. For example, CityFibre and Toob in the UK have a strategic partnership that allows CityFibre wholesale customers to use Toob's network, and Toob can sell services through CityFibre's network.

[8] The splits are based on consolidated accounts rather than on equity.

The cumulative amount spent per capita on FTTH in Europe is high and rising (**Figure 3.8**). The EU has encouraged infrastructure-based competition in FTTH networks, which inevitably means that there is a degree of overbuild and that investment does not flow to certain areas. However, overbuild also bakes in a higher degree of network resilience because there are multiple FTTH connections to the same area, thereby preventing a single point of failure from disrupting data traffic. The level of FTTH-on-FTTH overbuild was 1.37 aggregate premises passed to 1 unique premises passed at the end of 2021; this ratio will only grow as cable operators start to upgrade to FTTH. The total cumulative investment on all FTTx by the end of 2022 was the equivalent of €646 for every premises in Europe (including those not yet covered), which works out at €333 per member of the population, €194 of which was invested by ETNO members in their home markets.

FIG 3.8 : *Cumulative FTTH capex per capita, ETNO and others, 2015–2022f*

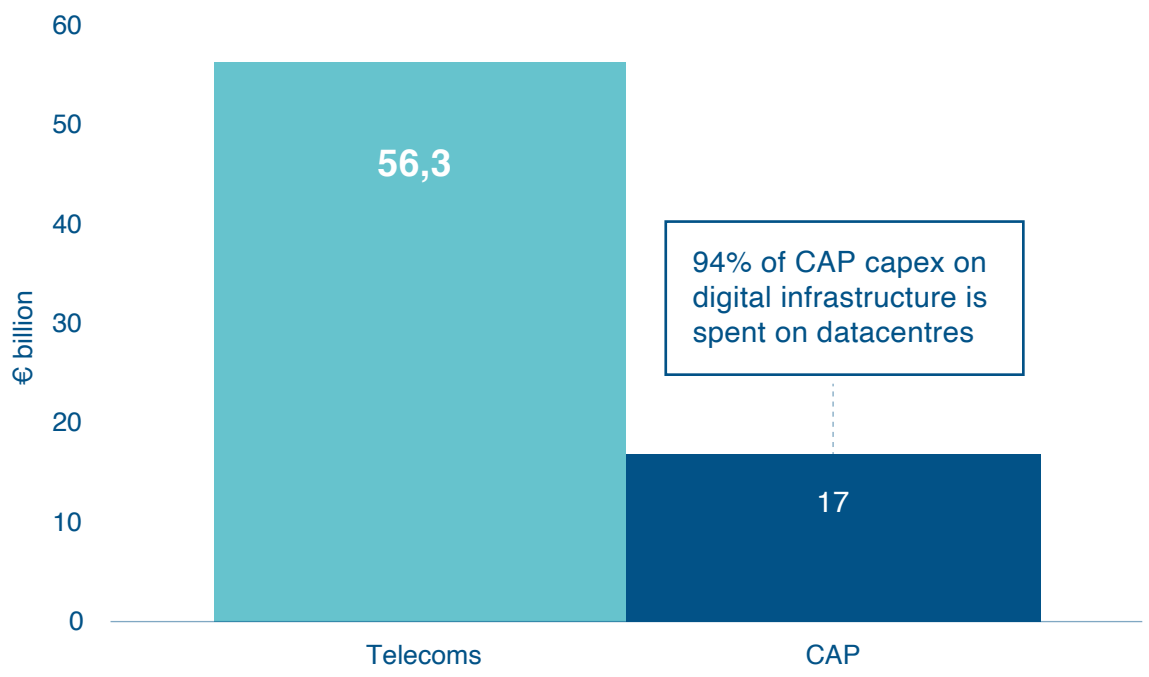


Source: Analysys Mason, 2022

Investment in digital infrastructure: telecoms players versus CAPs

The investment discussions above include all capex of established and new telecoms players. Large-scale CAPs also invest in digital infrastructure, but in reality there is very limited overlap with what telecoms operators invest in. CAPs' level of direct investment in digital infrastructure in Europe (that is, investment over and above that in content, applications and services that are sold to their customers) amounted to an estimated €17 billion per year between 2018 and 2021 (**Figure 3.9**). About 94% of CAPs' direct investment in infrastructure worldwide was directed towards data centres, and this proportion is unlikely to be significantly different in Europe. As such, we can estimate that CAPs invested approximately €16 billion in data centres and approximately €1 billion in a mix of transport networks (primarily very large international/subsea routes) and internet peering/direct transit and caching. CAPs have so far invested almost nothing in European physical networks that are closer to end users than caches, and certainly nothing at all in European fixed access or the physical RAN. Telecoms operators' investments in larger data centres have stalled because hyperscale cloud businesses enjoy economies of scale. However, edge cloud could partly reverse this trend because operators are well-versed in managing highly distributed asset sets.

FIG 3.9 : *Direct capex on digital infrastructure, total European telecoms sector and CAPs, 2021*



Source: Analysys Mason, 2022

There is very limited overlap in terms of what digital infrastructure asset classes telecoms operators and CAPs invest in, and they may be said to be largely complementary. However, operators and CAPs do enter into voluntary commercial agreements that work both ways.

- CAPs may buy transport links from telecoms players.
- Telecoms operators may buy cloud infrastructure and applications from CAPs as traditional IT workloads and, increasingly, network functions move to the cloud

SECTION 2

Demand for digital services

In this section, we consider the demand side of the telecoms and digital services market, including revenue for consumer and enterprise services and the relative amounts spent with operators and CAPs (also known as OTTs).

2-1 DEMAND FOR BASIC COMMUNICATIONS SERVICES

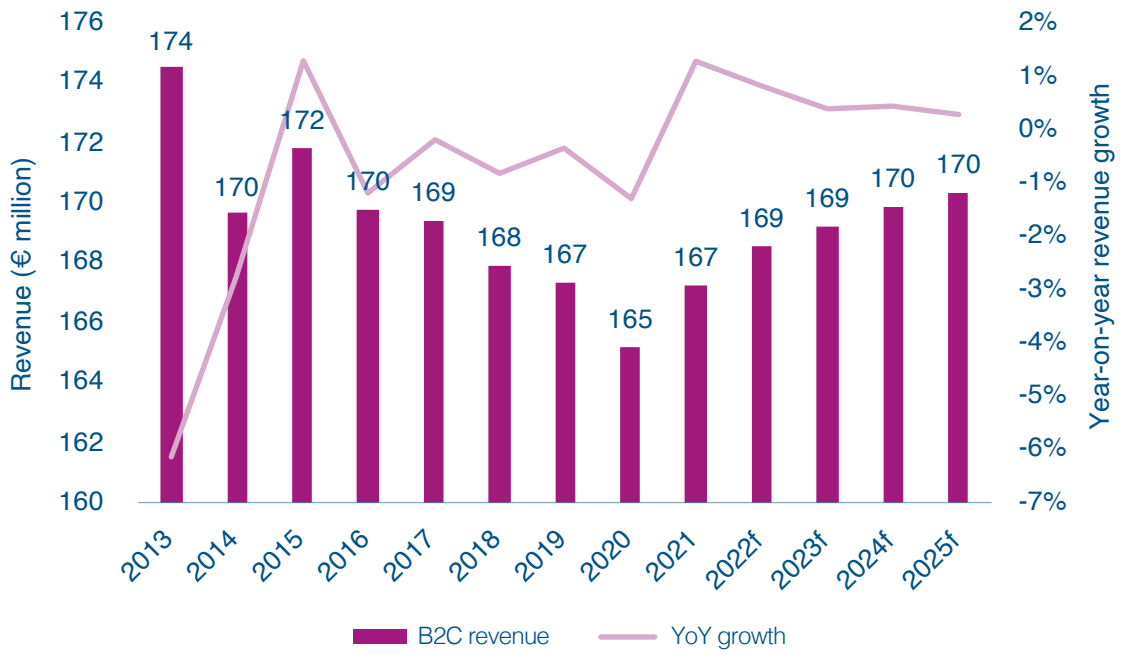
The COVID-19 pandemic increased the demand for data among both consumers and businesses because consumers had to remain indoors and employees were forced to work from home. Working from home and remote schooling are now less common than they were during the height of the pandemic, but the increased dependence on connectivity and digital content and services has remained. This higher level of demand is expected to continue for a variety of online services, ranging from e-commerce to video streaming.

In general, digital services can be broken down into those that are sold directly to consumers (B2C) and those that are used by businesses (B2B). There is overlap in terms of the sorts of services sold, but the markets operate very differently.

Revenue patterns

Consumer service revenue at an operator group level increased by 1.3% year-on-year in 2021 (**Figure 4.1**). This is a very small increase, but is nonetheless a departure from the continuous shallow revenue decline prior to the pandemic. The pandemic had a significant impact on revenue in 2020 due to the reduction in travel and associated roaming revenue, as well as consumers' financial uncertainty, which affected their ability to pay for services. Competition and regulation continue to put downward pressure on prices, but the ongoing importance of fast and reliable connectivity means that the telecoms market is more resilient to demand shocks than other sectors where spending is less discretionary. The 2021 increase should be understood as a rebound; it is difficult to imagine that retail B2C spend will grow significantly over the next few years.

FIG 4.1 : *Consumer telecoms service revenue and year-on-year growth, Europe, 2013–2025f*

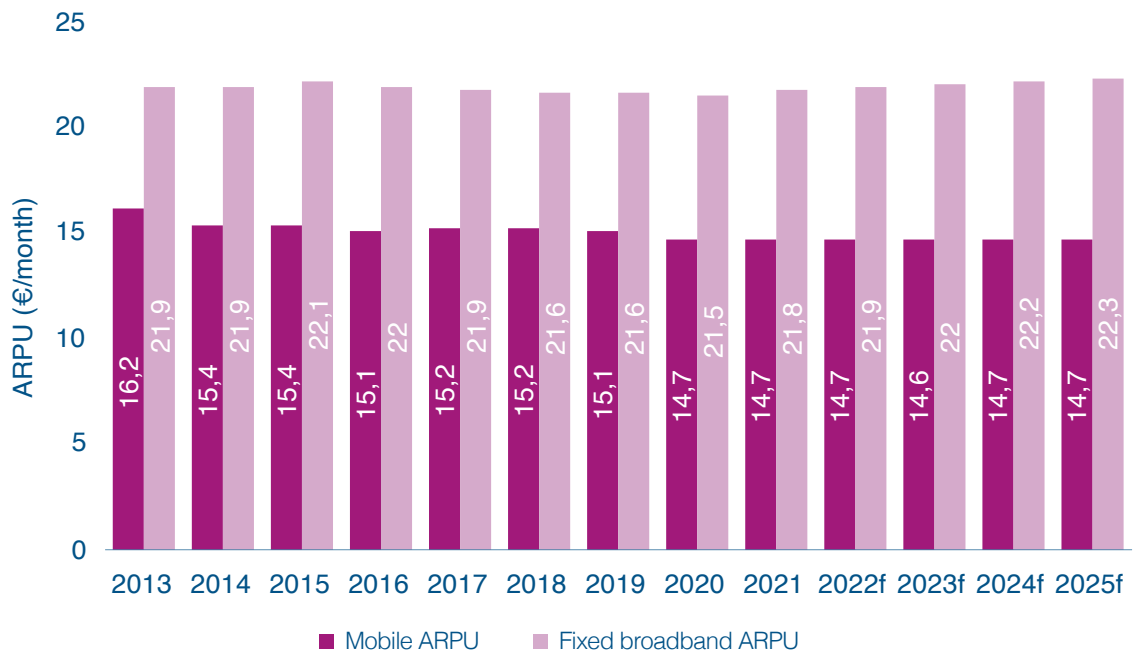


Source: Analysys Mason, 2022

Mobile ARPU in Europe is likely to remain at around €14.7 for the foreseeable future (**Figure 4.2**). The decline of mobile ARPU since the onset of the pandemic demonstrates that increasing usage does not translate into higher revenue and, as discussed in **section 1-1** above, FMC is becoming increasingly common among operators and contributes to mobile ARPU erosion. Mobile operators in most regions have also struggled to charge premium prices for 5G services, thereby offering little support for reversing the trend of declining ARPU through the use of faster technologies.

Fixed broadband ARPU has consistently remained at about €21–22 for the past 10 years, despite the sizeable investments in FTTH upgrades (**Figure 4.2**). As in the mobile market, strong retail competition, exacerbated by a legacy of regulation that focuses on incentivising resale over investments, limits operators' ability to raise prices significantly for FTTH services. However, they are still able to charge a small premium on average.

FIG 4.2 : *ARPU for mobile and fixed broadband services, Europe, 2013–2025f*

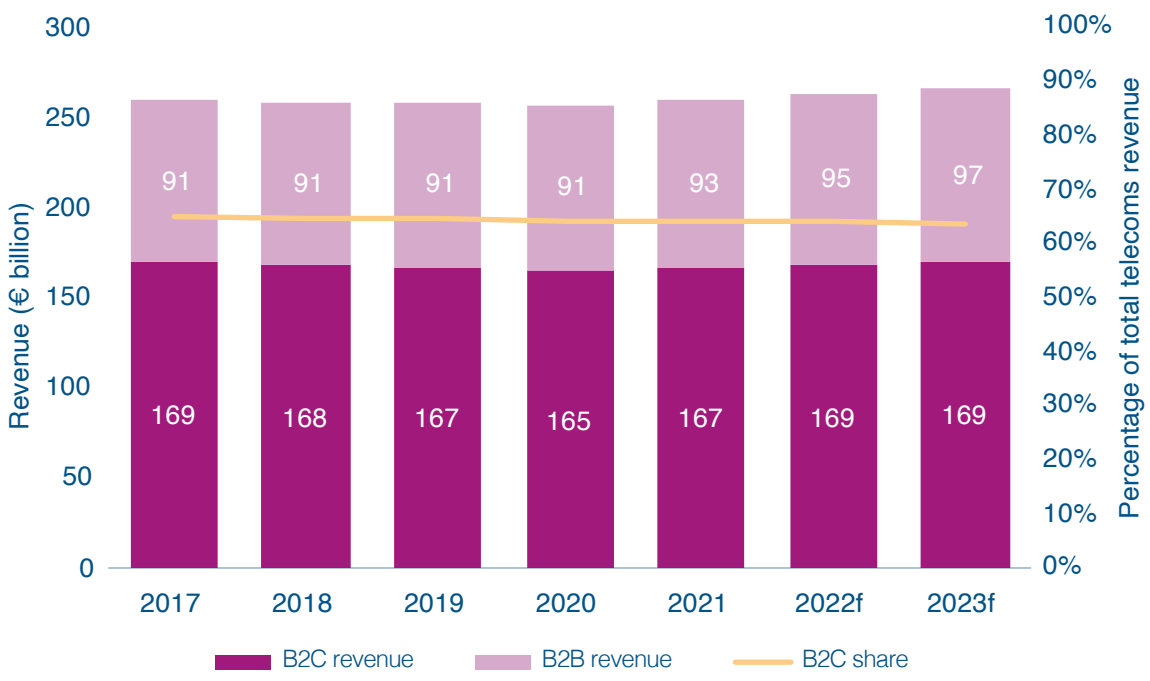


Source: Analysys Mason, 2022

B2B and B2C revenue comparison

The split of total telecoms revenue between B2B and B2C services has been largely stable in recent years; B2C services have accounted for 63–65% of the total since 2012 (**Figure 4.3**). 5G is part of government-supported industrial strategies to recover from the pandemic in some countries. Operators are also likely to use 5G as a key selling point when expanding their B2B offerings. It is possible that there will be a faster increase in B2B revenue as 5G coverage becomes more widespread because a wider range of enterprise use cases will be available.

FIG 4.3 : ***Operators' B2B and B2C revenue and the B2C share of the total telecoms revenue, Europe, 2017–2023f***



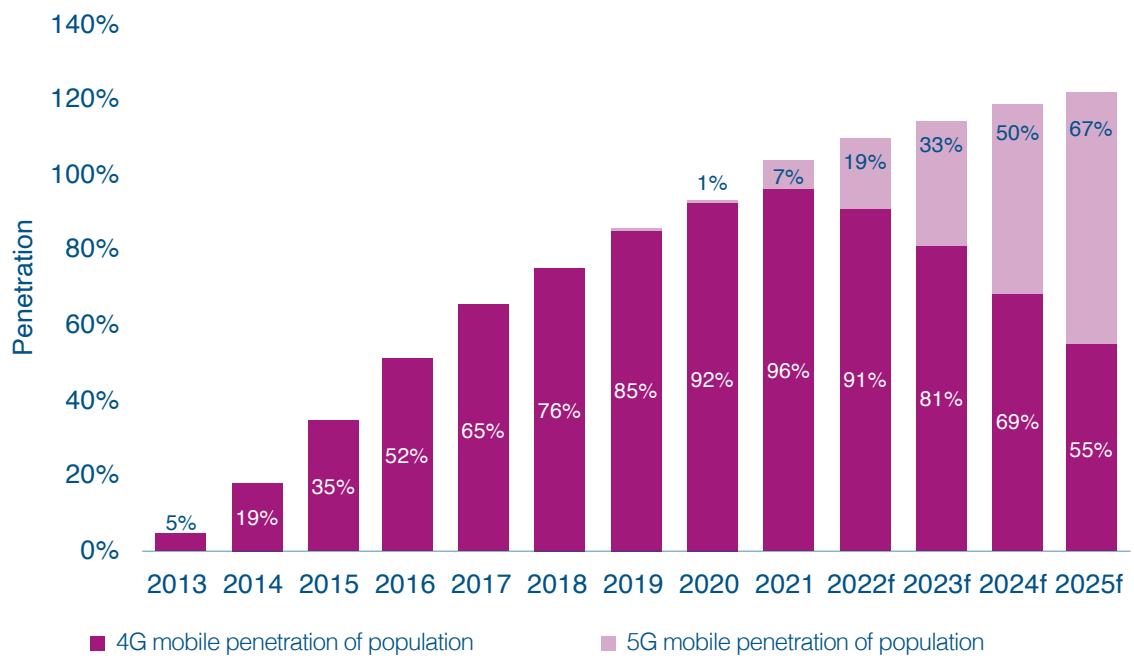
Source: Analysys Mason, 2022

Mobile connections

5G coverage is beginning to grow rapidly in Europe, albeit from a low initial base (just 7.3% of the population was covered in 2021). It is estimated that the 5G population penetration will reach 67% in Europe by 2025 (**Figure 4.4**), which represents an enormous increase from the current situation. 4G coverage, which is almost universal in Europe, is expected to begin to decline as operators move their networks over to 5G infrastructure; we expect that it will fall to 55% by 2025.

> 5G covers 73% of Europe, but uptake remains low: only 6.4% of all mobile connections in Europe are 5G.

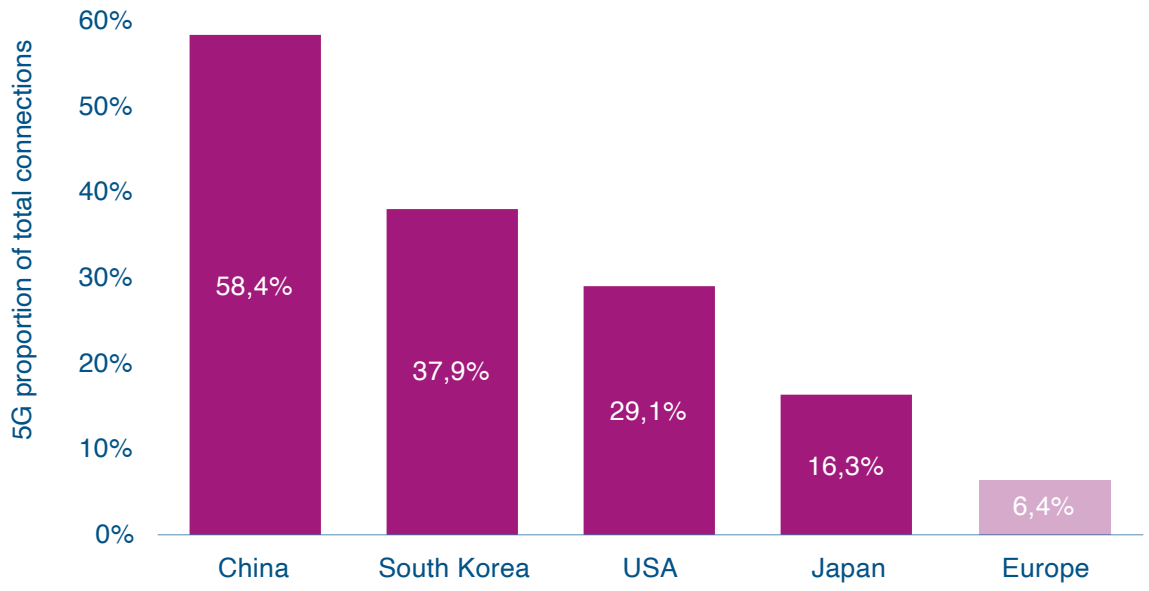
FIG 4.4 : *Population penetration of 4G and 5G, Europe, 2013–2025f*



Source: Analysys Mason, 2022

5G connections require upgraded mobile devices (most commonly new-generation smartphones) to access 5G connectivity. As such, the conversion of 5G coverage into 5G subscriptions in Europe continues to lag behind that elsewhere in the world. The 5G share of all connections is the highest in Asia–Pacific; over half of Chinese and more than a third of South Korean mobile connections use 5G. The 5G share of mobile connections in Europe has grown to 6.4% as of 1Q 2022, up by 3.6 percentage points from last year's report (**Figure 4.5**). As such, we expect that the absolute number of 5G connections in Europe will grow from 31 million in 2021 to 361 million by 2025.

