GSMA

Spectrum Pricing and Renewals in Europe

Supporting consumers and economic growth

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www.gsmaintelligence.com
info@gsmaintelligence.com

Authors:

Kalvin Bahia,
Senior Director of Economics, GSMA Intelligence

Jakub Zagdanski,
Principal Economist, GSMA Intelligence

Pau Castells,
Head of Economic Analysis, GSMA Intelligence

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Executive summary

Europe needs policy reforms to restore its digital ambitions

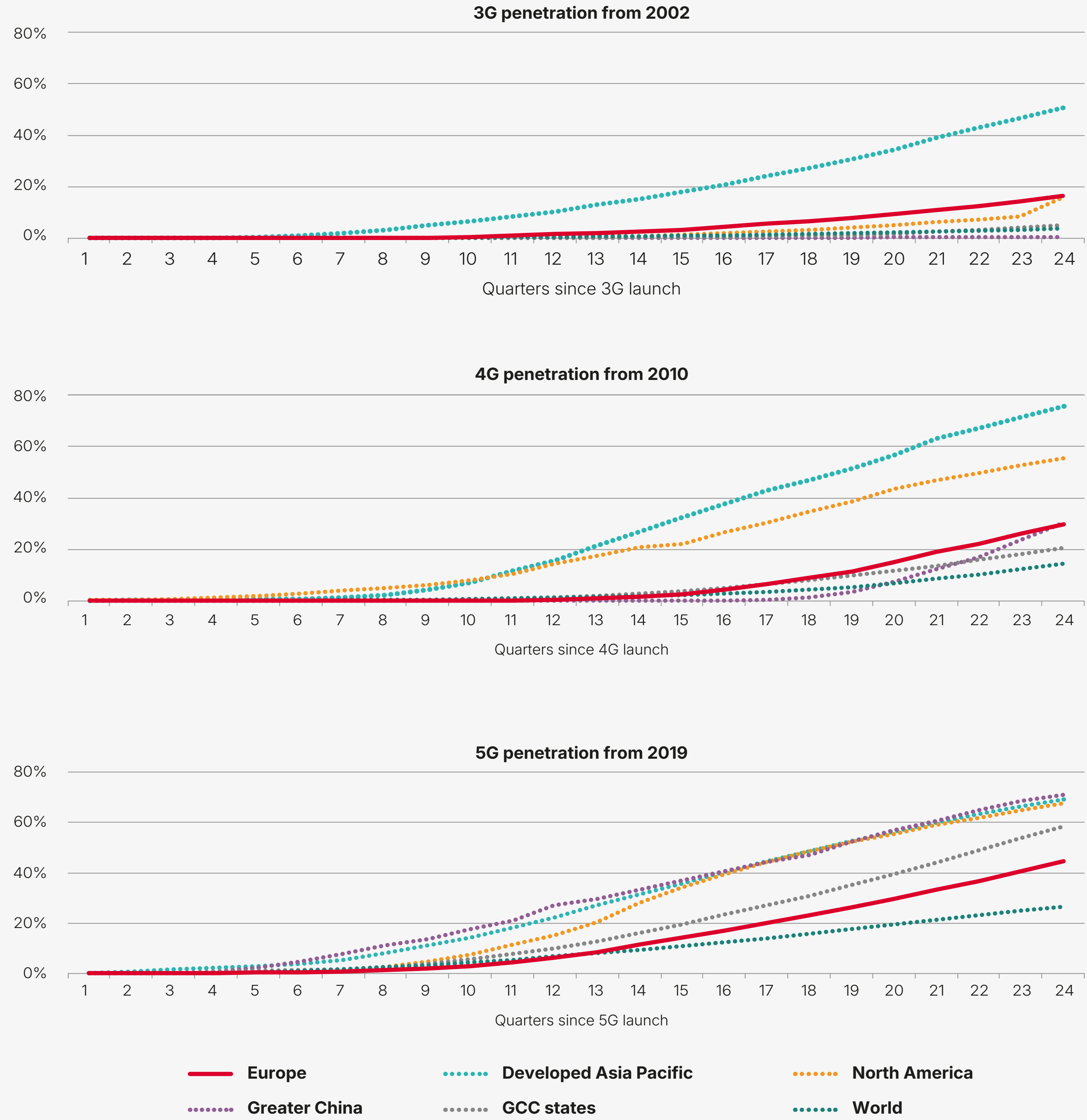
Secure and sustainable digital infrastructure is essential for thriving modern economies. Mobile connectivity plays an important role in the digital ambitions of every European nation, enabling citizens and businesses to access reliable and affordable connectivity. This is why digital infrastructure is a core priority of the European Commission's Digital Decade.