FIG 4.5 : *5G share of all mobile connections, China, Europe, Japan, South Korea and the USA, 1Q 2022*



Source: Analysys Mason, 2022

However, the 3.6-percentage point growth in Europe is much lower than that elsewhere in the world. In the same period, the share of 5G connections grew by:

+3.6% in Europe

+8.6% in South Korea

+9.0% in Japan

+15.7% in the USA

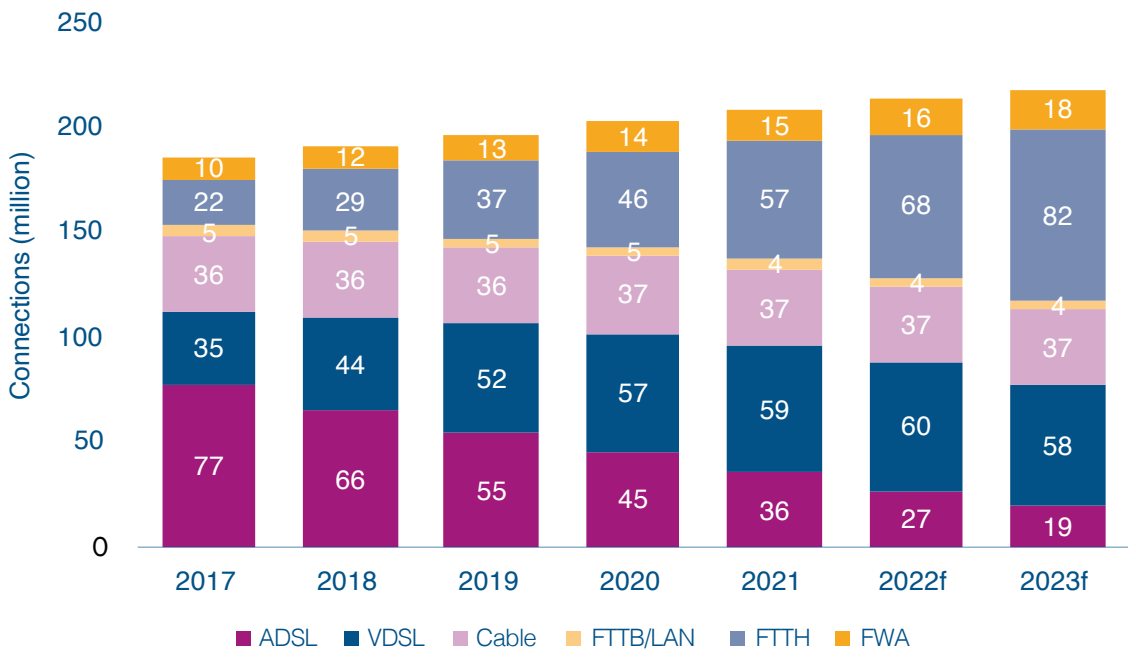
+42.9% in China

Coverage in Europe and the lower levels of mobile usage may be partly responsible for making Europeans less inclined to upgrade to 5G-ready devices, though both factors vary significantly across the continent.

Fixed broadband connections

ADSL technologies were once the backbone of European fixed networks, but they are now reaching obsolescence (**Figure 4.6**). The use of VDSL, usually combined with a fibre-to-the-cabinet (FTTC) topology, appears also to have peaked and this technology is being superseded with FTTH. Similarly, the number of cable broadband connections, which had been growing in recent years, is now estimated to have peaked and several cable operators have signalled their intentions to upgrade to FTTH. FWA, which is currently a small component of European broadband, has received a boost from 5G and some operators are now investing in it to cover areas where FTTH access is either practically impossible or severely uneconomic. The number of FWA connections is forecast to increase from 16 million in 2021 to 18 million by 2023, but this overall figure disguises FWA's main role as a functional alternative in certain circumstances, with uneven take-up between countries.

FIG 4.6 : ***Fixed broadband connections by technology, Europe, 2017–2023f***



Source: Analysys Mason, 2022

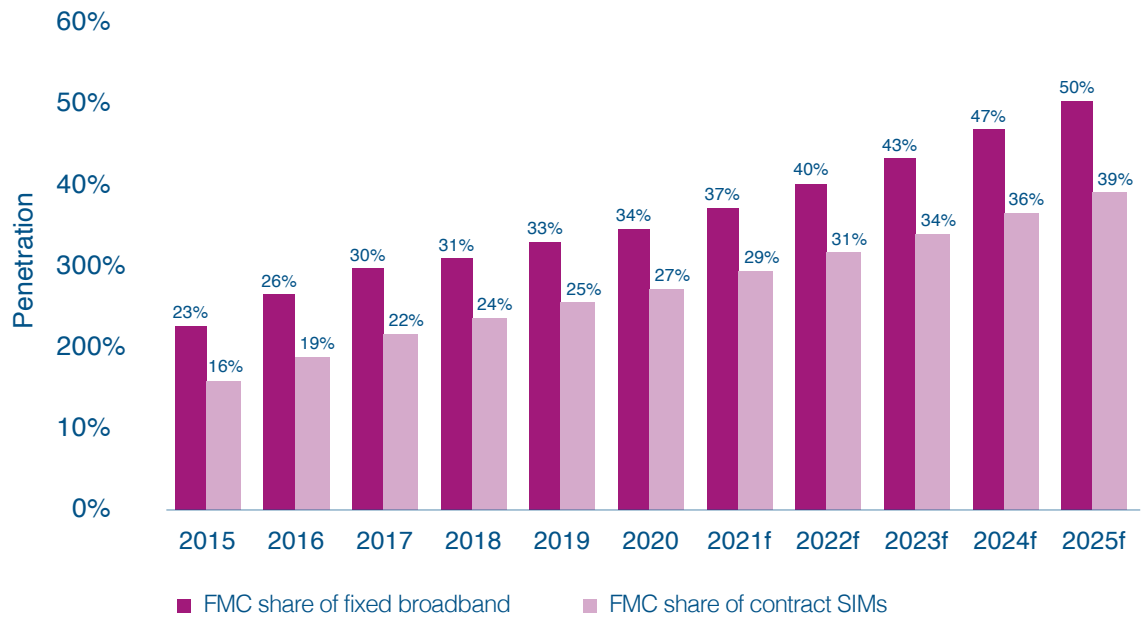
Operators' strategies regarding their existing cable and copper networks will vary, but the use of both technologies will fall significantly as gigabit-capable connectivity becomes increasingly important. The number of FTTH connections is set to grow the fastest out of all technologies, but FTTH will only represent 41% of connections by 2023. This demonstrates the importance of continuing to support other connectivity access solutions because more than half of Europeans will still use them in 2025.

Fixed–mobile convergence

FMC will increase in importance across Europe, mostly due to competition and M&A activity. It is a strategy that operators have pursued because it can help to minimise customer churn (which is typically high in mobile markets) and reduce costs.

FMC continues to account for a minority of contracts (**Figure 4.7**). Nonetheless, the FMC share grew from 31% in 2020 to 33% in 2021, and FMC is particularly common among fixed broadband subscriptions (it accounted for over 37% of subscriptions in 2021). However, this European average masks large national variation. The FMC share of contracts is expected to grow across most of Europe, but few countries will reach the same levels of penetration as Spain, France and Portugal, which have high FMC market shares.

FIG 4.7 : ***FMC share of fixed broadband subscriptions and contract mobile SIMs, Europe, 2015–2025f***

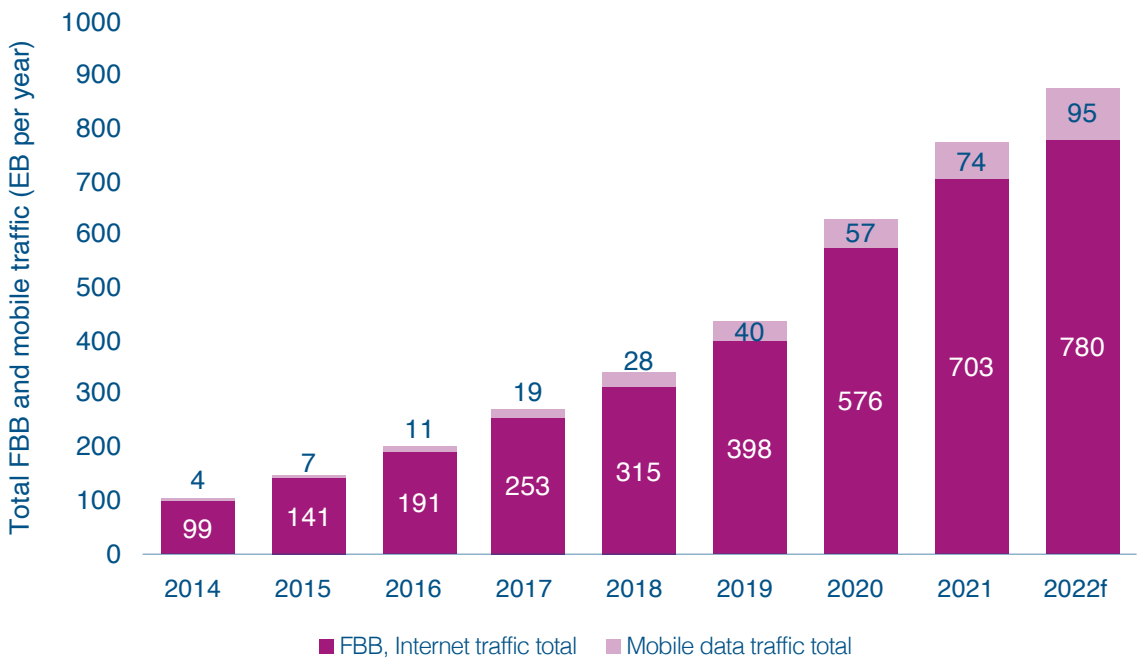


Source: Analysys Mason, 2022

Fixed and mobile usage trends

The use of both fixed and mobile data has been climbing for many years (**Figure 4.8**). The COVID-19 pandemic caused some disruption to long-term trends, and the immediate post-pandemic period will partly reflect a correction back to earlier patterns, even though changes catalysed by the pandemic (such as increased working from home and multiple CAP video subscriptions per household) are likely to continue.

FIG 4.8 : *Fixed and mobile data usage, Europe, 2015–2022f*[9]



Source: Analysys Mason, 2022

[9] The 2022 estimate is based on 2Q 2022 data

During the pandemic, consumers relied proportionately more on residential fixed services than on mobile networks. As a result, fixed data traffic grew more quickly than it had in previous years. Mobile data traffic growth accelerated only in those countries with a high proportion of mobile-only consumers; it decelerated in others. Data traffic is currently undergoing a post-pandemic correction in Europe. Evidence from other advanced economies suggests that fixed and mobile traffic growth rates will eventually converge and that mobile networks will account for 10–15% of all data traffic on average (but with substantial variations).

Hours of usage have a natural limit, but there is a continuous supply of novel applications and services and of more bandwidth-hungry video formats that push demand up. This means that mobile operators need to walk a very fine line. On the one hand, they must offer larger mobile data deals to meet consumer demand and match competition, which in turn risks further reducing consumer incentives to use home Wi-Fi. On the other hand, the increase in data traffic stretches the sector and its viability because operators are required to fund continuous build-outs in the face of a limited ability to monetise traffic because a few very large tech companies extract most of the value from internet access.[10] Indeed, a report published in May 2022 by Axon Partners Group for ETNO (based on Sandvine data) indicated that content originating in six hyperscale businesses (Alphabet, Amazon, Apple, Meta, Microsoft and Netflix) accounted for 56% of all data traffic worldwide.[11] The proportion in Europe is unlikely to be greatly different.

It is still unclear what the future impact of virtual and augmented reality will be on bandwidth demand, and hence on telecoms infrastructure. A recent study suggested that VR users in the metaverse will require more than five times as much data than if they were streaming traditional HD video.[12]

[10] GSMA (2022), *The Internet Value Chain 2022*.
[11] ETNO (2022), *Europe's internet ecosystem: socio-economic benefits of a fairer balance between tech giants and telecom operators*.
[12] Arthur D Little (2022), *The metaverse: what's in it for telcos?*

2-2 TRENDS FOR DIGITAL SERVICES SUPPLIERS

Digital services are the full range of activities that can be accomplished over IP networks. For the B2C segment, these include services:

- that historically were core to operators (especially voice and messaging)
- where telecoms operators have established themselves as part of the competitive landscape (especially IPTV)
- that are a new opportunity for operators as well as other players (this list is potentially endless; examples of services where operators do play include financial services, physical and digital security and e-health services).

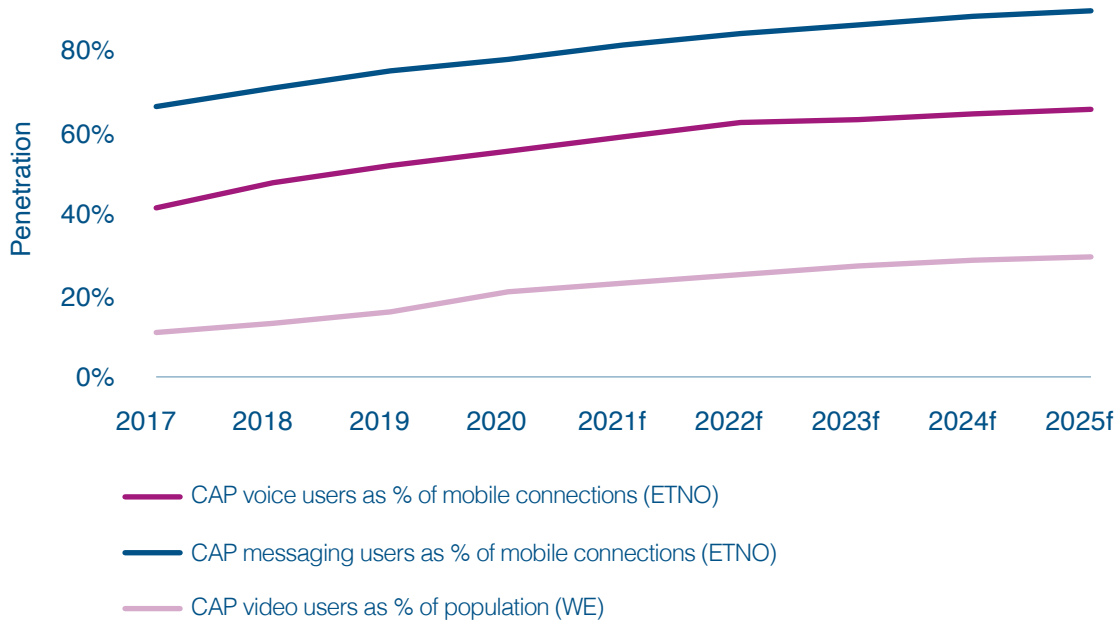
B2C digital services present new ways for operators to expand their portfolios, grow revenue, foster loyalty and drive customer engagement. However, operators face huge challenges in this space from global hyperscale CAPs that dominate the current B2C digital services market. Operators that have shifted more towards a netco-servco split are faced with a set of challenges and opportunities.

- They must build upon their historical connectivity-focused revenue streams by developing their own digital services that have to compete against those from international CAPs.
- They have an opportunity to rethink their business priorities independently of the link that bound services to local network infrastructure in the vertically integrated model.

B2C digital services: operators and CAPs

The take-up of CAPs' services has been increasing for years and is expected to continue to do so (**Figure 5.1**). CAPs' voice and messaging products have become commonly used; WhatsApp and Telegram are among the most well-known.

FIG 5.1 : *Penetration of CAPs' services, ETNO members and Western Europe, 2017–2025f*



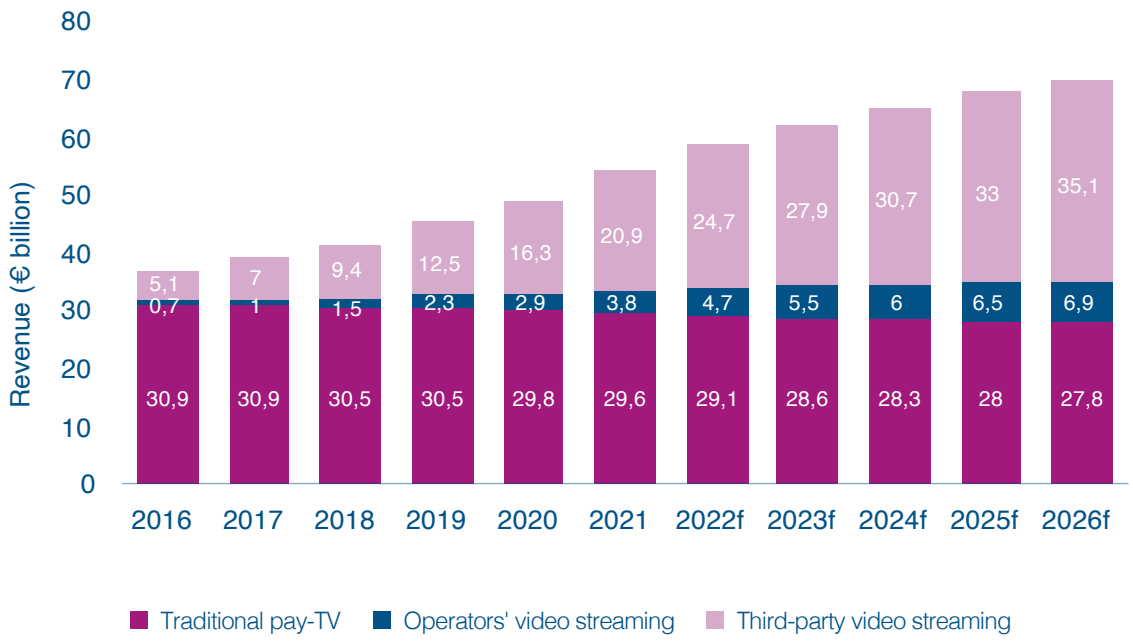
Source: Analysys Mason, 2022

Messaging apps will continue to be the most common form of CAP service used by consumers. These apps are used during about 80% of mobile connections and penetration is still growing. The penetration of voice and video apps is also rising, but growth rates are starting to slow.

Market conditions suggest that CAPs might struggle to become any more competitive with their monetisation strategies. Some CAPs that have established themselves as the largest players in their space have started to come up against new challengers (for example, Disney+ to Netflix) in the past 2 years. This, added to the reality that some types of digital service applications are reaching near-saturation levels, means they will need to find further revenue streams over time. Some CAPs are now implementing, or planning to implement, new strategies to monetise online services; these include paid-for premium services on top of their existing free, advertising-funded products. Examples include Twitter Blue, Telegram Premium and Snapchat+. Others have already implemented price rises, price tiers or usage restrictions (for example, Netflix).

Traditional pay TV is still (just) the largest component of the B2C video market. It accounted for 54% of the total market in 2021, but made up 84% as recently as 2016 (**Figure 5.2**). This share will continue to decline slowly and will be overtaken by that of third-party video streaming in 2024, but traditional pay TV will nevertheless remain a significant part of the market. Operators' video streaming services still account for a much smaller market share than either third-party streaming video or traditional pay-TV services, but revenue from these services is expected to almost double between 2021 and 2026.

FIG 5.2 : ***Revenue from traditional pay TV, operator video streaming and third-party video streaming services, Europe, 2016–2026f***[13]



Source: Analysys Mason, 2022

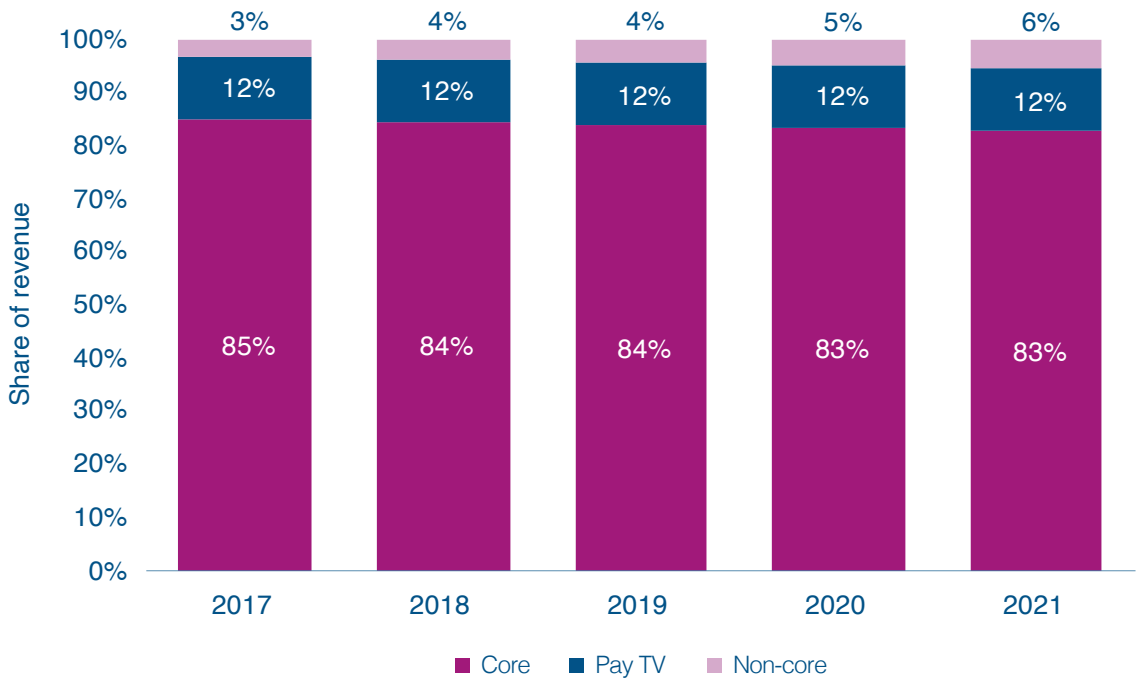
[13] Traditional pay TV includes broadcast and linear IP television channels to which customers subscribe and pay a set amount for a certain subscription length. Operators' video streaming refers to operator-run streaming services, such as MagentaTV from Deutsche Telekom. Third-party video streaming mostly consists of services such as Netflix and Disney+ that are not operated by the businesses that own the networks over which the service is delivered to the consumer.

National pay-TV players (some of which are telecoms operators) continue to play a key role in the delivery of sports video. Demand for sports is frequently national rather than international in character, which ties in with operators' national footprints. Moreover, rights are most frequently granted at a national level. High-quality live-streaming of major events to tens of millions of viewers can also be a technical challenge for the parties involved. Telecoms operators must handle large amounts of data traffic that is simultaneously sent to the last mile or edge network infrastructure, while CAPs must guarantee service quality.

Nonetheless, CAP giants are entering the market for live-steaming major events, too. Amazon now streams the English Premier League in the UK, and will be sharing the rights to the UEFA Champions League in 2024–2025 with BT Sport. BT Sport itself was the subject of a carve-out that was completed in 2022, and is now 50% owned by Warner Bros Discovery, itself a recent carve-out from US telco AT&T. This entry of a CAP provider into national sports delivery showcases the changing TV environment; telecoms operators now have to compete with giant multinational streamers for key events.

ETNO members continue to generate the vast majority of their revenue from their core product: connectivity (**Figure 5.3**). However, the core (connectivity) share of the total revenue declined slightly from 85% in 2017 to 83% in 2021, while the non-core proportion doubled from 3% to 6%. The pay-TV share remained stable at 12%, which demonstrates its resilience as a revenue creator even as the take-up of third-party video streaming services grows rapidly.