Since the launch of 5G networks in 2019, mobile operators have invested almost €200 billion on their networks and have expanded 5G coverage to 93% of the population, representing significant steps made towards the Digital Decade targets. However, Europe is not on track to achieve these targets and faces growing pressure to keep pace with other leading global regions. These include the developed Asia Pacific region, North America, the Gulf Cooperation Council (GCC) states and Greater China.

Continued investment is needed for Europe to advance its mobile infrastructure and support the evolution of high-quality connectivity, including wider deployment of 5G standalone (SA). A robust and supportive regulatory environment is required, including on spectrum, to deliver Europe's digital objectives and ensure it remains competitive in the decade ahead.

Figure i

Market penetration of 3G, 4G and 5G since launch[1]



Penetration is calculated by dividing connections by total population. A 3G/4G/5G connection is defined as a 3G/4G/5G SIM card (or phone number, where SIM cards are not used) that has been registered on the mobile network at the end of the period. Connections differ from subscribers in that a unique subscriber can have multiple connections.

Source: GSMA Intelligence

1 In this report, Europe refers to the 27 EU countries plus the UK, Switzerland and Norway. Developed Asia Pacific includes South Korea, Japan, Singapore, Brunei, Australia and New Zealand North America includes the US and Canada. The GCC states include Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE. Greater China includes mainland China, Hong Kong and Taiwan.

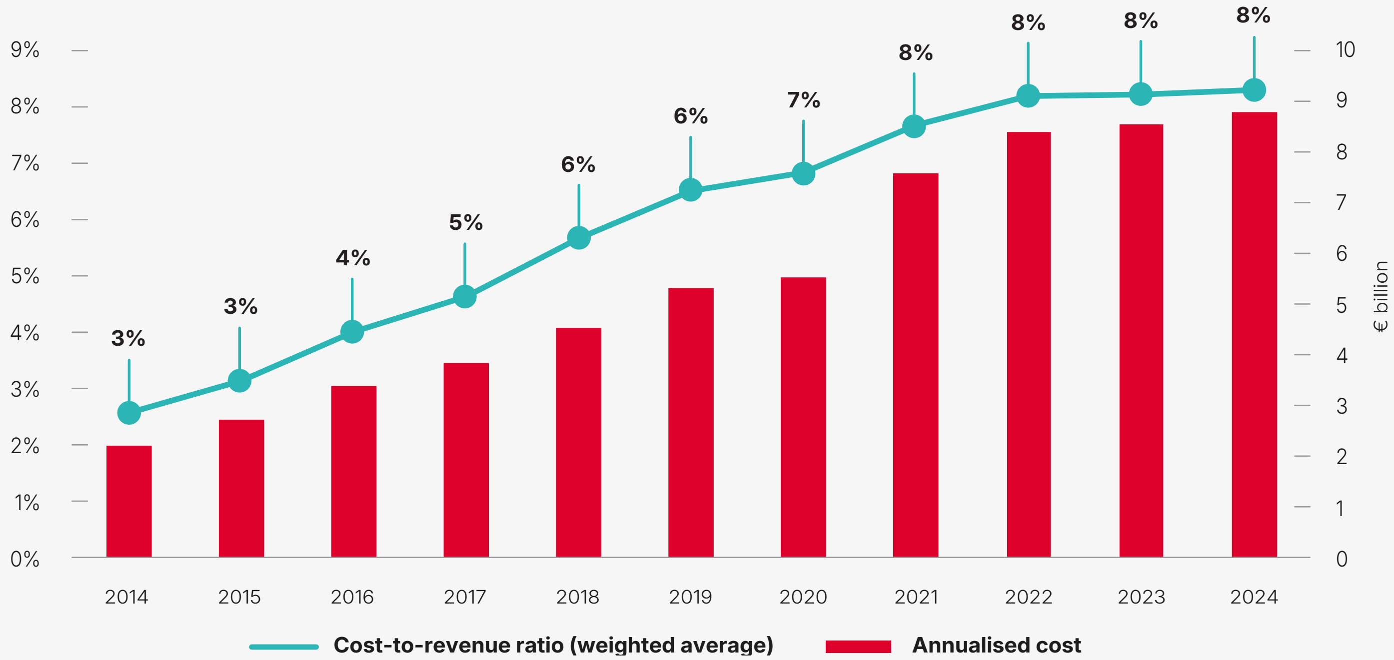
Spectrum costs in Europe contribute to a vicious cycle that constrains investment