FIG 5.3 : *Breakdown of total revenue, ETNO members, Europe only, 2017–2021*[14]



Source: Analysys Mason, 2022

[14] Core services include all connectivity products and services that operators provide, such as voice, while non-core refers to all other services, such as security, cloud and IoT products. Pay TV has been split out as neither core or non-core, and covers both traditional and OTT TV subscriptions that operators sell to customers through their platforms.

Big data analytics

Hyperscale CAPs' internal and external data monetisation is at the very centre of their business models. Operators have also invested heavily in data platforms for their internal operational requirements. These platforms carry out big data analysis to support more-precise customer engagements or to provide better experiences for subscribers, as well as to support network functions and operational systems. External data monetisation is a challenge, largely because of the strict requirements set out for the telecoms sector by the current ePrivacy Directive. European operators have been involved with selling aggregate and anonymised data in compliance with data protection rules for a number of years, and this activity offers the potential for additional revenue streams. Some examples of ETNO members' external data monetisation solutions, and the verticals they address, are shown in **Figure 5.4**.

FIG 5.4 : *Examples of ETNO members' external data monetisation services in a range of verticals*

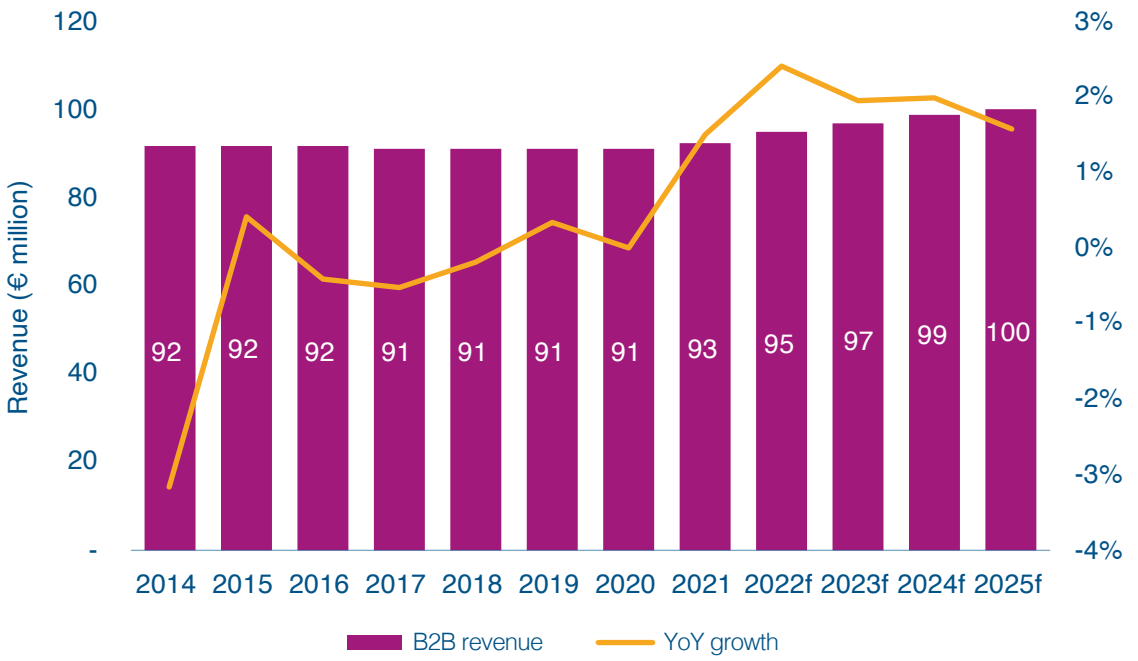
Sector	Applications	Operators (solution name)
Retail	Shopper behaviour, competitive intelligence, supply chain assurance and customer profiles	BT (BT Business), Orange (Flux Vision), Telia (Crowd Insights), Swisscom (Mobility Insights) and Telefónica (Telefónica Tech)
Government	Smart cities, traffic monitoring, digital behaviour, mobility and disease surveillance	BT (BT Business), Telenor (BDSG), Telia (Crowd Insights) and TIM (Cloud Hub)
Transport	Traffic analysis, environmental monitoring, emissions surveillance and population flows	Orange (Flux Vision), Telia (Crowd Insights), BT (BT Business) and Swisscom (Mobility Insights)
Manufacturing	Smart factories, automation, remote robotics, supply chain monitoring, environmental surveillance and health and safety	Telia (IoT Platform), A1 Telekom (A1 Digital), Elisa (IndustrIQ) and Deutsche Telekom (IoT Cloud)

Source: Analysys Mason

B2B services

B2B connectivity revenue has been flat for many years, but is forecast to rise significantly over the next 3 years (**Figure 5.5**). This will be driven by a combination of factors, including pandemic-induced shifts in working practices, because remote working requires a greater spend on connections and higher-quality connectivity. Revenue is estimated to reach €100 million by 2025, up from €93 million in 2021.

FIG 5.5 : ***Operators' B2B connectivity services revenue and year-on-year growth, Europe, 2014–2025f***

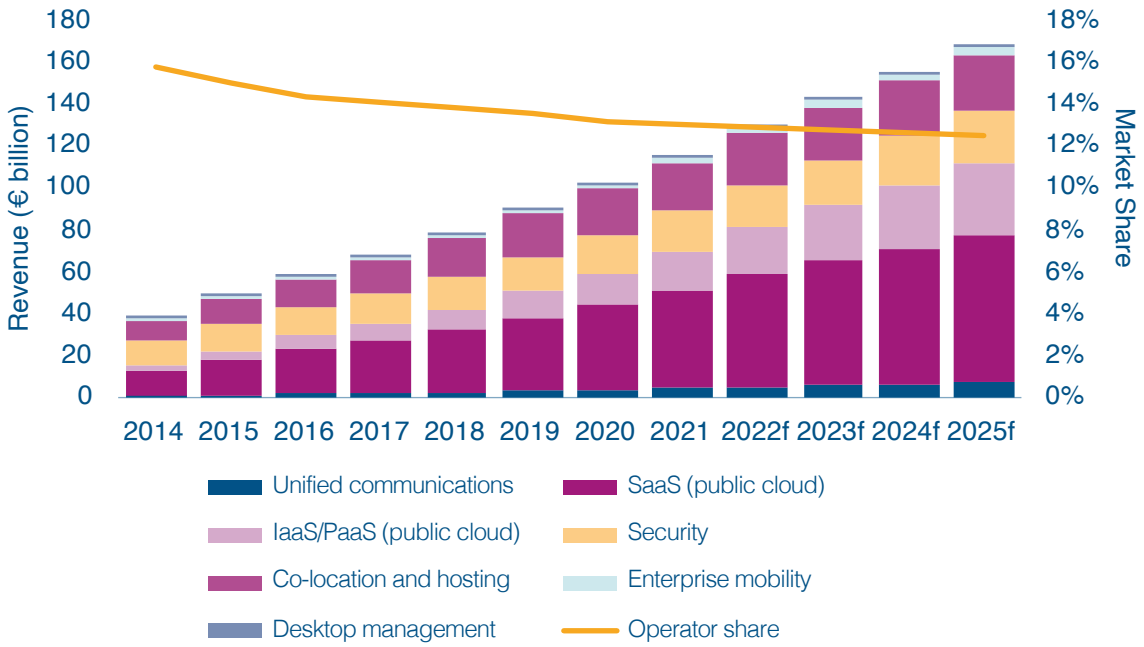


Source: Analysys Mason, 2022

The pandemic also changed businesses' services requirements; they moved from on-premises telecoms equipment with dedicated connections to virtual private networks (VPNs) and software-defined, wide-area networks (SD-WANs) to enable accessible and safe remote working. Secure-access service edge (SASE) has emerged as a concept as an extension to operators' SD-WAN strategies. SASE includes packaging SD-WAN connectivity with cloud security products and provides an opportunity for operators to increase their B2B security revenue and defend connectivity spending. Building SASE is part of a broader growth strategy that enables operators to make use of their long-standing relationships with businesses and bundle core connectivity services with non-connectivity and ICT services.

Total non-connectivity-related spending is continuing to increase as cloud computing becomes an increasingly essential aspect of many businesses' operations (**Figure 5.6**). Security is also generating more revenue in absolute terms (though it also demands higher investments), but its share of the overall non-connectivity-related spending has fallen. Security spending has the added benefit of increasing the resilience of networks to cyber attacks. One possible reason for the relative decline is that cyber security has moved from being a niche concern to a core part of operations for many enterprises, and has become integrated into products and services, thereby lessening the need for a separate purchase.

FIG 5.6 : *Non-connectivity-related B2B services revenue and operators' market share, plus a data table for non-connectivity-related B2B services revenue, Europe, 2014–2025f*



Operator	2014	2015	2016	2017	2018	2019	2020	2021f	2022f	2023f	2024f	2025f
Unified communications	0.9	1.3	1.7	2.2	2.7	3.4	4.0	4.7	5.3	5.9	6.6	7.2
SaaS (public cloud)	11.4	16.5	21.7	25.3	29.6	35.0	40.1	46.1	53.1	59.1	64.7	70.1
IaaS/PaaS (public cloud)	3.5	4.6	5.9	7.5	9.5	12.2	15.3	18.9	22.6	26.4	30.3	34.1
Security	11.4	12.6	13.3	14.2	15.3	16.6	17.6	18.8	20.2	21.6	23.0	24.4
Co-location and hosting	9.8	11.8	13.8	16.0	18.5	20.8	22.0	23.1	24.3	25.3	26.2	27.1
Enterprise mobility	0.8	1.0	1.1	1.3	1.5	1.7	1.9	2.2	2.6	2.9	3.3	3.6
Desktop management	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Total	**37.9**	**48.0**	**57.7**	**66.7**	**77.4**	**90.0**	**101.4**	**114.2**	**128.4**	**141.6**	**154.5**	**167.0**

Source: Analysys Mason, 2022

Operators' share of the enterprise ICT market is continuing to fall, from 16% in 2014 to an estimated 12% in 2025. The market is growing sufficiently quickly that operators' revenue will continue to grow in absolute terms. However, revenue for IT specialists, especially those that are active in the rapidly growing SaaS market, will increase more rapidly, thereby lessening operators' share of the total market.

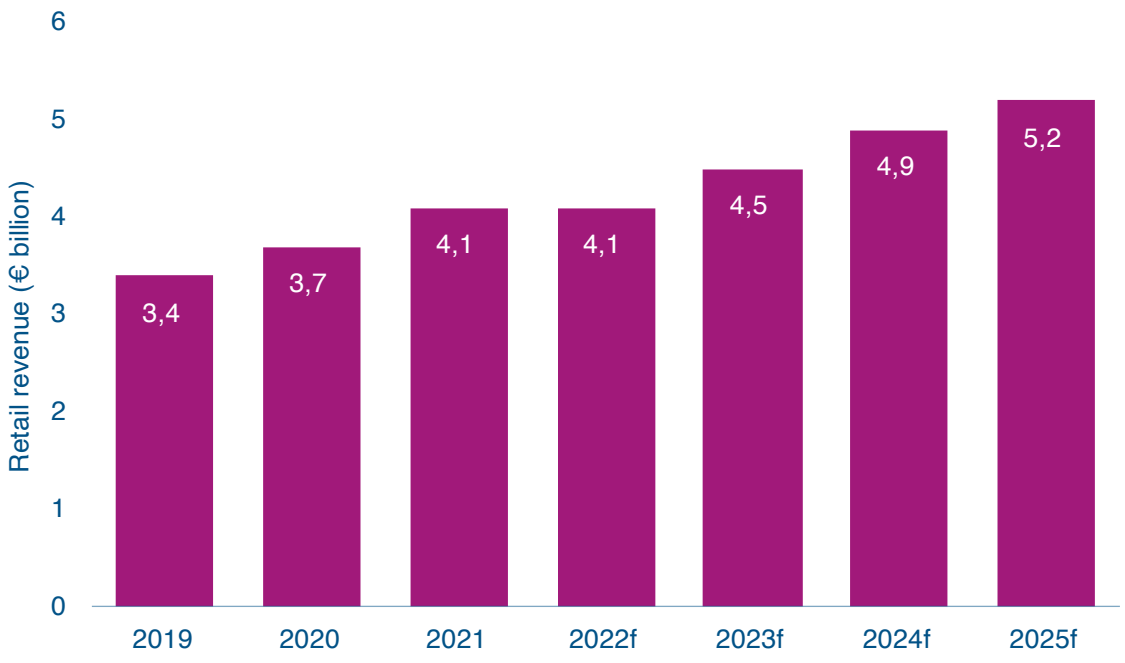
Digital security services

Businesses' focus on security has been increasingly rapidly in recent years due to high-profile cyber attacks and a shift in regulation in many European countries to putting the cost of lost data from a cyber attack onto private companies. Operators' digital security service portfolios have grown to include new services such as endpoint security, mobile security, cloud security and IoT security.

Many specialist cyber security firms supply a wide variety of commercial, off-the-shelf cyber security products for businesses and consumers. However, the fast-growing area of mobile security, part of the wider area of mobile device management, is one area in which operators may have a particular advantage. When a mobile user is browsing the internet via mobile data, they are already using an operator's network, so it is easier to use that operator for security than to protect an unrelated laptop. Operators have made a number of acquisitions of cyber security firms in recent years to improve their expertise in this area. Examples include Telefónica's purchase of cyber-resilience firm Govertis in 2020, Orange's acquisition of full-service cyber security company SCRT and Telsys SA in 2022 and BT's acquisition of a large stake in cyber-risk quantification firm Safe Security in 2021. These purchases allow cyber security companies' technical expertise to be combined with operators' large customer bases, thereby creating a highly profitable revenue opportunity because the marginal cost of additional software subscriptions is close to zero.

Operators received a boost to their cyber security revenue during the pandemic because many organisations, faced with a hugely increased attack surface due to remote working, quickly upgraded their security solutions. Growth will not continue at that pace (growth was flat coming into 2022), but it will steadily increase over time, and the total European revenue will exceed €5 billion by 2025 (**Figure 5.7**).

FIG 5.7 : *Operators' cyber security retail revenue, Europe, 2019–2025f*

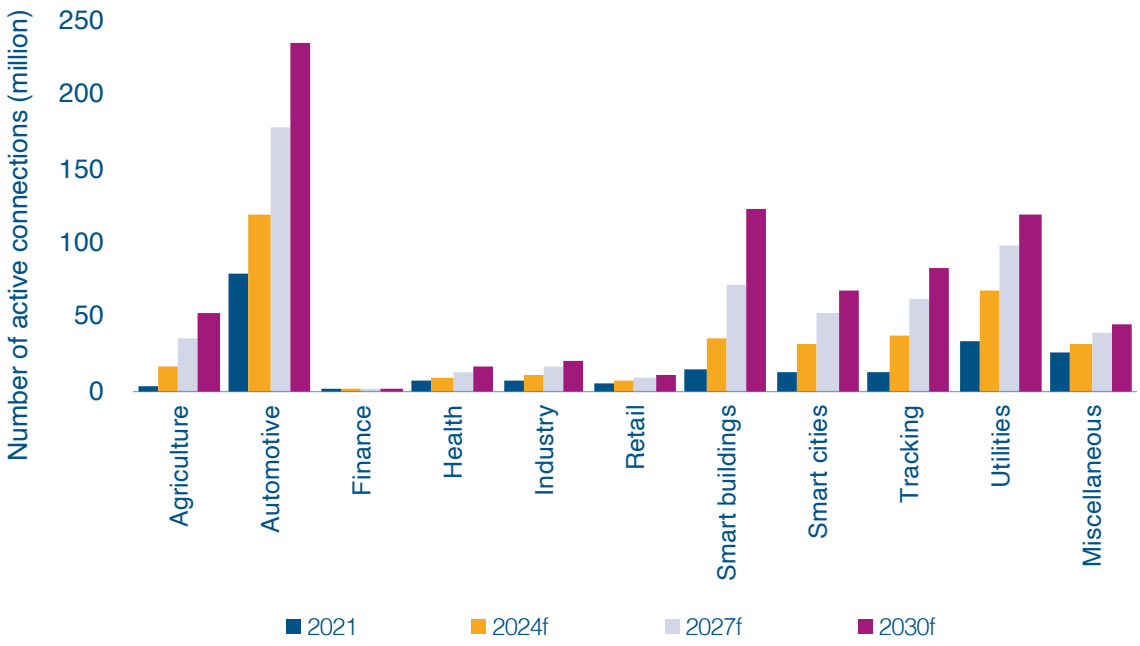


Source: Analysys Mason, 2022

The Internet of Things

The Internet of Things (IoT) is an area of growth for operators in terms of both revenue and the number of connections. IoT refers to the web of interlinked sensors and remotely controlled devices that are able to communicate with each other and with other connected devices. IoT devices are becoming of particular importance in the automotive industry and can help to create smart buildings that are energy-efficient and user-friendly (**Figure 5.8**).

FIG 5.8 : *Number of active IoT connections by vertical industry, Europe, 2021–2030f*



Vertical industry	2021	2024f	2027f	2030f
Agriculture	4.1	16.9	35.1	52.7
Automotive	80.1	119.5	177.6	235.3
Finance	0.1	0.1	0.1	0.1
Health	6.8	9.8	13.1	16.9
Industry	6.5	11.6	16.3	21.0
Retail	6.0	7.8	9.1	10.5
Smart buildings	14.5	35.3	71.7	123.6
Smart cities	12.6	31.4	52.0	67.9
Tracking	13.9	38.5	61.8	82.4
Utilities	33.1	67.6	99.0	120.2
Miscellaneous	26.4	32.8	39.6	45.0
Total	**204.1**	**371.5**	**575.6**	**775.7**

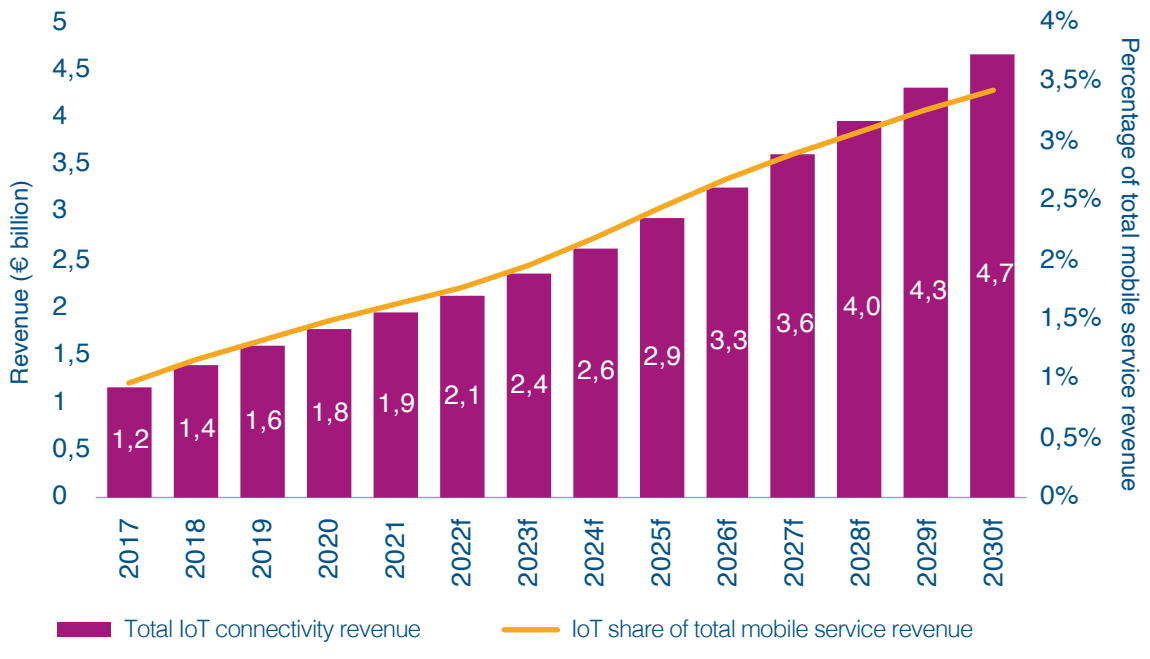
Source: Analysys Mason, 2022

The rate of growth in the number of IoT connections fell during the pandemic but is predicted to resume its rapid rise over next 10 years. The average year-on-year growth in the number of IoT connections worldwide fell from 30% in 2019 to 23% in 2021, with operators in China grew faster in 2019 than others but those in Europe performing better in 2021.