An important part of delivering the vibrant infrastructure laid out in the Digital Decade targets is understanding the investment environment in Europe. Compared to leading regions, many European markets have lower returns on investment, which impact their ability to invest in networks. The result is that investment per subscriber in Europe has been consistently lower than in other high-income countries over the past 15 years, which is a reason why many European markets are lagging behind in terms of network quality and the deployment of 5G SA.

One of the factors contributing to this is spectrum costs. In the last 10 years, total spectrum costs in Europe, as a proportion of revenue, have tripled to around 8%.[2] The reason for this is that the revenue generated from each MHz unit of spectrum has declined by 54% since 2014, but the price of spectrum has not declined to the same extent. Even though the majority of spectrum has been assigned via auctions, the prices paid by mobile operators have often been driven by non-market factors, such as high reserve prices, annual fees and decisions around auction design that have limited the amount of spectrum available and therefore artificially increased spectrum costs.

Figure ii

Aggregate spectrum-cost-to-recurring-revenue ratio (excluding high-cost 2.1 GHz licences)



Source: GSMA Intelligence

2 These costs exclude the extremely high costs paid for 3G licences in the 2.1 GHz frequency band, particularly in the UK and Germany.

Europe has an opportunity to reset its spectrum policy with upcoming renewals

Breaking out of Europe's vicious cycle will require policy reforms that improve the ability of and incentive for operators to invest as well as enabling them to more effectively monetise their investments. Many of the necessary reforms have been identified in the Letta and Draghi reports on EU competitiveness and the single market,[3] including spectrum policy

Fortunately, policymakers have an opportunity to address this, as more than 500 spectrum licences are due for renewal in the next 10 years. If current prices are maintained, then operators will incur €104 billion in spectrum costs in the 2025–2035 period. If automatic low-cost renewals are implemented, it could save up to €30 billion in spectrum costs over the next 10 years, improving the viability of further network investment.