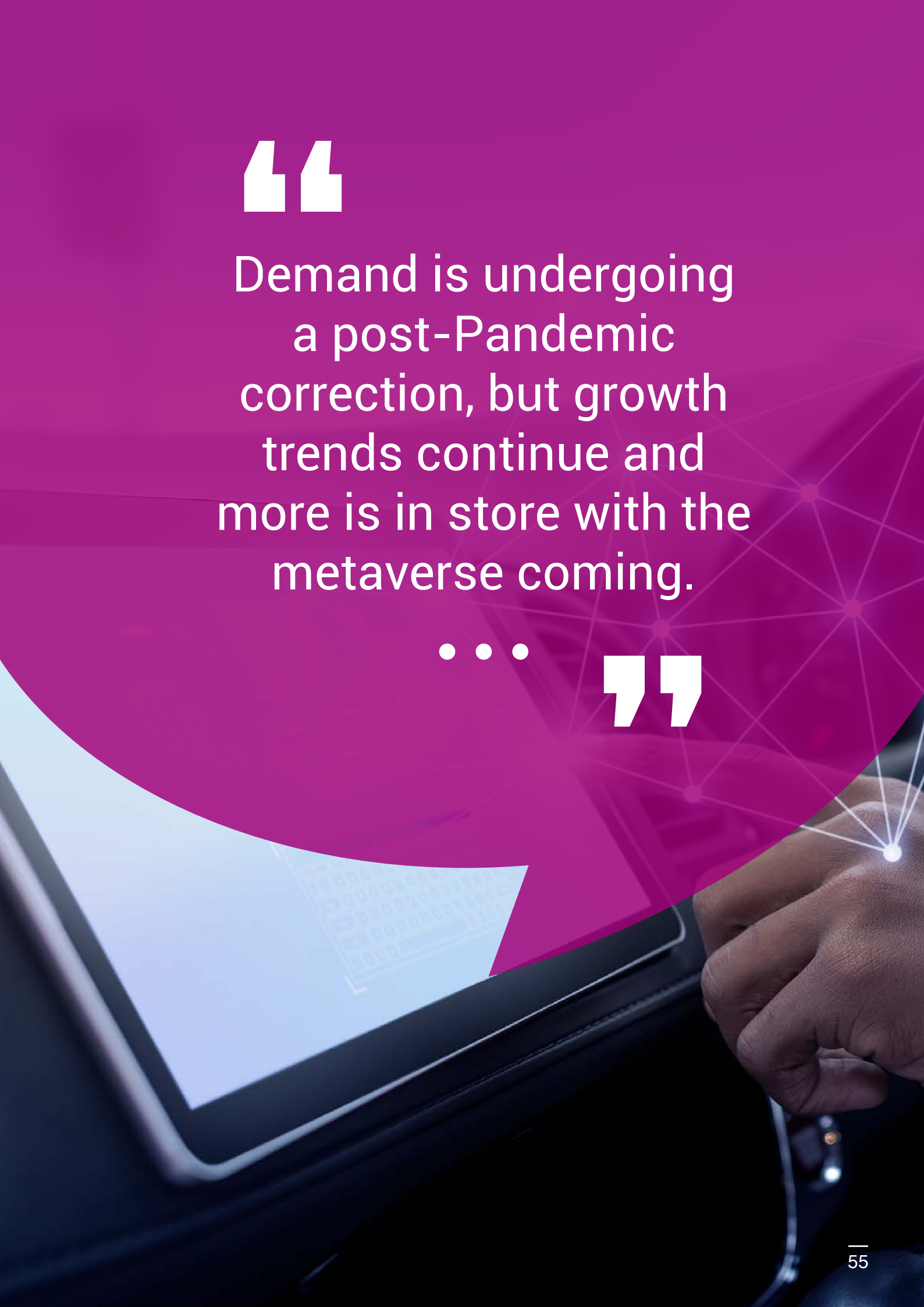
The number of IoT connections will grow the fastest in the smart buildings sector which represents a combination of government initiatives to create smart cities, automate aspects of building management, increase energy efficiency and minimise carbon emissions. This diversity of IoT use cases is accompanied by a wide variety of connection technologies. Diversity is required because the connectivity needs of an air conditioning controller are different to those of a passive road traffic monitor, which means that operators need to be able to provide many different connection options to take full advantage of the IoT opportunity.

Operators' IoT connectivity revenue is expected to continue its steady growth, and will reach €4.7 billion per year by 2030 (**Figure 5.9**). IoT connectivity revenue is expected to account for 3.4% of operators' total mobile service revenue in 2030, up from 1.6% in 2021. Revenue is growing more quickly in China than in Europe; Telefónica is the only operator outside of China to experience a higher rate IoT revenue growth in 2021 and 2020 than in 2019. All three of the main Chinese operators reported IoT revenue growth of more than 20% in 2021, and this is primarily attributed to the increase in the availability of 5G and the use of device management platforms.

FIG 5.9 : ***Operators' IoT connectivity revenue and the IoT share of mobile service revenue, Europe, 2017–2029f***



Source: Analysys Mason, 2022



“Demand is undergoing a post-Pandemic correction, but growth trends continue and more is in store with the metaverse coming. • • • ”

SECTION 3

How network providers can help to deliver a new digital future

In this section, we consider the future of European telecoms networks and how they can deliver long-term social and economic benefits in an environmentally sustainable manner.

3-1 ENSURING EFFICIENT, FIT-FOR-PURPOSE NETWORKS FOR ALL

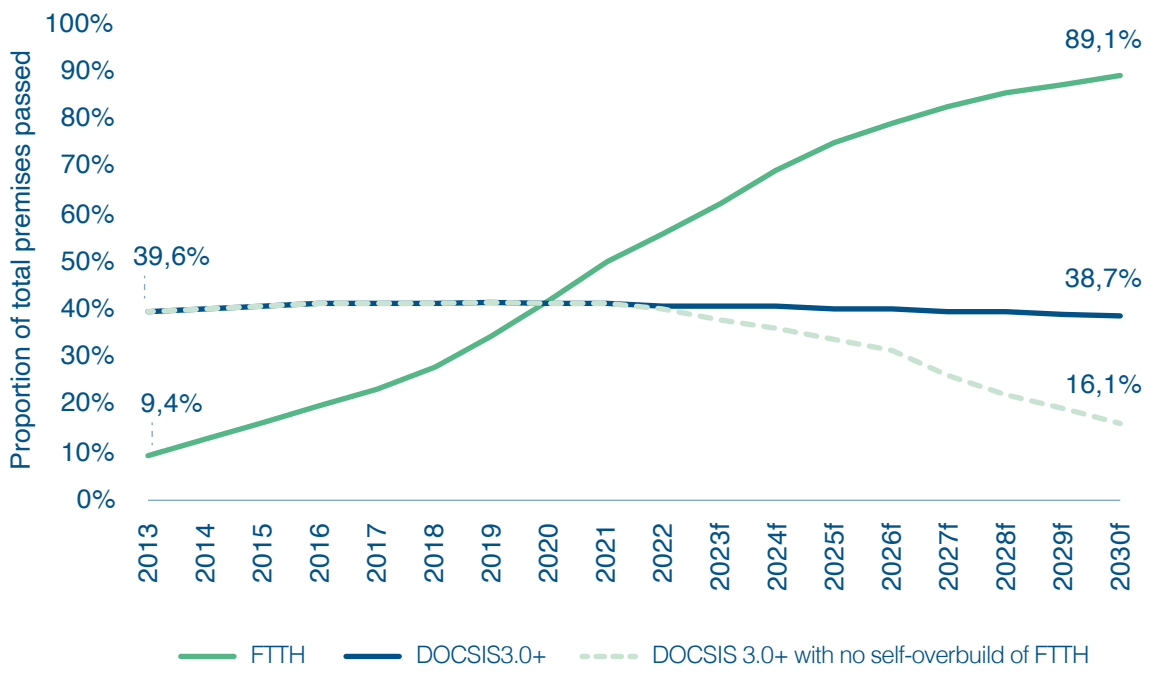
Ensuring that all European citizens have access to fit-for-purpose networks is a key aim of the European Digital Decade targets; it is also an aim of non-EU member states. However, it will come at a great financial cost, and both industrial and telecoms-specific policies have a direct impact on telecoms operators' ability to deliver on this aim. In this section, we outline what work there is still to do and describe the barriers to, and benefits of, achieving this goal. As things stand, the risk is that the EU will fall short of its "gigabit for everyone by 2030" objective.

FTTH and gigabit access

The fiberisation of the local loop is the single largest investment activity in the telecoms industry since the roll-out of telephony itself. FTTH promises lower capex and opex in the long term, greener telecoms services and futureproof infrastructure with performance levels that are far ahead of any alternative wired or wireless options. Interest rates have been low in Europe, and this has resulted in a low cost of debt funding in some countries. However, this does not fully apply to traditional telecoms operators who tend to be highly leveraged, are obliged to meet equity investors' return expectations and hence are subject to a relatively high cost of capital. The continuing commitment to investors by ETNO members is partly a response to the need to maintain network leadership, but it is also justified by good take-up levels: FTTH is turning from a 'nice-to-have' to a 'must-have'. However, there is a limit to how far coverage can extend on purely commercial terms, and the rising cost of debt will hamper investments that are currently at the margins of what is commercially viable.

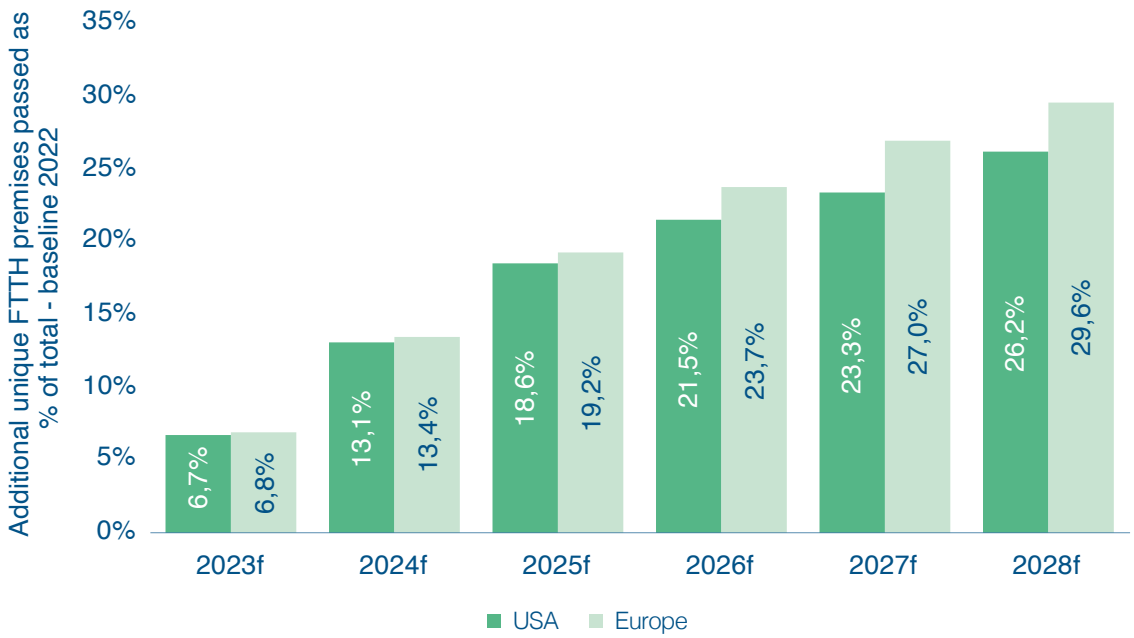
We forecast that FTTH coverage (unique premises passed) will reach 89.1% in Europe by 2030 (**Figure 6.1**). For the European Union (EU-27), the forecast is similar and the EU will reach 90.4% of premises passed by VHCN by 2030. This is equivalent to passing 250 million unique premises out of an estimated 280 million. Cable broadband (DOCSIS 3.0 and above) will cover 39.3% of premises (110 million premises) by the same date and nearly all of the cable footprints will have been overbuilt by FTTH. In fact, many, if not most, European cable operators will have overbuilt some or all of their own hybrid-fibre coaxial (HFC) networks with FTTH by 2028. Coverage of non-self-overbuilt DOCSIS3.0+ will be just 16% (about 45 million premises). Cable operators upgrading to FTTH increases infrastructure competition at a retail level, and perhaps also at the wholesale level if cable operators elect to provide wholesale access.

FIG 6.1 : *Premises passed by FTTH and DOCSIS3.0+, Europe, 2013–2030f*

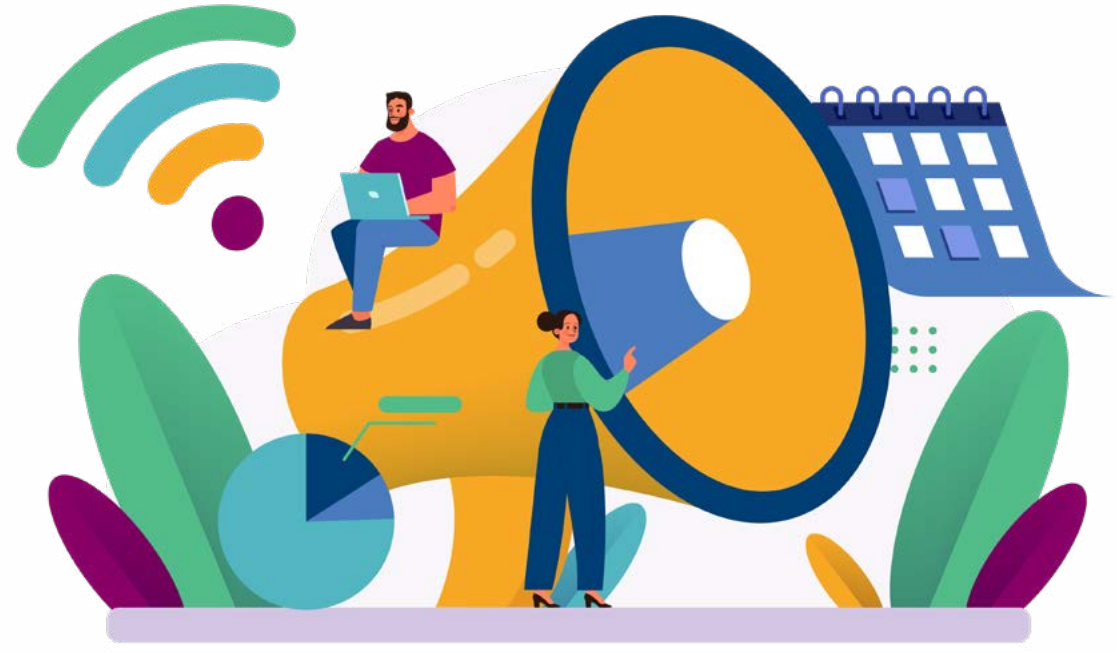


Source: Analysys Mason, 2022

FIG 6.2 : ***Additional unique FTTH premises passed forecast over 2023f–2028 as a proportion of all premises passed in 2022, Europe and the USA***

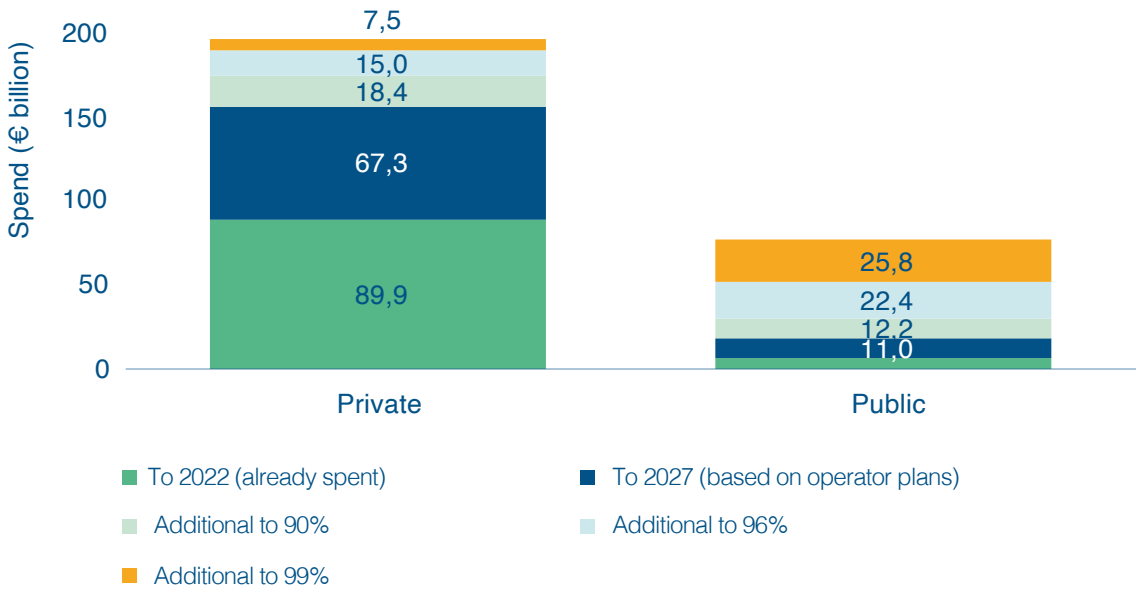


Source: Analysys Mason, 2022



The 250 million premises passed by FTTH will be covered by an average of about 1.5 FTTH networks by 2030, but this leaves 30 million premises that will not be served by a wired gigabit network. This goes against the targets set out in the Digital Decade programme. **Figure 6.3** shows a projection of the total costs required to cover 90%, 96% and 99% of premises with FTTH, with an estimate of what would have to be covered by public money.

FIG 6.3 : *Cost of deploying future FTTH networks by coverage, Europe*



Source: Analysys Mason, 2022

The cost of FTTH per premises passed will rise to several thousands of euros to cover the last 10% of premises, so 5G FWA and hybrid solutions may be more commercially prudent than FTTH. However, achieving genuinely gigabit services in remote areas using 5G FWA may also come with considerable additional costs. These include costs due to:

- the need for engineer-installed outdoor antennas to optimise performance
- the need to upgrade remote cell sites with 5G where the commercial case for 5G mobile is weak, or to build new sites where otherwise they would not be required
- higher opex for FWA than for FTTH
- a shorter asset-life for FWA than for FTTH.

Figure 6.3 does not include the final 1% of very-hard-to-reach premises. The capacity and coverage of low-Earth-orbit (LEO) satellite constellations by operators such as SpaceX Starlink (USA), Amazon Kuiper (USA), AST SpaceMobile (USA), Telesat Lightspeed (Canada) and OneWeb (UK) have exploded since 2021. Indeed, the total global capacity at the end of 2022 will be over 10 times higher than that at the end of 2021. In addition, the EU has its own initiative, IRIS2, which is meant to enter into service in 2024. The fundamental purpose and business models of these satellite operators extend into many fields, but the rapidly falling cost of satellite bandwidth may make it a more-viable complementary connectivity solution for the last 1% of properties, even if satellite broadband performance does not match that of terrestrial broadband.

“Will the EU meet its “gigabit for all by 2030” target? Our report expects gigabit coverage to reach 90% in 2030, meaning that tens of millions Europeans risk being left behind.”

5G networks and spectrum

Spectrum is a critical input for mobile networks. The less spectrum that is available to MNOs, the poorer (slower) the service. Mobile network usage continues to rise worldwide, but the intensity of usage is itself a consequence of underlying demand and supply-side factors including, importantly, the amount of spectrum that is available to MNOs and the timing and conditions under which it is assigned.

Regulators in most European countries have now assigned spectrum (via auctions in nearly all cases) in the 3.4–3.8GHz band (the most important band for 5G mobile), and many have assigned spectrum in the other two principal bands for 5G, 700MHz and mmWave. **Figure 6.4** shows the allocation of spectrum in the 5G bands as of November 2022.

FIG 6.4 : ***Assignment of spectrum in the main 5G bands, Europe, November 2022***

Country	Spectrum assigned in the 700MHz band (MHz)	Spectrum assigned in the 3.4–3.8GHz band (MHz)	Spectrum assigned in the mmWave band (MHz)
Albania	0	0	0
Austria	60	390	0
Belgium	60	370	0
Bosnia	0	0	0
Bulgaria	0	300	0
Croatia	60	320	1000
Cyprus	60	400	0
Czech Republic	60	400	0
Denmark	80	390	2850
Estonia	0	390	0
Finland	60	390	2400
France	60	310	0
Germany	60	300+100 local	0
Greece	60	390	1000
Hungary	50	390	0
Iceland	40	300	0
Ireland	0	340	0
Italy	75	200	1000
Latvia	80	150	0
Lithuania	40	300	0
Luxembourg	60	330	0
Malta	0	300	0
Montenegro	0	0	0

Netherlands	60	0	0
North Macedonia	0	0	0
Norway	60	400	0
Poland	0	0	0
Portugal	60 (10 unsold)	400	0
Romania	0	345 (85 unsold)	0
Serbia	0	0	0
Slovakia	60	390	0
Slovenia	75	380	1000
Spain	60 (15 unsold)	380	0
Sweden	40	320+80 local	0
Switzerland	70	300	0
UK	80	390	0

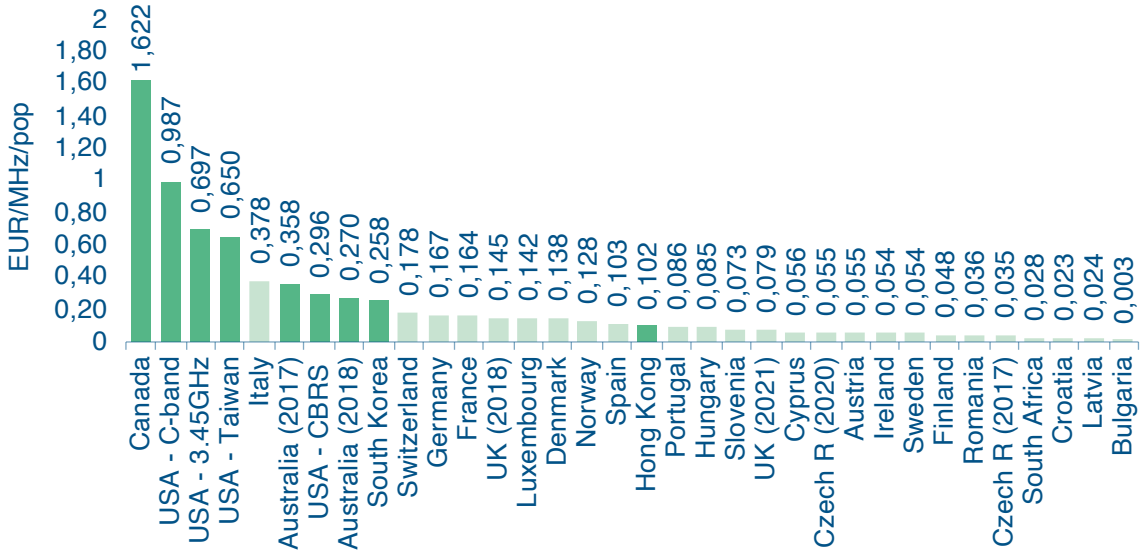
Source: Analysys Mason

The amount of spectrum assigned varies considerably between countries in Europe, though there are now few countries where an assignment in at least one band has not been made. There are also major differences in the conditions of the licences in terms of coverage and roll-out speed. These vary from effectively no coverage conditions in countries such as Finland, Sweden and the UK to a very tightly defined set of conditions in Germany.

The ITU's minimum technical requirements to meet the IMT-2020 criteria for radio interfaces are at least 100MHz of contiguous spectrum per operator. The aggregation of non-contiguous blocks of spectrum is possible, but 100MHz of contiguous spectrum enables faster networks and allows for more-efficient network operation. 19 of the 36 European countries listed in **Figure 6.4** have at least 1 operator with 100MHz of contiguous spectrum, while 18 have at least 2 operators and 16 have 3 or more.

The prices paid for mid-band spectrum (3.4–3.8GHz) in Europe have not been especially high compared to those in Canada and the USA, though US licences are indefinitely renewable after an initial 15 years, thereby making direct comparison difficult (**Figure 6.5**). Nonetheless, the prices paid in Europe have varied greatly: Italian operators paid nearly eight times more per megahertz per member of the population (MHz/pop) than Finnish operators. This variation was due to differences in the amount of spectrum available to bidders in some cases.

FIG 6.5 : ***Prices paid for spectrum in the 3.4–3.8GHz band, normalised to a 20-year duration, worldwide***



Source: Analysys Mason, 2022

Industrial and IoT spectrum policies in Europe

The full 5G vision has long been about more than providing faster speeds and more capacity for generic mobile broadband. The promise is that 5G technology will also be used for industrial use cases and for private networks, and that it will thereby expand economies.

Regulators have evaluated the ways in which to ensure that spectrum regulation facilitates the use of 5G for these use cases. Regulatory approaches range from spectrum being earmarked for B2B use or for private networks (as in Germany and Sweden, for example) to obligations being placed on MNO spectrum owners to support industrial requirements such as improved indoor or remote site coverage.

These two approaches tally with the two basic models for private networks:

- where the industrial network user deploys a private network using either dedicated local spectrum (where available) or unlicensed spectrum, and an operator or vendor potentially plays a role in building, integrating and managing the network
- where the industrial network user takes a configurable slice of an existing public network; this model can be deployed on 4G and 5G non-standalone networks via software upgrades, but it is an integral feature of future 5G standalone networks.

Spectrum reservations or specific obligations may generally reduce investment for operators, there is a role for them in both private networks models. Existing operators act as experienced network builders and integrators in the first model, without being traditional licensed operators. Virtualisation introduces new ways for new types of enterprise users to expand the geographical presence of their networks in the second model, without commissioning new physical network infrastructure; in other words, it offers considerable scope for capex avoidance.

These models can coexist under some circumstances, and the geographical coverage of the networks will define which approach works best to a great extent. Nevertheless, consideration has to be given to whether the first model acts to the detriment of not only of the second, but also of more traditional mobile use. Setting aside spectrum for local use cases, where take-up by industries could be quite weak, could have an impact on the quality of networks enjoyed by the majority of users.

3-2 MAKING NETWORKS GREENER AND MORE ENERGY-EFFICIENT

Operators have had a commitment to reducing the impact of their operations on climate change for a long time. Much of the initial commitment has focused on decoupling energy consumption from greenhouse gas (GHG) emissions, but net-zero targets require the elimination or offsetting of emissions in the upstream and downstream value chains. Energy consumption has historically not been a matter of great strategic concern for operators because energy costs amounted to about 2% of revenue and tended not to fluctuate greatly. However, the rapidly rising cost of electricity (and of other forms of power) over the past year has redoubled their focus not only on energy efficiency, but, more importantly, on reducing energy consumption. The telecoms sector also offers digital services and technological solutions that contribute to the acceleration of the green transition of companies in all sectors, thereby helping them to reduce their environmental impact. Some of these solutions are considered in the enablement section below.

> “83% of total energy used by telecom companies in 2021 came from renewable sources, up from 71% in 2018.”

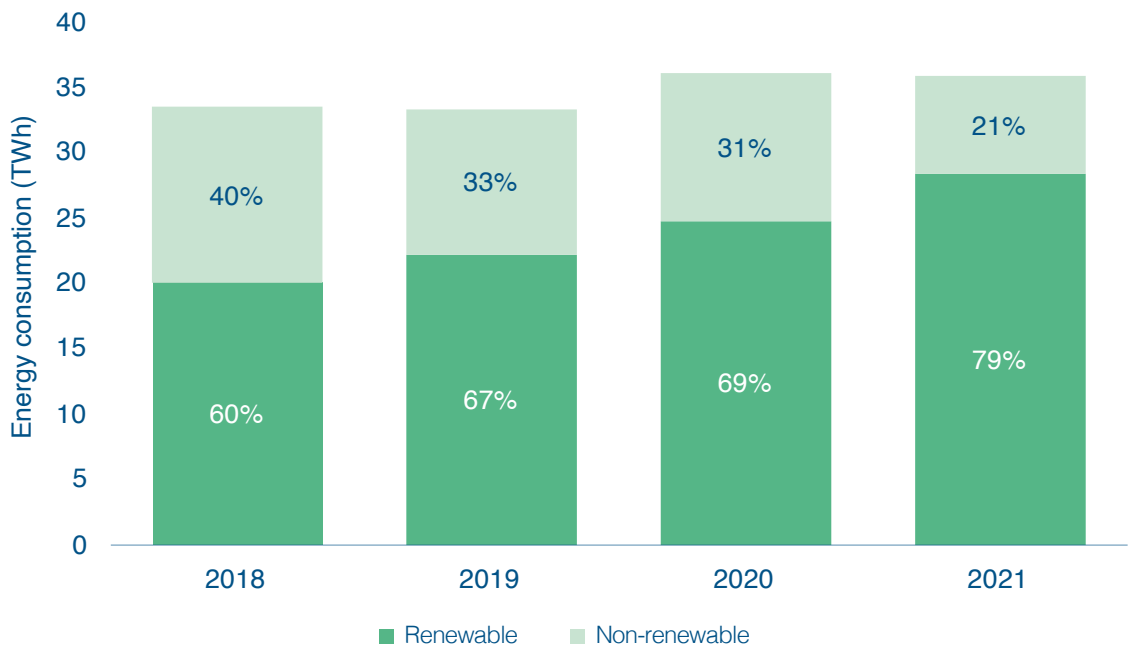
In this section, we analyse operators' ongoing efforts to minimise their own contribution to climate change, how they are optimising the networks to help their customers and suppliers to make a positive environmental impact and how they are driving towards lower energy consumption and lower energy costs in their own networks.

Decoupling greenhouse gas emissions from energy consumption

ETNO members have taken significant steps to reduce their absolute carbon emissions. Operators need to have a clear understanding of how much they are emitting and where these emissions come from to reach the net-zero target. The Greenhouse Gas Protocol divides emissions into scope 1 (carbon coming directly from an operator's activities), scope 2 (energy consumed for those operations) and scope 3 (all emissions throughout the value chain). Scope 3 emissions are the hardest to measure and reduce because they include emissions incurred in the course of customers' use of an operator's products, but most ETNO members are still ultimately aiming to bring their scope 3 emissions down to net zero.

The total energy used by ETNO members is fairly stable. There was in a non-organic increase energy consumption at a group level in 2020 brought about by a major acquisition outside Europe (**Figure 7.1**). The proportion of this energy usage that comes from renewable sources has been steadily growing at a group level, and now accounts for 79% of the total.

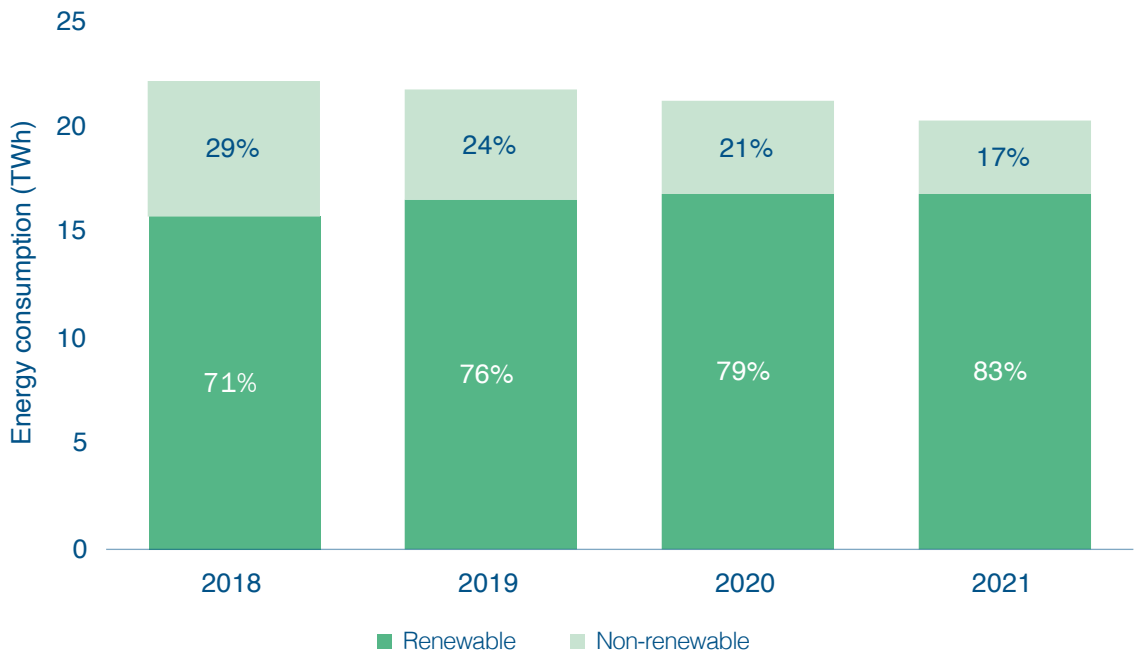
FIG 7.1 : *Scope 1 and 2 energy consumption from renewable and non-renewable sources, ETNO members at the group level, 2018–2021*



Source: Analysys Mason, 2022

Energy usage fell in 2020 and 2021 in ETNO members' European operations alone (**Figure 7.2**). The impact of investments in renewable energy can clearly be seen: 83% of energy came from renewable sources in 2021, based on the market definition of scope 2.[15]

FIG 7.2 : *Scope 1 and 2 energy consumption from renewable and non-renewable sources, ETNO members, Europe only, 2018–2021*

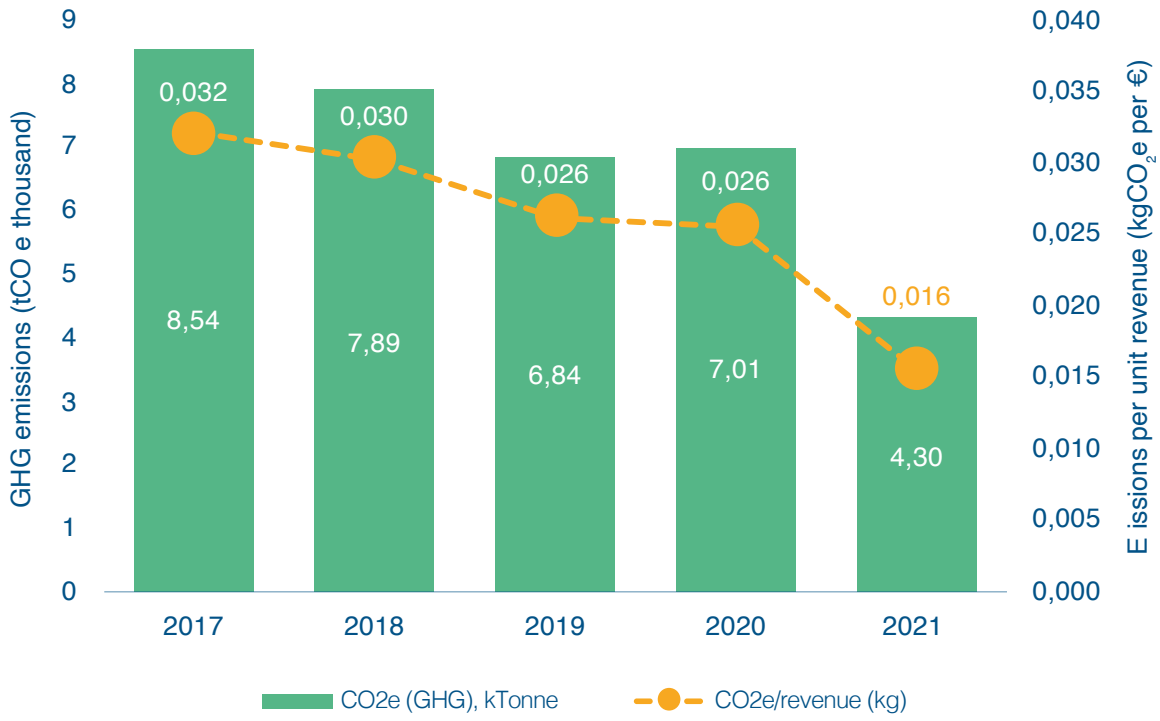


Source: Analysys Mason, 2022

[15] There are two different ways of defining scope 2 emissions: the location method and the market method. The location method involves only looking at the overall emissions of the grid of the country that operations are located in, while the market method focuses on the specific supply mixture that an operator buys. Because of the greater level of granularity and the frequency with which operators have bespoke supply agreements, most operators use the market method for reporting their scope 2 emissions.

ETNO members' GHG emissions, including those generated outside of Europe, fell by 39% between 2020 and 2021, based on the market definition of scope 2. Emissions per unit of revenue fell to half of the 2017 value. This indicates that operators' strategies for increasing their use of renewables and pursuing energy efficiency is succeeding, despite increasing data usage.

FIG 7.3 : *Scope 1 and 2 GHG emissions and emissions per unit of revenue generated, ETNO members at the group level, 2017–2021*[16]

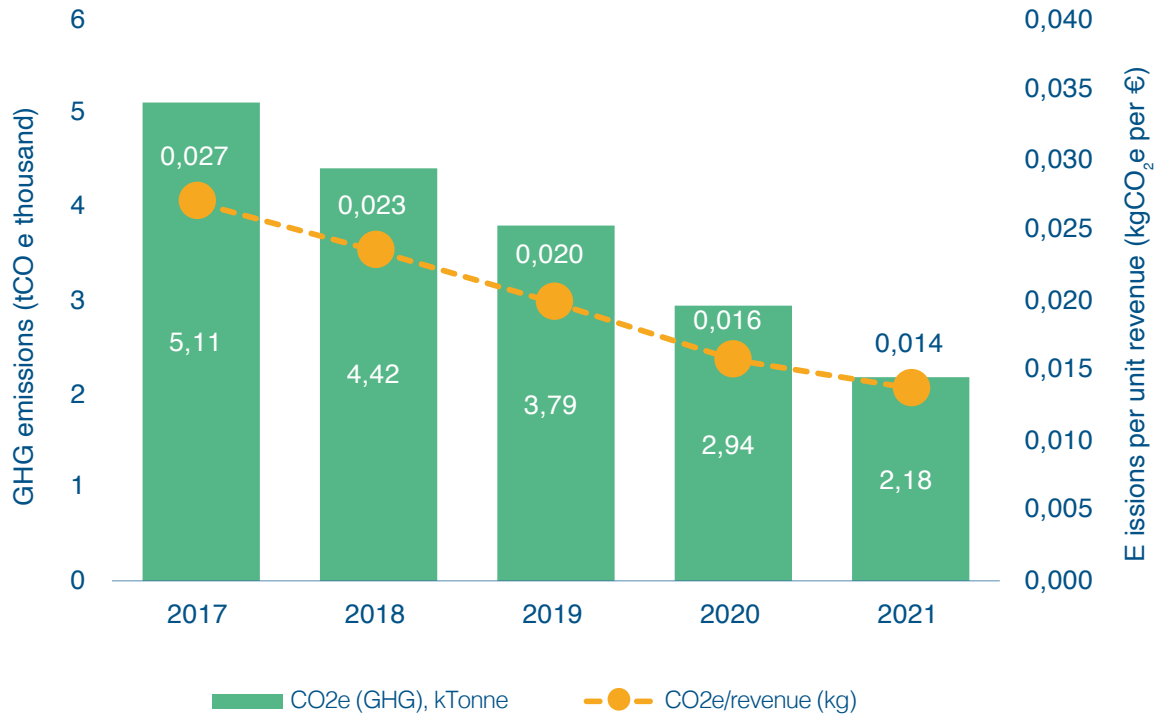


Source: Analysys Mason, 2022

[16] tCO2e refers to tonnes of carbon dioxide equivalent. This serves as a fungible measure because there are many different kinds of greenhouse gas. kgCO2e per € refers to the kilograms of carbon dioxide equivalents that are generated to create €1 of revenue.
The slight rise in emissions in 2020 is attributable to the integration of Sprint into T-Mobile in the USA. The steep fall in 2021 is due to the elimination of T-Mobile USA's scope 2 emissions based on the market definition in that year.

Operators' emissions within Europe have fallen consistently year-on-year (**FIG 7.4**). Additionally, the carbon intensity of revenue generated has followed a similar decline; emissions per unit of revenue roughly halved between 2017 and 2021.

FIG 7.4 : *Scope 1 and 2 GHG emissions and emissions per unit of revenue generated, ETNO members, Europe only, 2017–2021*



Source: Analysys Mason, 2022

Telecoms operators will also enable changes in our society that lead to greater reduction in GHG emissions than can be made in operators' own operations. Some operators have set 'enablement' targets to measure how communications may offset the negative impact of each kilowatt hour of energy used or tonne of carbon dioxide from the communications user. Reducing or eliminating the use of transport and logistics by implementing remote communications is the clearest enablement use case; others include smart city, buildings and metering solutions.

Example A: smart utilities

Telenor worked with water firm Xylem to reduce water usage and minimise waste. Xylem implemented Telenor's Avensor IoT system to enable the real-time remote monitoring and control of pump stations so as to only release the amount of water required and avoid excess flow that would otherwise have to be disposed of. This reduces the number of employees required to effectively control remote pump stations, thereby helping to make this a sustainable solution.

Example B: green digitisation

Cloud computing offers a significant opportunity to centralise computing resources in order to make their use more efficient. However, the data centres underpinning cloud computing can consume vast amounts of electricity thereby necessitating greater fossil fuel consumption. Deutsche Telekom's development of environmentally friendly data centres offers customers a less-carbon-intensive approach to cloud computing. Deutsche Telekom built a data farm in Magdeburg, Biere, that has less-stringent cooling requirements and uses about 30% less energy than equivalent data centres thanks to the use of intelligent design principles. This means that customers can reduce their energy dependency and benefit from the efficiencies and speed of cloud computing.

Example C: greening data centres

Orange has implemented a new cooling system for its newest data centres that replaces standard air conditioning with an innovative, intelligent cooling system using external fresh air. This new technology reduces energy consumption by 90%. Orange built the new cooling system into its large data centre in Normandy in 2013, where it obtained a power usage effectiveness of 1.3, compared with 1.8 for Orange's other data centres in France. As a result of this earlier technology, Orange reduced its cooling energy consumption by over 50% since 2013. Orange is now also using this technology in other data centres in France, Belgium and Cameroon.

Fostering a sustainable economy in the telecoms industry

The vast majority of ETNO members are targeting net-zero carbon emissions, though the exact dates by which they aim to achieve this vary considerably. The reason for the significant gap between most operators' net-zero target dates for scopes 1 and 2 compared to those for scope 3 is that the latter involves emissions generated by customers in the course of using operators' services. As a result, it is an all-encompassing definition of emissions, and requires working with multiple stakeholders across the value chain to bring it down to net zero. All ETNO members have announced dates for the net elimination of scope 1 and 2 emissions, but not all have committed to scope 3 (**Figure 7.5**).

FIG 7.5 : ***Selected scope 1 and 2 and scope 3 emission reduction targets, ETNO members at the group level***[17]

Operator	Target date for net-zero emissions (scope 1 and 2)	Target date for net-zero emissions (scope 3)
BT	2031	2041
Deutsche Telekom	2025	2040
KPN	2030	2040
Orange	2040	2040
TDC	2028	2030
Telefónica	2040	2040
Telenor	2030	N/A
Telia Company	2030	N/A
TIM Group	2030	N/A

Source: Analysys Mason

The practical details of achieving net-zero scope 3 emissions will involve greater levels of operator involvement with equipment suppliers and large customers. Operators can use their influence to try to promote more environmentally friendly and energy-efficient methods for manufacturing, transport and storage.

[17] This table refers to net-zero targets as announced by companies and does not take into account if these targets have been validated against the Science Based Targets initiative (SBTi) Net-Zero Standard. To check progress in SBTi, click here https://sciencebasedtargets.org/companies-taking-action

Deutsche Telekom's journey to 100% renewable energy

Deutsche Telekom achieved a major climate milestone in 2021: it met 100% of its electricity needs using renewable sources. To reach this point it actively worked with its power generator partners worldwide to secure reliable supplies of renewably generated electricity and helped to fund new renewable installations.

Energy firms that want to build new solar or wind installations may struggle to ensure that there will be sufficient demand over a long period of time to make the initial investment economically viable. Deutsche Telekom helped to overcome this problem in the USA by signing multi-year power purchase agreements (PPAs) with new solar and wind farms for 12–15 years. This allows Deutsche Telekom to consistently access clean energy while providing a secure source of demand for the generators. These PPAs allowed two new wind parks to be built in the USA.

23% of Deutsche Telekom's energy needs are now covered by these PPAs, which it primarily uses outside of Europe. It is easier to access 100% renewable supplies without having to commit to long-term PPAs within Europe because there is a higher level of renewables in the energy mix. In addition, Deutsche Telekom has embarked upon on-site generation projects such as the Dittenheim solar farm that it built with Ericsson, in which solar panels were integrated with mobile broadband towers to provide up to two thirds of the electricity required during peak demand periods.

Operators are working to ensure that the justified focus on net zero does not eclipse other important environmental issues. They are turning to the principles of the circular economy to help to reduce their environmental impact. The circular economy refers to a model of economic activity in which there is not a linear movement from raw materials to waste, but instead, the maximum effort is made at every level of the value chain to reuse and recycle, and thereby to reduce the amount of materials and resources required.

Waste, particularly e-waste, has traditionally been a challenge for the telecoms industry. E-waste refers to electronic refuse (principally mobile phones, computers and tablets), which is difficult to recycle and reuse. However, operators have taken the lead over the past few years, and many now have active phone exchange programmes and are making outreach efforts to educate consumers about how they can limit their contribution to environmental degradation. Examples include Orange's RE programme through which it provides extensive support to consumers to trade in their old phones for refurbishment or recycling, thereby limiting the growth of e-waste.