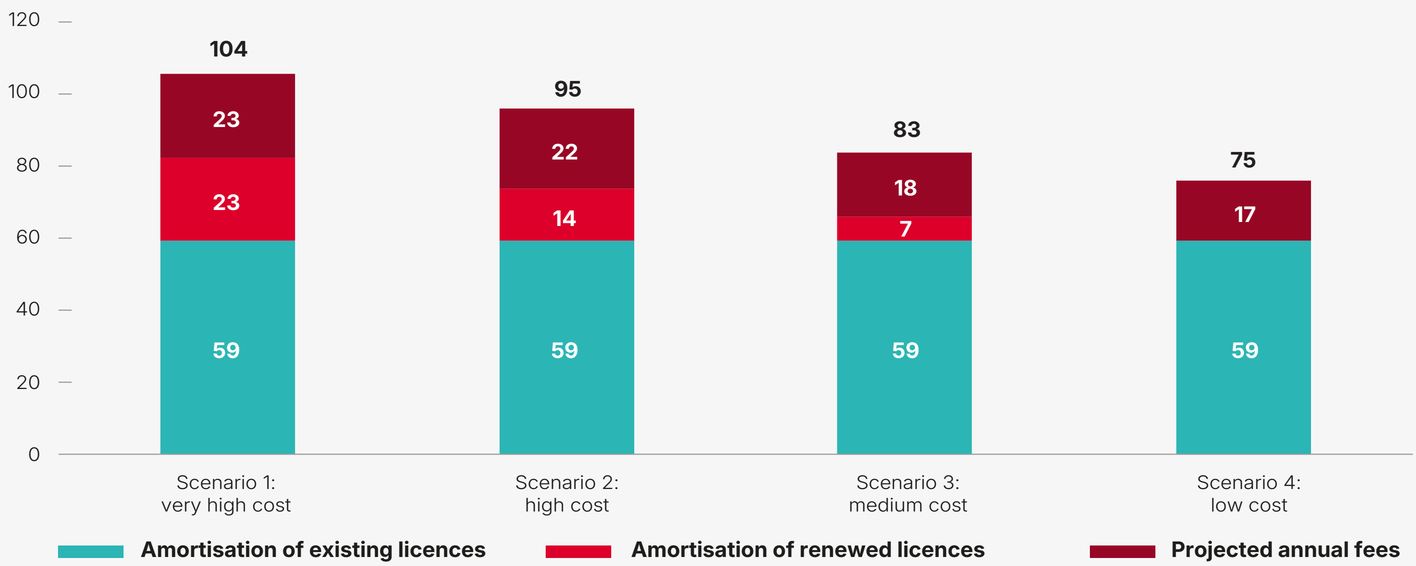
To put the €30 billion figure into context, it exceeds the investment that is needed to upgrade to 5G SA across all existing 5G networks in Europe. Lower spectrum costs have a positive impact on mobile network quality (which in turn positively impacts productivity in the economy). Because of this, GSMA research shows that renewing licences at no cost could increase network speeds by up to 23% and generate up to €75 billion in Europe's GDP by 2035.

Nevertheless, under the low-cost scenario (with no cost attached to licence renewals), operators will still incur €75 billion in spectrum costs during the 2025-2035 period due to payment of ongoing licences prior to renewal, as well as annual spectrum fees. Further investment could therefore be unlocked by reducing or removing annual fees, which amount to €17 billion over the next 10 years in the low-cost scenario.

Figure iii

Cumulative spectrum costs under different renewal scenarios

€ billion, 2024 prices



Note: Excludes cost in countries where reliable data could not be obtained (Bulgaria, Estonia, Latvia, Luxembourg and Switzerland). Scenario 1 (very high cost) assumes renewals are charged at historical prices. Scenario 2 (high cost) assumes renewals are charged based on more recent international price benchmarks. Scenario 3 (medium cost) assumes renewals are priced in line with declining revenue per MHz per connection. Scenario 4 (low cost) assumes free-of-charge renewals. Due to rounding, the total costs may not be equal to the sum of the cost breakdowns.

Source: GSMA Intelligence estimates

3 The future of European competitiveness, Draghi, 2024 and Much more than a market, Letta, 2024

Europe will also need new spectrum that is priced sustainably

Aside from the renewal of existing bands, European regulators can support digital development by ensuring additional spectrum is made available to meet future demand for 5G and 6G, and that it is licensed and priced efficiently. Based on expected demand, Europe needs to ensure mobile operators have in total at least 2 GHz of mid-band spectrum by 2030 to ensure networks do not become congested, while 3 GHz may be needed by 2035.