Operators are also using waste quotas to keep themselves accountable and ensure that they meet their targets for reducing the amount of equipment that is sent to landfill. More broadly, the growing implementation of a resource hierarchy is helping to limit unnecessary waste. This hierarchy puts 'rethinking' at the top and ultimately ends in 'refuse'. Operators can implement new design principles to stop waste from occurring as part of the rethinking process and can then focus on ensuring that the waste that is generated is disposed of

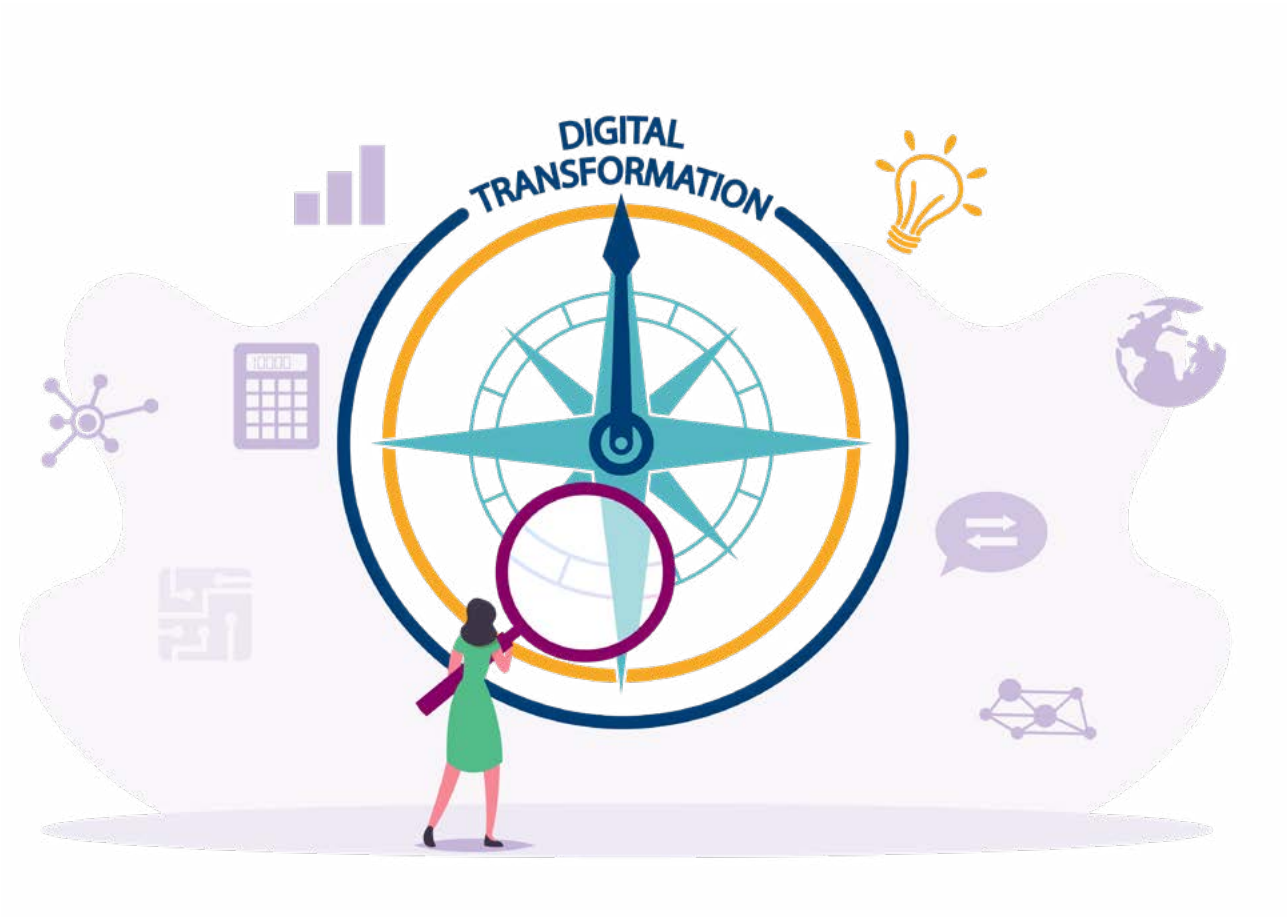
as responsibly as possible. Recycling and extending the life of advanced network equipment is an expensive and complex process, and governmental and EU support is essential to make it economically and environmentally efficient.

Tackling the cost of energy

Reducing energy use has become acutely important from both an economic and an environmental prospective as energy prices have soared worldwide, and particularly in Europe. Several ETNO members reported sharp cuts to profitability in 3Q 2022, partly due to hikes in energy prices.

Radio access networks (RANs) account for over half of operators' electricity use, and each successive generation of mobile technology requires more energy to function. 5G thus presents a paradox: it is more energy-efficient than earlier generations, but it will add an additional layer of energy consumption until legacy generations are switched off. Operators and vendors are highly aware of this issue and there have been several developments aimed at reducing the energy burden (such as 5G deep sleep mode). Future iterations of 5G, especially any roll-out that increases the number of active elements (such as massive MIMO antenna arrays, radio units and cell sites), threaten to increase power usage even more.

There are numerous ways to minimise the additional energy usage of 5G networks in the short term. Indeed, many equipment manufacturers and operators are working on novel software upgrades to improve network efficiency. The aim of these approaches is to more closely align power consumption with real-time usage; 'smart sleep' functions that power down equipment during periods of low usage are good examples of this. Ericsson now offers a Micro Sleep and Low Energy Scheduler Solution that can reduce energy consumption by up to 15% as part of its 5G software package. Using advanced, liquid-based cooling at base stations is another important approach.

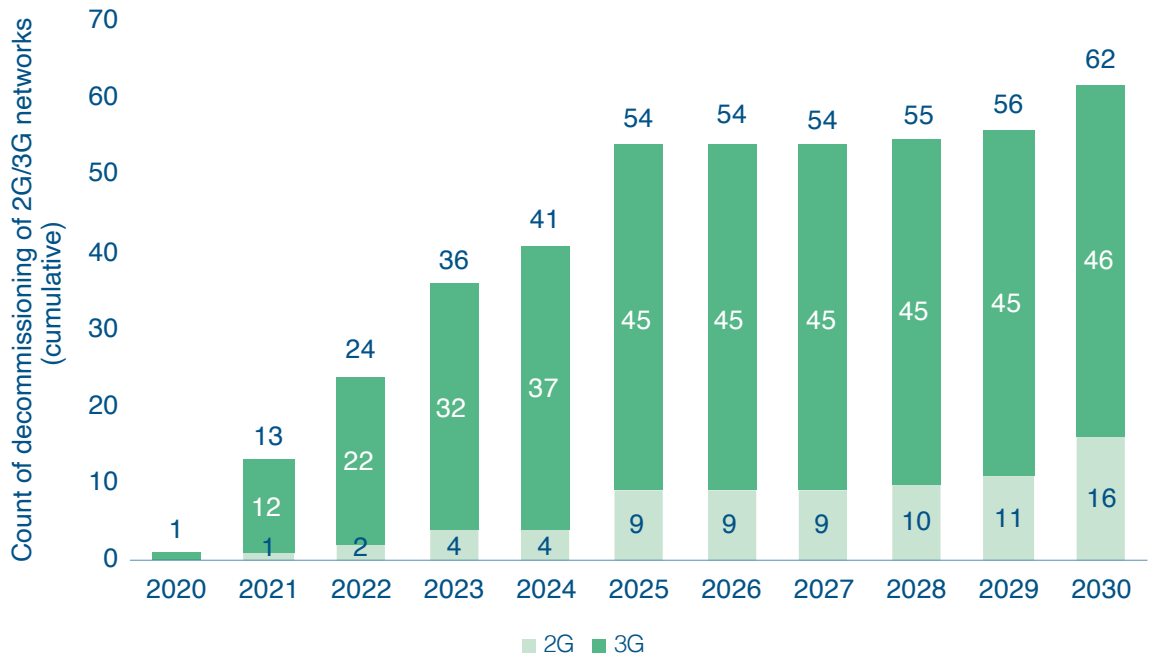


Decommissioning legacy networks

Achieving greater power efficiency in 4G and 5G networks is important to reducing energy usage, but decommissioning legacy mobile and fixed networks will have a more profound impact. ETNO members are all engaged in this process, but they face practical and regulatory headwinds in achieving this swiftly.

2G networks will be decommissioned after 3G networks in most cases (or not at all), despite being an older and slower technology. This is because 2G is still very important for IoT functions and basic voice services, while 3G has been mostly replaced by 4G and 5G. As a result, the 2G shutdown will proceed slowly in many countries, while there are expected to be 45 decommissioned 3G networks in Europe by 2025 because these networks will become increasingly obsolescent and expensive to run (**Figure 7.6**).

FIG 7.6 : ***Cumulative number of decommissioned 2G and 3G networks, Europe, 2020–2030***



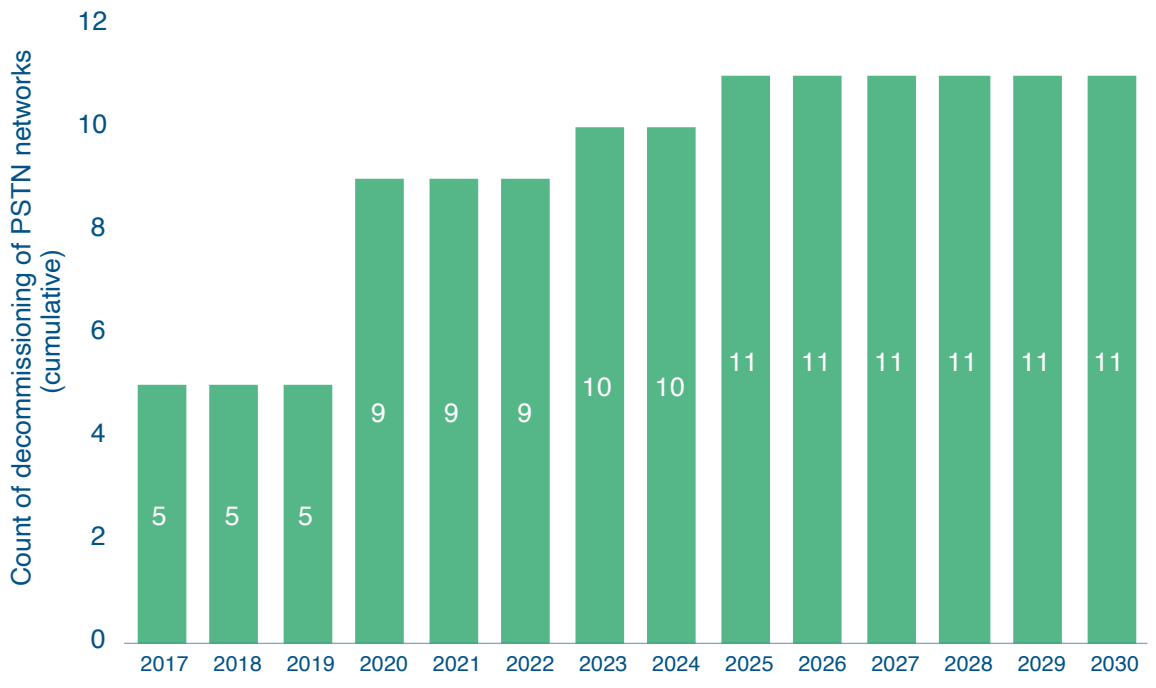
Source: Analysys Mason, 2022

Research suggests that MNOs who are currently maintaining a full suite of 2G, 3G, 4G and 5G services via separate base stations could lower their mobile network energy consumption by up to 40% if they switch off both 2G and 3G.[18] Most ETNO members are planning to shut off their 3G networks by 2028.

However, upgrading to FTTH and decommissioning copper networks and copper-based technologies could have a more profound impact on energy consumption than any remedy in the RAN. Different operators have very different network structures, so the total amount of energy that they can expect to save varies considerably, but moving from a copper-based network to FTTH-only infrastructure is likely to reduce energy use by 80% on average. Indeed, BT indicated in 2022 that an FTTH/GPON line uses only about 12% of the energy of an FTTC/VDSL line (excluding the CPE).[19]

So far, most decommissioning efforts have focused on PSTNs (**Figure 7.7**). This in itself can reduce energy consumption by up to 10%, but multiple operators plan to shut down their copper networks nonetheless. Decommissioning copper networks typically involves shutting down exchanges, which FTTH requires (generally 80%) fewer of. A fully modernised fixed access network would therefore account for under 10% of an integrated operator's energy usage. Moreover, new FTTH roll-out technologies and engineering techniques, such as shallow trenching (slot-cutting) and using existing aerial infrastructure (poles), could drastically reduce the carbon impact of the construction itself. However, these benefits will only be realised with the right policies.

FIG 7.7 : *Cumulative number of decommissioned PSTNs, Europe, 2017–2030*



Source: Analysys Mason, 2022

[18] For more information, see Analysys Masons' *Decommissioning legacy networks will be key to reducing operators' energy usage*.
[19] See also Telefónica (2022), *Connectivity solutions' Life Cycle Assessment*, which states that the environmental impact of FTTH per unit of data is 18 times lower than that of copper, and that the environmental impact of 4G/5G is 7 times lower than that of 2G/3G.

Telenor and Telefónica will be the first operators to shut down their copper networks in 2025 (**Figure 7.8**), though many others are planning progressive shutdowns over the course of the 2020s, with most aiming for a complete shut-off by 2030/2031. These include Orange France and Altice Portugal, both of which are targeting 2030.

FIG 7.8 : *Planned pre-2030 copper shutdown dates, Europe*

Operator	Year
Telenor	2025
Telefónica	2025
Telia Company	2026

Source: Analysys Mason

Hedging against energy price hikes while investing in renewables

Smart energy solutions will have a limited impact on energy consumption, and decommissioning takes time. Regulation is rightly in place to protect vulnerable consumers so all operators must find ways to protect themselves financially from energy price hikes.

Self-generation is one option, but it is likely to be small-scale unless operators truly diversify into the business of power generation itself. TIM is building new photovoltaic plants with an installed power of around 10MWp (megawatts-peak). It anticipated that these plants would produce 3GWh in 2020 and around 13GWh per year at full capacity. However, this is only equivalent to 0.8% of TIM's total energy consumption.

Self-generation schemes have their uses (and could be a means of guaranteeing supply in times of crisis), but PPAs are more likely to deliver on the twin aims of energy reduction and environmental benefits. These long-term contracts (usually 10–20 years) both facilitate the construction of energy-generating capacity by providing lenders with security and guarantee a stable price for energy over that period. Taking out PPAs mirrors the way in which operators themselves solicit long-term commitments to FTTH builds from anchor tenants in many respects.

Operators that are moving to make their networks dependent on renewable technologies are helping to fund a virtuous circle in which electricity generators have a better return on renewables and so maintain a higher level of investment and innovation.

SECTION 4

Operators can play a key role in determining the pace of European technology innovation

In this section, we go into further detail regarding important telecoms innovations such as Open RAN, 5G standalone networks, next-generation optical access networks, cloud edge and 6G, as well as Europe's contribution to their development and deployment. European telecoms players are active in all of these areas, but it is nonetheless fair to say that European initiatives are hampered by a lack of scale and investment capacity. Players from other countries and regions are making the biggest moves in particularly important areas such as Open RAN and 5G slicing.

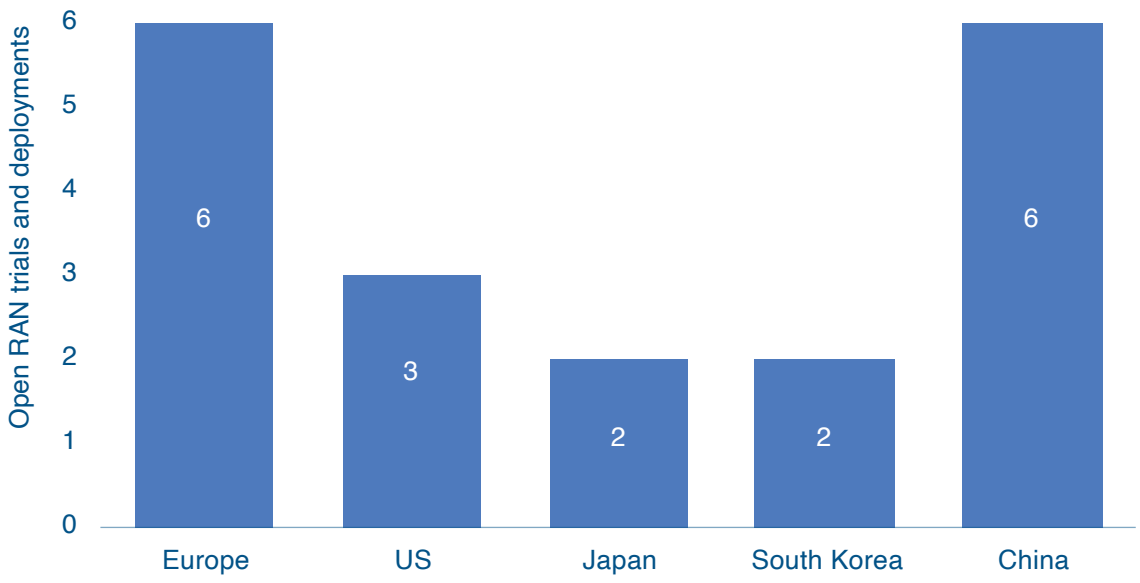
Innovation in Europe is seen as being key to ensuring the modernisation of the EU industry in terms of technology, products, services and business models. As such, the EC has various policies to support innovation. It announced a new European Innovation Agenda in July 2022 to position Europe as a leader in innovation. The EC's latest European Innovation Scoreboard (EIS), a policy to monitor and measure innovation across Europe, found that the EU's innovation performance improved by 10% between 2015 and September 2022.

4-1 OPEN RAN

Open RAN refers to the disaggregation and virtualisation of components across mobile access networks. It is attractive to operators because it allows them to select the best components from multiple vendors without being locked into any single technology roadmap.

ETNO members have been at the forefront of developing Open RANs, and several firms have contributed to the setting of technical specifications via the O-RAN Alliance and ETSI. However, their deployment activity has so far been largely confined to small-scale trials; the main Open RAN deployments in the world are from Rakuten Mobile in Japan and Dish Wireless in the USA at the time of writing (**Figure 8.1**).

FIG 8.1 : *Open RAN trials and deployments in China, Europe, Japan, South Korea and the USA, 2022*



Source: Analysys Mason, 2022

Implementing Open RAN can be complex because multiple vendors' products must be integrated into a single network. As a result, it is larger operators that have started to test and deploy Open RAN first, including players such as Deutsche Telekom, Orange, Telefónica, TIM and Vodafone.

Telefónica has successfully concluded several trials and aims to deploy Open RAN across 50% of its network by 2025. It aims to have 1000 active Open RAN sites across Germany by the end of 2022, as well as numerous smaller networks in the UK via its O2 subsidiary.

Deutsche Telekom has successfully completed an Open RAN trial in north-eastern Germany that showcases Europe's first integration of massive MIMO (mMIMO) radio units using O-RAN open fronthaul interfaces to connect to virtualised RAN software. It also operates an Open RAN lab ('i14y lab') in Berlin as part of a consortium funded by the German government, which enables the development and testing of open and disaggregated network components.
TIM has deployed Open RAN in parts of its 4G network in Italy and is planning to introduce it in its 5G network as well. Vodafone has launched Open RAN in multiple countries across Europe, including Italy, the Netherlands, Romania, Spain and the UK. It aims to have 2500 active Open RAN sites by 2027 and hopes that 30% of its network will use Open RAN by 2030. Orange plans to use solely Open RAN in new networks from 2025 and operates an Open RAN Integration Centre in France to test new Open RAN technologies.

Cloud computing plays a key role in the function of Open RAN, and some operators have taken advantage of this to build DIY private clouds to support their Open RAN deployments in order to avoid vendor lock-in. This method has been used by TIM in Italy and Vodafone in the UK.

4-2 5G STANDALONE NETWORKS AND THE ROLE OF SLICING

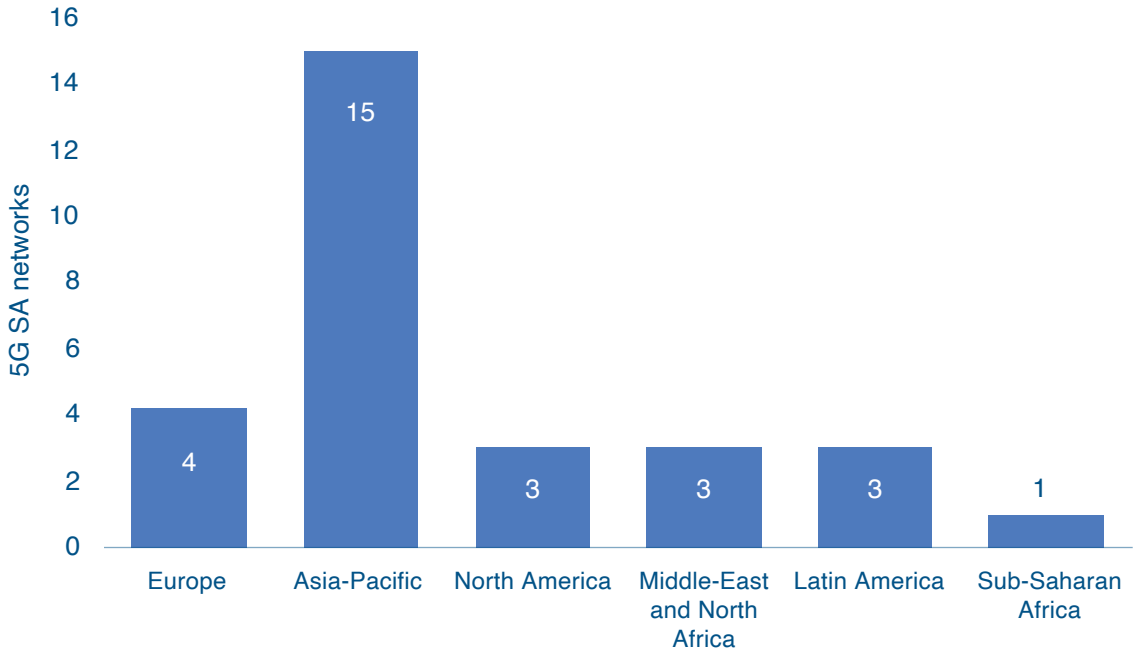
5G can offer much more than just faster speeds and more-reliable connections. The fundamental improvement in the flexibility and applicability of connectivity that it enables can accelerate the digital transformation of organisations and society. Network slicing plays a crucial role in this, especially from an innovation and industrial strategy viewpoint.

However, 5G networks must be fully implemented to realise these benefits, which means that 5G standalone (SA) networks need to proliferate. Most current 5G networks are 5G non-standalone (NSA) due to their lower roll-out costs. 5G NSA networks use upgraded 5G antennas on existing LTE (4G) evolved packet cores, whereas 5G SA networks use a new 5G mobile core.

5G NSA networks can deliver 5G mobile services, but the full capabilities of 5G can only be delivered using 5G SA networks. 5G SA enables services with low and/or guaranteed latency, which opens up the possibility of delivering a range of applications beyond best-efforts mobile broadband. 5G SA's potential to enable network slicing has attracted particular attention. Network slicing is defined as using common infrastructure to create separate, end-to-end virtualised networks that can then be used for specialised functions. For example, a network slice that prioritises minimum latency and maximum reliability could be created for remotely controlled vehicles, while another slice that targets greater connection density and energy efficiency could be used for IoT applications. The logical and dynamic isolation of FWA traffic from mobile broadband is probably the simplest use case and is already in use in some (non-European) countries. The Oslo public transport network is an example of non-5G network slicing in a real-world environment; Telia helped to transform the communications-based train control system to a radio-network-controlled system rather than rely on analogue signalling.

Four operators have deployed commercial 5G SA services in Europe as of 2022 (**Figure 9.1**); this is only one more than in the previous year. All except one is still small-scale, and the initial focus for two has been to isolate FWA traffic rather than to provide more-specialised functions or to enable third-party services to use the network. There have been several other active commercial trials. 5G SA deployments have been subject to delays, and not just in Europe. Not all operators are interested in developing these capabilities. However, the number of deployments in Europe is likely to increase significantly from 2023; indeed, Orange and A1 Telekom Austria have imminent roll-out plans.

FIG 9.1 : *5G SA commercial networks by geography, 3Q 2022*



Source: Analysys Mason, 2022

> 4 operators have deployed commercial 5G standalone services in Europe in 2022. A significant increase is expected for 2023.

4-3 NEXT-GENERATION OPTICAL ACCESS NETWORKS

Most new European FTTH deployments now use XGS-PON equipment. This delivers 10Gbit/s symmetrical access on a point-to-multipoint (PTMP) basis, meaning that users can buy multi-gigabit symmetrical services. Further generations of optical access over PONs are being developed and are beginning to appear in commercial networks.

The extraordinarily high speeds that XGS-PON technology enables act as a differentiator in hyper-competitive markets. There are currently few practical uses other than downloading and uploading very large files very quickly. However, the combination of these technologies with new ultra-wideband Wi-Fi6E and Wi-Fi7 will offer a radical step-change in the kind of bandwidths and latencies that are available at an affordable price to end users and devices. The widespread availability of multi-gigabit and sub-1ms links to individual devices, when combined with edge cloud, creates the kind of infrastructure fabric that could foster truly innovative extended reality (XR) services for consumers and businesses.

Optical access technologies also serve an important longer-term purpose because they allow operators to converge the hitherto separate networks for B2B dedicated links and for mobile x-haul into a single technology platform. Next-generation xPON radically reduces the cost of x-haul through the use of shared network infrastructure, thereby opening up opportunities for densified and virtualised local mobile networks that would otherwise have been commercially unviable.

- 25GS-PON, which delivers a 25Gbit/s symmetrical service, is a non-standards-based technology that was developed principally by Nokia. It has been trialled by many operators in Europe; the first live demo in the world was on Proximus's network in Antwerp in 2020. The first commercial service in the world launched in the USA in 2022. Other ETNO members that have trialled 25GS-PON include Deutsche Telekom, KPN, Openreach (BT) and TIM. Openreach and Proximus are some of the operators that are members of the 25GS-PON MSA Group, whose aim is to promote 25GS-PON.
- 50G-PON, which delivers 50Gbit/s downstream and is based on an ITU standard, is likely to become commercially available in about 2 years' time, but trials are already taking place. Swisscom completed the world's first trial of 50G-PON technology on a live network in June 2022. It plans to start commercial deployment in 2025.
- 100G-PON and even faster access networks are currently at a lab stage.

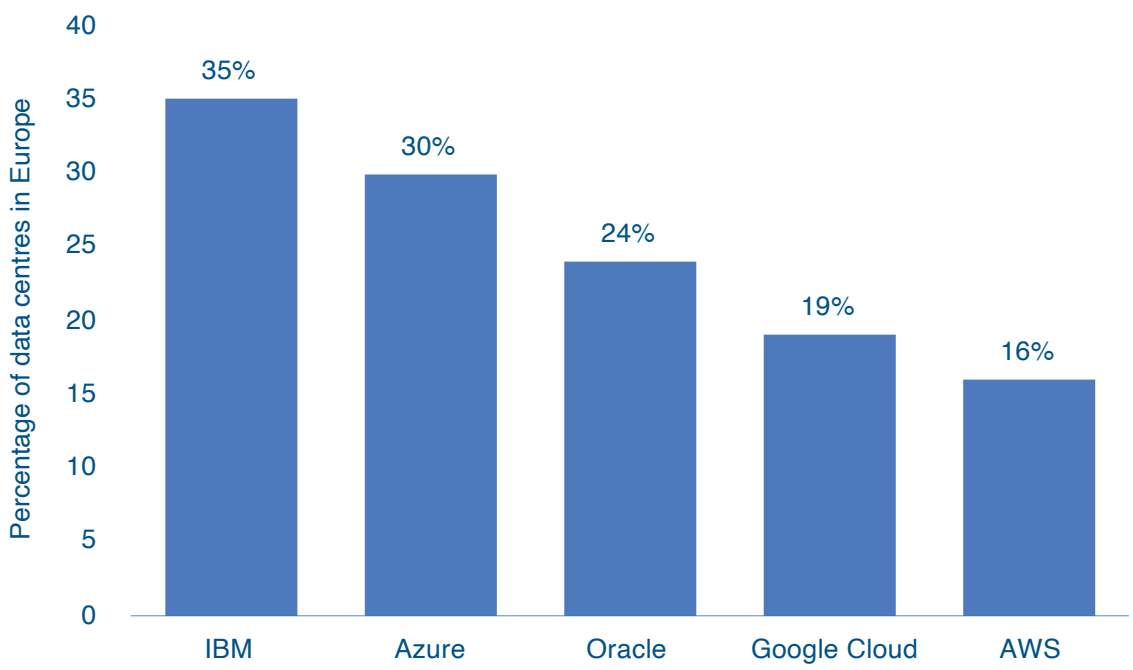
Network slicing is not confined to mobile networks; operators are exploring the ability to isolate virtual slices for special purposes on optical access networks. The ability to use network slicing to offer wholesale access in a way that grants the virtual network operator (the wholebuyer) a high degree of operational autonomy without heavy capital outlay is of particular interest.

4-4 OPERATORS AND CLOUD: INVESTMENTS IN EDGE CLOUD COMPUTING

Cloud computing is defined as the use of centralised computing resources to execute digital processes without having to own and maintain one's own servers. Access to such centralised resources is sold on an ongoing basis. ETNO members use cloud computing for their own operations and offer cloud services to customers.

Many of the data centres used for cloud computing are now based in Europe following significant expansion in recent years (**Figure 11.1**). For example, Oracle opened a second French cloud region in Paris in June 2022.

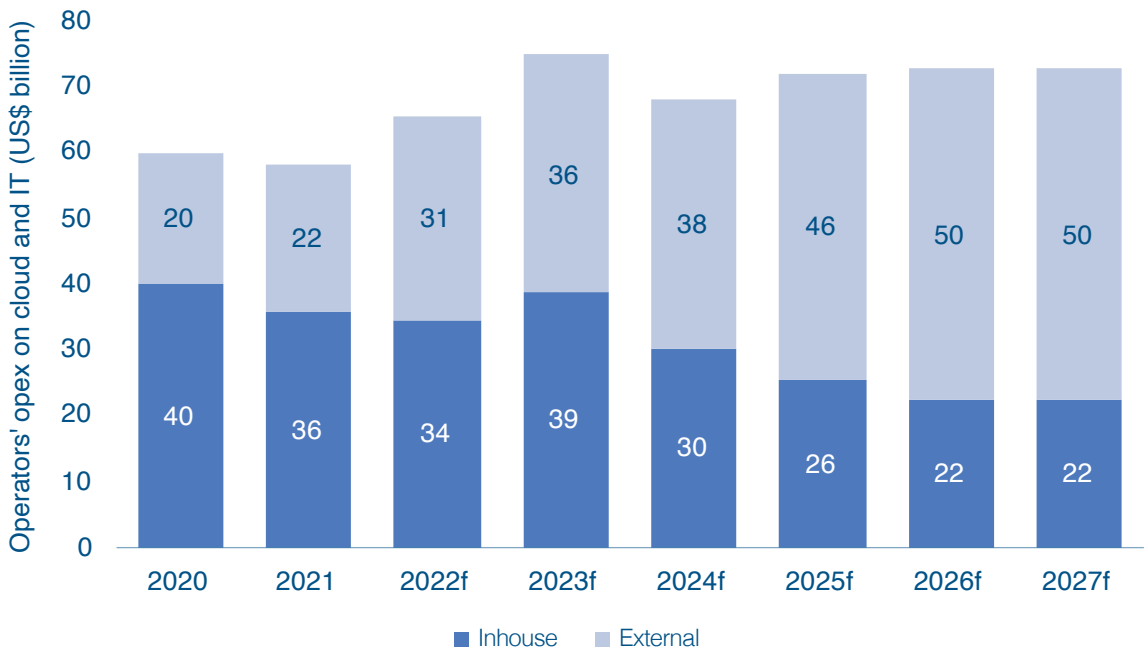
FIG 11.1 : ***Percentage of leading public cloud providers' data centres in Europe, 2022***



Source: Analysys Mason, 2022

Operators worldwide are spending increasing amounts on both cloud computing and wider IT in order to manage the growing level of information complexity that comes with 5G networks. The split of their costs between in-house spending and external spending is changing; the proportion of opex that is spent in-house is expected to decline radically over the next 5 years to US$22 billion (€20.5 billion) in 2027, while external spending is likely rise to US$50 billion (€46.5 billion) (**Figure 11.2**). This shift is being driven by cloud computing firms' high level of specialisation, which allows them to offer a far more cost-effective service than can be achieved with operators' internally developed proprietary systems. Spending is not expected to grow indefinitely and will probably start to level off in the late 2020s when as many processes as possible have been moved to the cloud.

FIG 11.2 : *Operators' cloud and IT opex, in-house and external, worldwide, 2020–2027f*



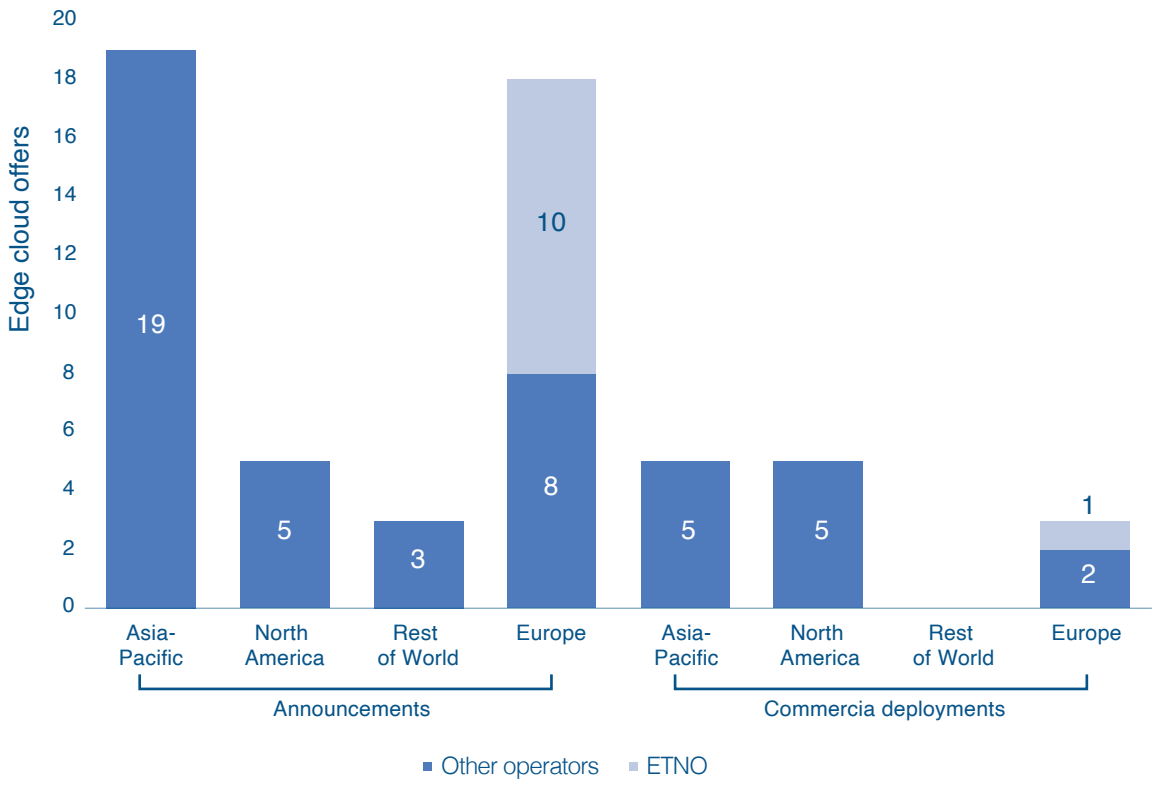
Source: Analysys Mason, 2022

Edge cloud computing is a form of distributed computing that involves bringing data processing nearer to end users. It is accomplished by spreading edge nodes that act as local data centres across a geographical area, which requires significant upfront investment. Increasing the number of edge nodes throughout Europe is a major goal of the EC's Digital Decade programme; indeed, the EC is targeting 10 000 edge computing nodes across the EU by 2030.

Operators are in a good existing position to increase the scale of edge computing in Europe because they already own and operate thousands of connectivity sites within densely populated and commercial areas. Edge computing nodes can be built next to towers and cell sites, thereby helping to further reduce latency and operational costs.

Multiple ETNO members have pursued edge computing projects and have often partnered with technical specialists to deliver cutting-edge solutions and to improve their own networks. Operators are also working together under the EC-sponsored framework of the Important Projects of Common European Interest to drive forward European investment in cloud developments. This type of project offers great advantages in terms of scope, co-operation and EU innovation, but its internal validation processes stand in the way of enabling a rapid time to market.

FIG 11.3 : *Announced and commercialised edge cloud offers, by global region, 2022*



Source: Analysys Mason, 2022

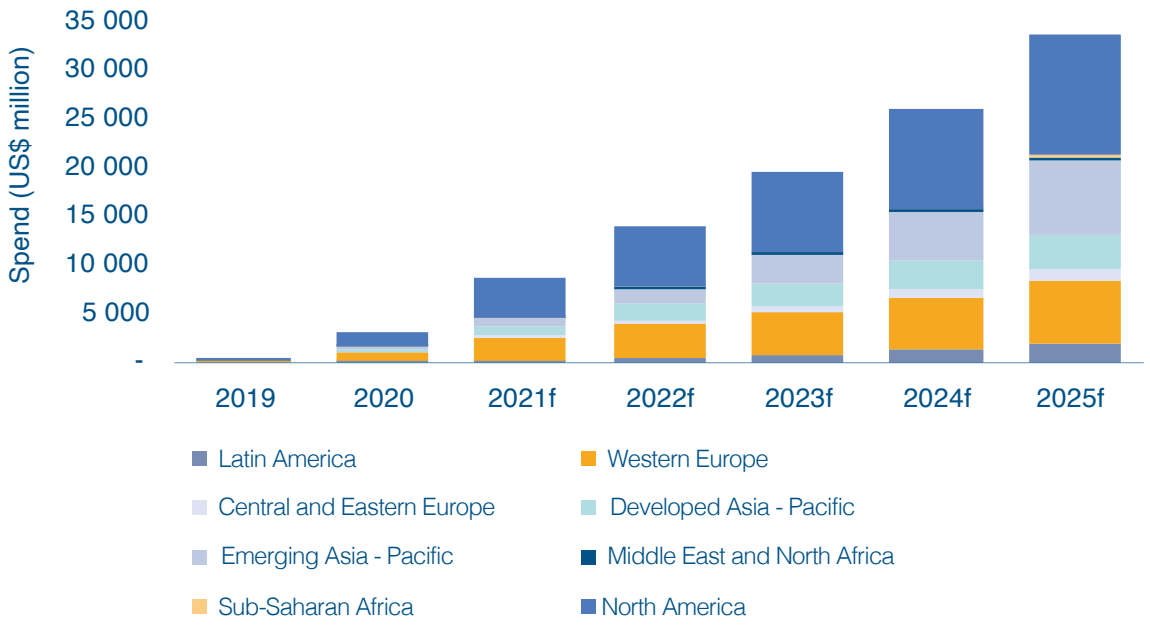
Telefónica announced a partnership with 5G enterprise firm Pente in 2022 to offer an integrated edge computing and 5G cloud service that provides cloud computing and automation of business processes.

Orange provides an enterprise edge computing solution called Intelligent EdgeFabric (IEF) that enables cloud applications to be run at the edge, with edge nodes providing a bridge between the central cloud and end devices. IEF is set up to be easily integrable with AI/ML, meaning that enterprises can increasingly automate their processes as their models are trained on real data emanating from the edge nodes.

TIM is aiming to increase the role of AI in edge computing, so has contributed to the AI@EDGE project that aims to automate 5G network components. Edge computing is particularly suited to this task because it can achieve the near-zero latency that is required to make live networks function in real time.

Enterprise spending on edge cloud computing is expected to grow rapidly worldwide, and will exceed US$30 billion (€28 billion) by 2025 (**Figure 11.4**). Spending will be the greatest in North America, but enterprises in emerging Asia–Pacific and Western Europe will also spend over US$5 billion (€4.7 billion) each.

FIG 11.4 : *Enterprise spending on public edge computing services, by region, worldwide, 2019–2025*



Region	2019	2020	2021f	2022f	2023f	2024f	2025f
North America	102	1496	4153	6346	8169	10 227	12 468
Latin America	0	70	242	478	819	1268	1822
Western Europe	61	891	2431	3607	4472	5424	6525
Central and Eastern Europe	0	46	154	296	494	749	1067
Developed Asia–Pacific	24	329	935	1561	2228	2969	3762
Emerging Asia–Pacific	0	209	754	1582	2928	4864	7405
Middle East and North Africa	0	20	68	134	226	346	494
Sub-Saharan Africa	0	4	14	28	50	88	158
Total (US$ million)	**186**	**3065**	**8750**	**14 032**	**19 386**	**25 935**	**33 701**

Source: Analysys Mason, 2022

4-5 OPERATORS' ROLE IN EMERGING METAVERSES

The metaverse refers to the growing web of interconnected 3D, avatar-driven applications and worlds that are being built; some of the most well-known companies in the space are Meta and Roblox. The metaverse is highly dependent upon fast and reliable connectivity, so there is significant potential for operators to become involved. Many ETNO members have started to explore what they can bring to the metaverse; some have focused on the provision of metaverse-specific connections, while others are developing their own applications.

Operators are collaborating to improve the AR/VR experience, which is critical to the success of the metaverse. For example, the Niantic Planet-Scale AR Alliance is working to build a comprehensive AR platform that can be used on multiple different headsets, and Deutsche Telekom, EE and Orange are contributing members.

Telefónica started to work with Qualcomm in September 2022 to develop a new XR ecosystem based on Qualcomm's Snapdragon platform and running through Telefónica's fixed and mobile networks. The aim is to offer a range of applications offered through the ecosystem and to bring new people into the metaverse by offering a user-friendly introduction to XR experiences. Orange Spain launched its own metaverse store also in September 2022, with which consumers can interact via VR headsets. It includes digital avatars of salespeople to help end users to find the right product.

Most operators are using the metaverse to capitalise on their technical advantage in connectivity provision, but some are now starting to explore the possibility of taking on a more active role in other elements of the value chain. For example, Telefónica is part of the Alaian Alliance of operators and has been working to create metaverse use case standards that maximise the interoperability between various applications and devices. It is also aiming to develop standardised network technologies that can be used to connect headsets from a range of vendors; this is vital to ensuring a wide take-up of metaverse apps. Operators' enthusiasm for the metaverse is illustrated by the wide array of events that they have held in the metaverse, though most operators believe that the primary economic impact of the metaverse will not be felt until the late 2020s, thereby limiting its immediate relevance for revenue generation.

4-6 PLAYING A LEADING ROLE IN THE DEVELOPMENT OF 6G

5G is still being rolled out in Europe, but the next generation of mobile network is currently being researched and defined. 6G is likely to be the main new mobile technology by the late 2030s. It is currently being created by a combination of vendors, operators, governments and academic researchers. ETNO members are playing a key role.

The EC has shown considerable interest in the development of 6G and has steadily increased its financial support for research projects. 35 6G projects were named to receive a combined total of €250 million of funding via the EC's Horizon Europe programme in October 2022. This funding fall into four distinct streams.

- Stream A targets the further development of 5G and focuses on Open-RAN and AI-based edge platforms that will help with the roll-out of 6G.
- Stream B supports entirely novel research projects that will not be commercialised for many years. They aim to produce new architecture for 6G systems and to improve non-terrestrial networks and low-latency communications.
- Stream C is assisting three projects that are trying to create smart networks and services (SNS) infrastructure that can act as a 6G enabler.
- Stream D will fund experimental SNS deployments throughout Europe that are intended to enable real use cases in vertical sectors such as healthcare and manufacturing to be tested.

Multiple operators have stressed that they do not expect 6G to be as revolutionary as 5G. BT and Vodafone announced in March 2022 that they believe that 6G will rely on the same underlying orthogonal frequency division multiplexing technology as 5G. Others believe that 6G will focus on specific use cases; for example, Orange's March 2022 6G white paper focused on the potential industrial and environmental challenges that the new generation of mobile technology can solve.

Ensuring that European technology sovereignty is preserved throughout the invention and adoption of 6G is a key aim for both ETNO members and the EC. This will require strong European contributions to the standardisation process as well as the development of a world-class research programme that helps to forge 6G technology that is in line with European values.

> "6G is a priority for Europe: 35 projects are expected to receive funding via the Horizon Europe programme."

> Operators are collaborating to improve the Augmented Reality and Virtual Reality experiences, which are critical to the success of the metaverse.

SECTION 5

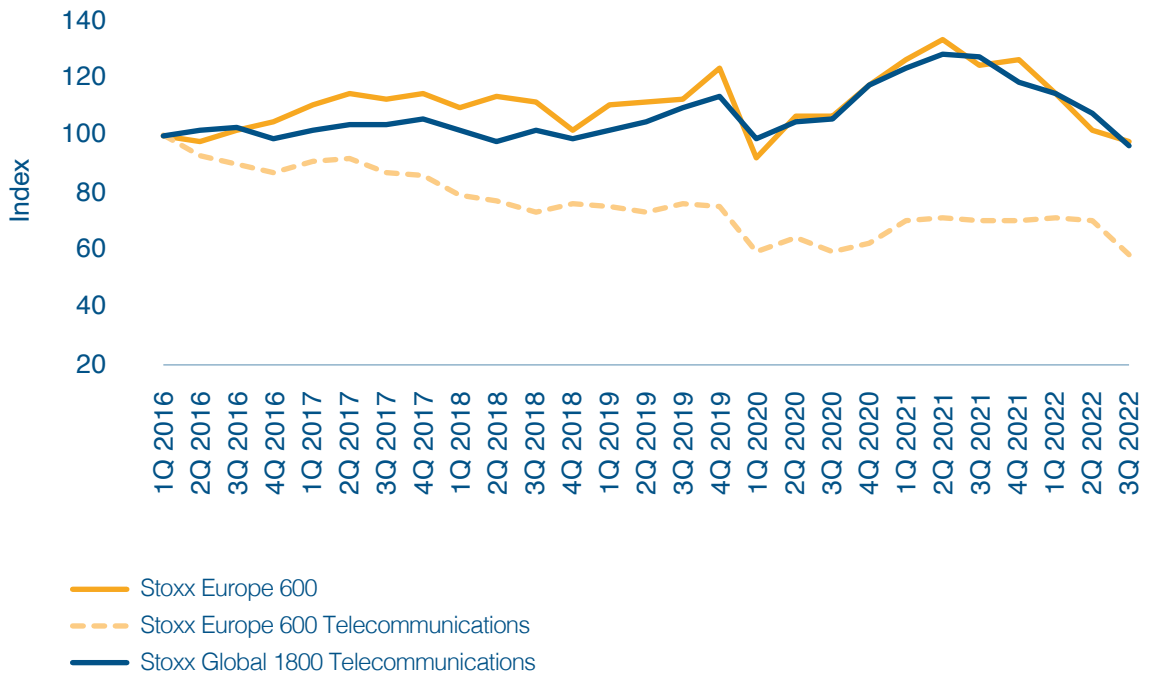
The continuing poor financial health of the telecoms sector is not in Europe's strategic interest

The European telecoms sector continues to struggle to translate demand for its services into financial robustness. Its market valuations have underperformed, its debt is high and its ability to make adequate returns on the high level of capital employed is questionable. This situation is not in Europe's strategic interest, mainly because it contributes to weakening the sector's ability to swiftly invest in resilient networks, but also because it is leading to the sale of service-related assets, which are highly relevant in terms of the overall innovative potential of the European economy.

5-1 EUROPEAN TELECOMS STOCKS UNDERPERFORM BOTH EUROPEAN OVERALL STOCK MARKETS AND GLOBAL TELECOMS INDICES

European telecoms stocks have consistently underperformed both global telecoms indices and European stock markets (**Figure 14.1**). They have not recovered to their pre-pandemic levels and are now significantly lower than they were in mid-2021.

FIG 14.1 : *Stoxx Europe 600 index, Stoxx Europe 600 index for telecoms and Stoxx Global 1800 index for telecoms, where the value in 1Q 2016 is set to 100, 4Q 2015–3Q 2022*

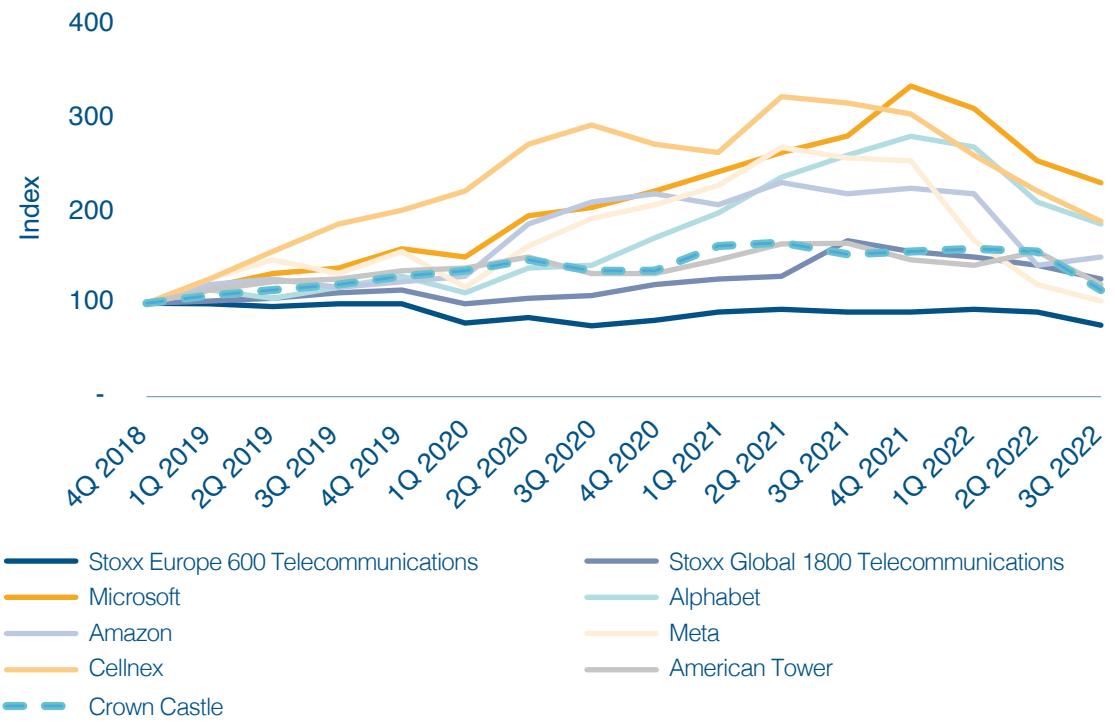


Source: Analysys Mason, 2022

Both general European stock prices and global telecoms stocks have suffered over the past year, but European telecoms firms did not benefit from a post-pandemic rise. This contributed to a widening of the gap between their share prices and broader European market movements, although this ratio appears to have stabilised over 2022 (both indices have fallen).

Operators are generally concerned that part of their historical value as service providers is continually being lost to CAPs (particularly hyperscalers). Part of operators' value has also been lost to pure infrastructure plays (sometimes called under-the-floors) such as towercos and fibrecos (much of this has actually been the result of operator sell-offs). All three groups (that is, CAPs/OTTs, telecoms operators and infrastructure plays) lost substantial stock value in the first three quarters of 2022 (**Figure 14.2**). Of course, these falls must be seen in the context of general economic woes; the falls in CAPs' stocks are also a market correction.

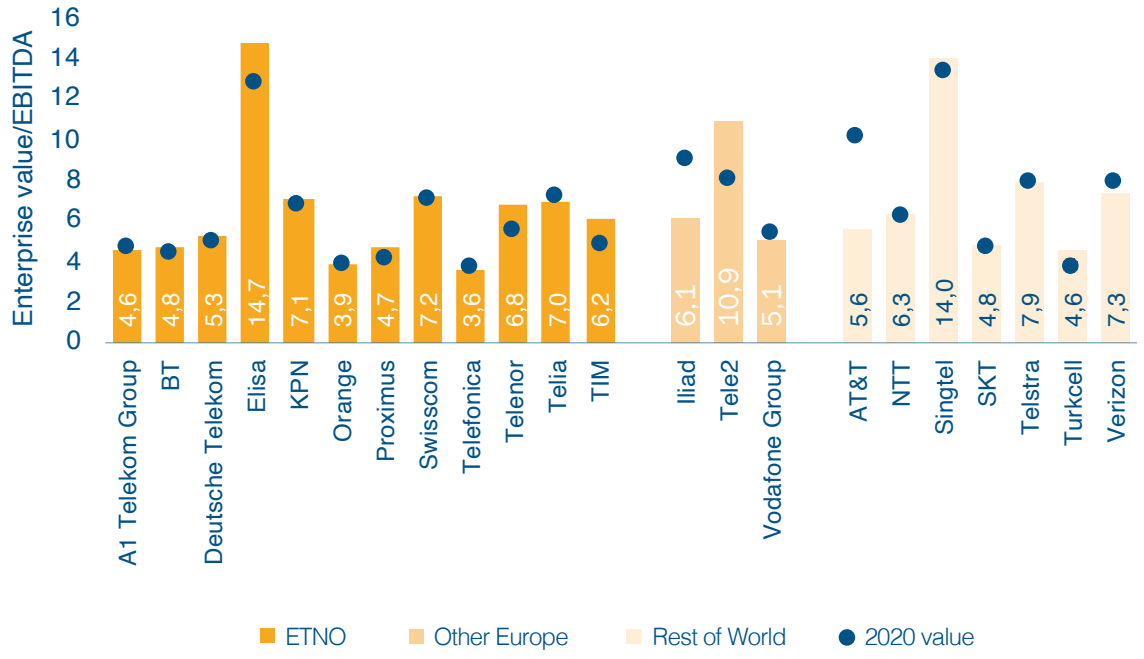
FIG 14.2 : *Stoxx Europe 600 index for telecoms, Stoxx Global 1800 index for telecoms and stock values for hyperscalers and towercos, where the value in 4Q 2018 is set to 100, 4Q 2018–3Q 2022*



Source: Analysys Mason, 2022

Enterprise value/EBITDA multiples for European telecoms stocks remain low, though the aggregate value for ETNO members increased from 4.7 to 5.0 over the last full financial year and the unweighted average grew from 5.8 to 6.3 (**Figure 14.3**). These low multiples reflect an ongoing lack of market confidence in the potential for sustainable long-term growth in European telecoms revenue.

FIG 14.3 : *Enterprise value/EBITDA, ETNO members and other operators, worldwide, end of the last full financial year as of November 2022*

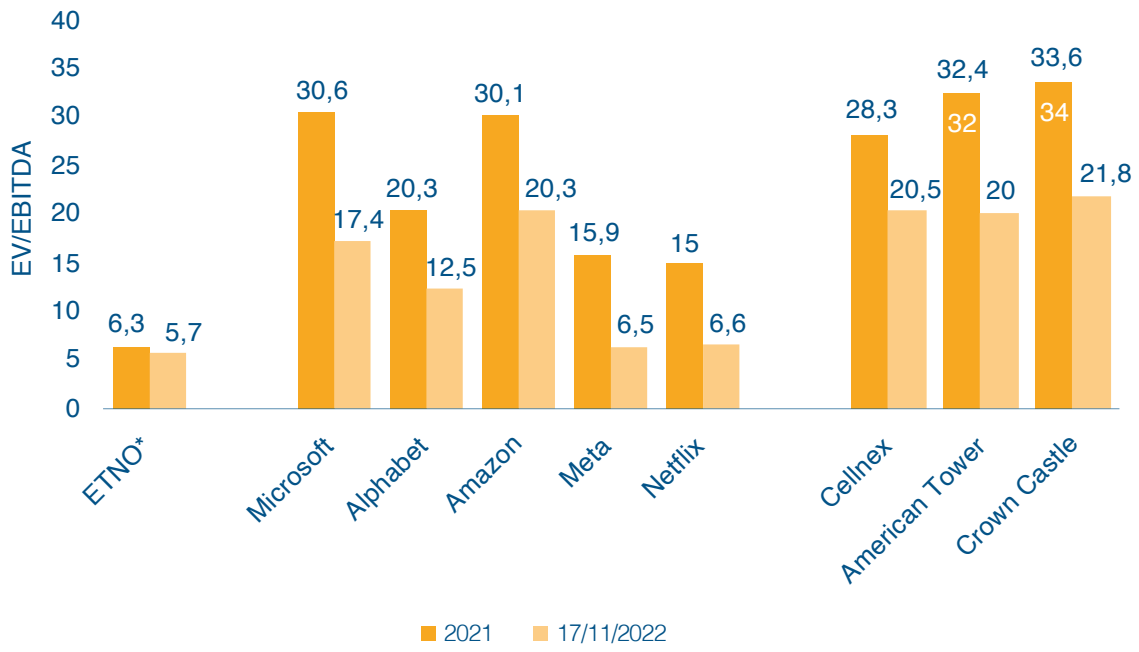


Source: Analysys Mason, 2022

> European telecom companies have underperformed peers on market valuation, investment, returns and debt ratios. This is a strategic weakness for Europe.

The business model used by most European operators seeks to benefit from tying the provision of physical connectivity to the service layer. The physical layer mostly consists of network infrastructure such as towers and cables, whereas the service layer increasingly resides in software. Markets appear to regard this as an inefficient means to maximise the value of these assets. As a consequence, they tend to punish communications businesses (in Europe and elsewhere) that are not focused on one or the other, and they have doubly punished telecoms businesses in Europe where pro-competition regulation has made it harder than elsewhere to gain advantage in the service layer via the connectivity business.

FIG 14.4 : *EV/EBITDA multiples, ETNO members, selected hyperscale CAPs and major telecoms infracos, worldwide, 2021 and 17 November 2022* [20]

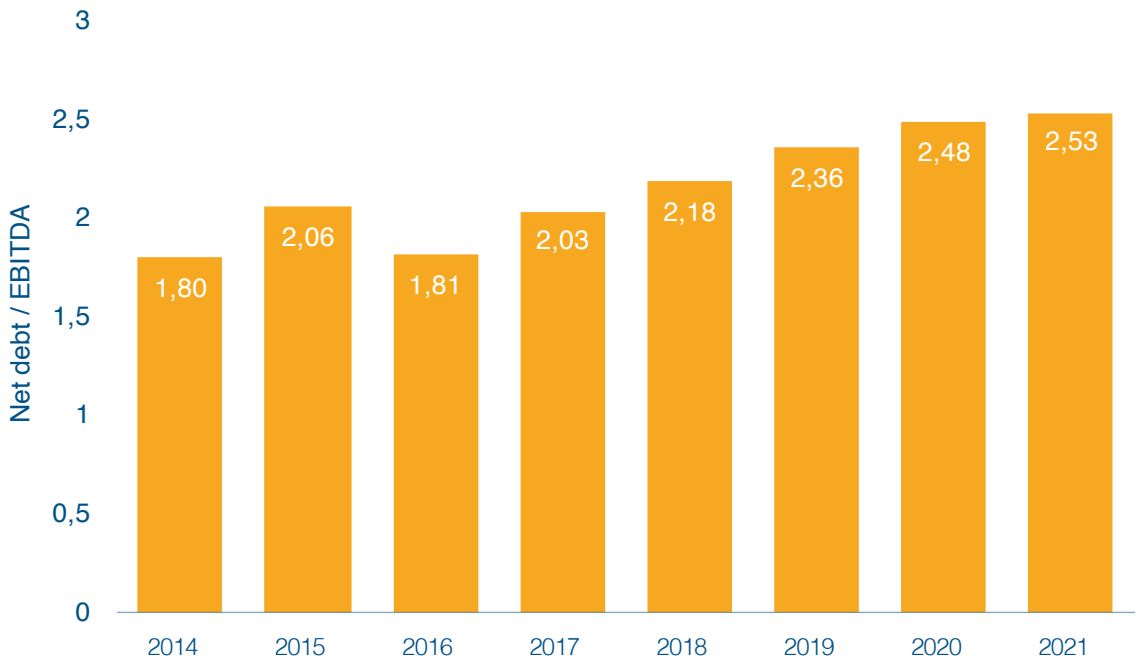


Source: Analysys Mason, 2022

[20] The ETNO data is based on the unweighted average among members.

Operators' net debt continues to grow. Indeed, net debt as a proportion of EBITDA has grown for the past 5 years for ETNO members at the consolidated group level (**Figure 14.5**). Structurally persistent high levels of debt are increasingly a problem as interest rates start to rise from historical lows.

FIG 14.5 : *Net debt/EBITDA, ETNO members at the group level, 2014–2021*



Source: Analysys Mason, 2022

The attempts to improve balance sheets run up against the need to continue to modern networks by deploying 5G and FTTH. FTTH is usually a greater capex burden than 5G, but the likelihood is that free cash flow will improve substantially once that transformation is completed. However, this is still several years off for many European operators, and there seems to be little prospect of mobile investment slowing down in a similar manner to that for fixed services.

The current capex burden has forced operators to sell non-core operating subsidiaries and various assets. Many ETNO members (and other European operators) have carved out tower businesses that are also open to third-party tenancies. The expectation is that these newly formed businesses will deliver improved return on operators' assets. Carved-out captive towercos of this kind attract interest from infrastructure investors and have commanded high valuations in relation to their EBITDA. As such, several operators have sold stakes in the new entities, and have thereby enabled new investors to enter the market as partners rather than competitors. There has also been a similar carve-out/sale plus leaseback approach to some data centre assets.

Many ETNO members have entered into co-investment partnerships for FTTH, sometimes for their entire physical footprint and sometimes for just parts of that footprint. This enables:

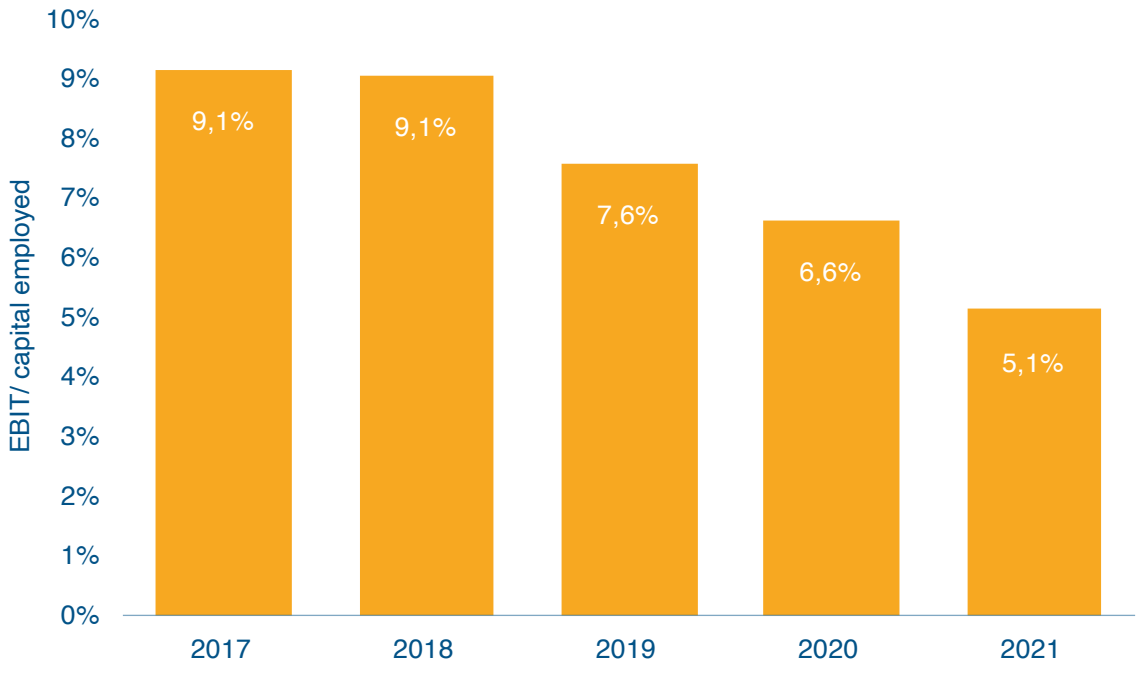
- faster roll-outs for FTTH and new tower infrastructure
- the fuller realisation of revenue growth potential
- operators to form partnerships with businesses that might otherwise be competitors.

Sales of assets and adjacent businesses have also occurred in other, more service-driven, areas. It has sometimes proven difficult for operators in mid-sized or small European national markets to compete effectively against large transnational entities in the consumer and enterprise digital services space.

These developments improve balance sheets and, particularly in the case of FTTH assets, lower future capex burdens and hence future indebtedness. However, they also introduce the risk of national operators losing control of end-to-end value chains, either to cloud players or to infracos. Partnerships with cloud players might result in operators yielding strategic direction and hence value to the cloud players. Infracos typically focus on single, usually passive, asset classes (towers, fibre and data centres), but some are starting to invest a wider variety of asset classes, and inactive equipment and skills, all of which combine to make infracos closer in nature to wholesale telecoms operators.

Return on capital employed (ROCE) has declined for ETNO members (**Figure 14.6**). The aggregate figure for 2021 (5.1%) is perilously close to the weighted average cost of capital for the telecoms industry, although an adjusted figure that excluded various write-downs would be closer to 6.1%.

FIG 14.6 : *Aggregate ROCE, ETNO members, 2017–2021*



Source: Analysys Mason, 2022

5-2 EUROPEAN TELECOMS OPERATORS' CONTINUING POOR RETURNS ARE NOT IN EUROPEANS' INTEREST

Low returns make the investment needed to achieve the 2030 Digital Decade targets more challenging, especially in the current economic climate where public subsidies are unlikely. Moreover, operators will be in an even weaker position if new metaverse services expand rapidly to the extent that networks (and especially mobile networks) require vast amounts of new investment. This is not simply a matter of networks in the conventional sense of radio and fibre; financially weakened European telecoms businesses will have to cede control if new XR-type services necessitate a massive densification of local digital infrastructure in the form of edge cloud nodes.

This issue is being discussed, among others, in an ongoing policy debate on whether CAPs should contribute to the network investment efforts that are currently shouldered by the European telecoms sector. The European Digital Rights and Principles Declaration from January 2022 established that all market actors that benefit from the dividends of the digital economy should make a "fair and proportionate contribution" to digital network investment. This discussion is key to advancing towards the achievement of the EU Digital Decade targets, and multiple different views are currently being put forward by stakeholders. More clarity on the policy objectives, scope, modalities and implications is expected during 2023. This is one of the debates that will shape the longer-term strength of the European telecoms sector, as well as its overall investment capacity.

Notwithstanding the issue of meeting the Digital Decade targets, there are further reasons, with strategic implications for Europe, to be concerned about the health of the European telecoms sector.

- Low profitability increases the risk that the European communications industry outsources the skills required for new technology paradigms, thereby yielding competence to non-European companies in China, India or the USA. The development of a stronger domestic position in the communications technology ecosystem has been a long-standing strategic challenge for Europe since the beginning of the 4G era.
- Low valuations make the communications sector more susceptible to aggressive M&A and potential hostile approaches from non-European actors, some of which may have little interest in developing a digital advantage for Europe. Yielding control to outside entities could seriously damage the European aim of open strategic autonomy and could dent any hope of a renaissance of innovation and investment in new digital communications technologies.
- In terms of governance and ownership models, we observe that, in addition to the vertically integrated model, several markets are now proceeding to separate network assets, fixed or mobile. Especially in Europe, this is a way to create value in a low-growth sector. The way in which structural separation is implemented is particularly delicate, as breaking up vertically integrated players might hamper resources and skills to pioneer technology, especially vis-à-vis global competitors.

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Austria

Belgium

Bosnia and Herzegovina

Bulgaria

Croatia

Cyprus

Denmark

Finland

France

Germany

Greece

Hungary

Iceland

Italy

Lithuania

Luxembourg

Malta

Netherlands

North Macedonia

Norway

Poland

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