There is a clear pathway to ensure that the minimum requirement of 2 GHz of mid-band spectrum is available by 2030 by assigning the upper 6 GHz band and considering the 3.8–4.2 GHz range. Assigning these bands would bring Europe in line with other leading countries such as the US, China and India. Beyond that, the 4.5 GHz and 7–8 GHz bands can offer solutions to the longer-term requirements in the 2030s.

Past experience in Europe shows that restricting spectrum will artificially inflate spectrum costs and leave many operators with insufficient spectrum. This will result in lower investment, slower deployment of new technologies and poorer network quality. Avoiding past challenges will allow Europe to be in a competitive position to advance into the 6G era, helping consumers and businesses become more productive.

Implications for spectrum policy

European spectrum policy requires a significant overhaul to address these concerns. The Digital Networks Act (DNA) in particular provides Europe with an opportunity to address the aspects of spectrum policy that have inhibited greater investment and hampered the continent's digital progress. The European Commission has acknowledged that spectrum assignment procedures and conditions do not sufficiently incentivise investment, and the DNA offers a mechanism to adopt a more modern and dynamic approach to spectrum policy.

Given the evidence set out in this study, policy tools such as the DNA should ensure that Europe's regulators take the following actions:

- **Prioritise enhancing certainty and investment incentives in renewal assessments.** Regulators should ensure spectrum renewals create the conditions for the industry to invest in networks, ensuring long-term certainty and viability of operations.

- **Simplify and optimise the renewal process by applying administrative extensions.** While well-designed auctions provide an important tool to assign spectrum when it is first put in the market for new bands, all existing mobile spectrum bands have already been assigned through competitive processes. Another auction would create uncertainty, which can be avoided through an administrative renewal, and any changes in the optimal distribution of existing bands can be achieved through spectrum trading.

- **Automatically renew licences with an indefinite duration.** An indefinite duration provides regulatory certainty for operators to invest in network expansion and modernisation on existing bands, removing the risk that their spectrum holdings will significantly change, and allows them to amortise spectrum-related investments over a longer time period when the life of the asset is longer than the life of the licence. To ensure that spectrum is assigned to the most efficient users over time, regulators should facilitate spectrum trading and leasing, which would be incentivised by the implementation of indefinite licences.

- **Do not set aside spectrum for a new entrant or for localised use.** Setting aside spectrum for a new entrant or for localised use has not been shown to produce benefits for consumers or enterprises in recent years. Unless regulators are able to produce new and robust evidence to the contrary, they should avoid reserving or setting aside spectrum in IMT bands. Spectrum reservations would artificially reduce the spectrum available for mobile networks, therefore increasing the spectrum prices in auctions, reducing the efficiency of network deployments and impacting network coverage and quality.

- **Renew licences well in advance of the licence expiry date.** It is important for regulators to provide operators with long-term regulatory certainty for licence renewals. Without this clarity, there will be a risk that operators could lose access to some of their existing spectrum or pay a higher cost, which creates uncertainty and will delay or reduce network investment.

- **Engage with the mobile industry to meet well-defined and achievable connectivity targets where they are needed.** Regulators may prefer operators to provide a firm and measurable commitment to certain network investments if they reduce or remove fees for spectrum renewals. It is important that such commitments are economically and financially sustainable and can be easily measured and monitored. Alternatively, regulators can consider market-based approaches to meet obligations, such as reverse auctions, that are detached from licence renewals. If governments require coverage or service obligations beyond what is feasible with these tools, then public subsidies will be needed.

- **Ensure that mobile operators have at least 2 GHz of mid-band spectrum by 2030 to deploy 6G.** Given existing IMT assignments in Europe, which currently stand at around 1 GHz, the short-term priority should be to assign the full upper 6 GHz band for licensed mobile by 2030, as well as allowing high-power use by operators in the 3.8–4.2 GHz band. If regulators use an auction when assigning new bands, they should set modest reserve prices, use auction formats without unnecessary complexity and ensure mobile operators have the opportunity to acquire the full spectrum they need.

€200 BILLION

investment by European operators since 2019

€110 BILLION

total spectrum costs paid by European operators since 2014

8%

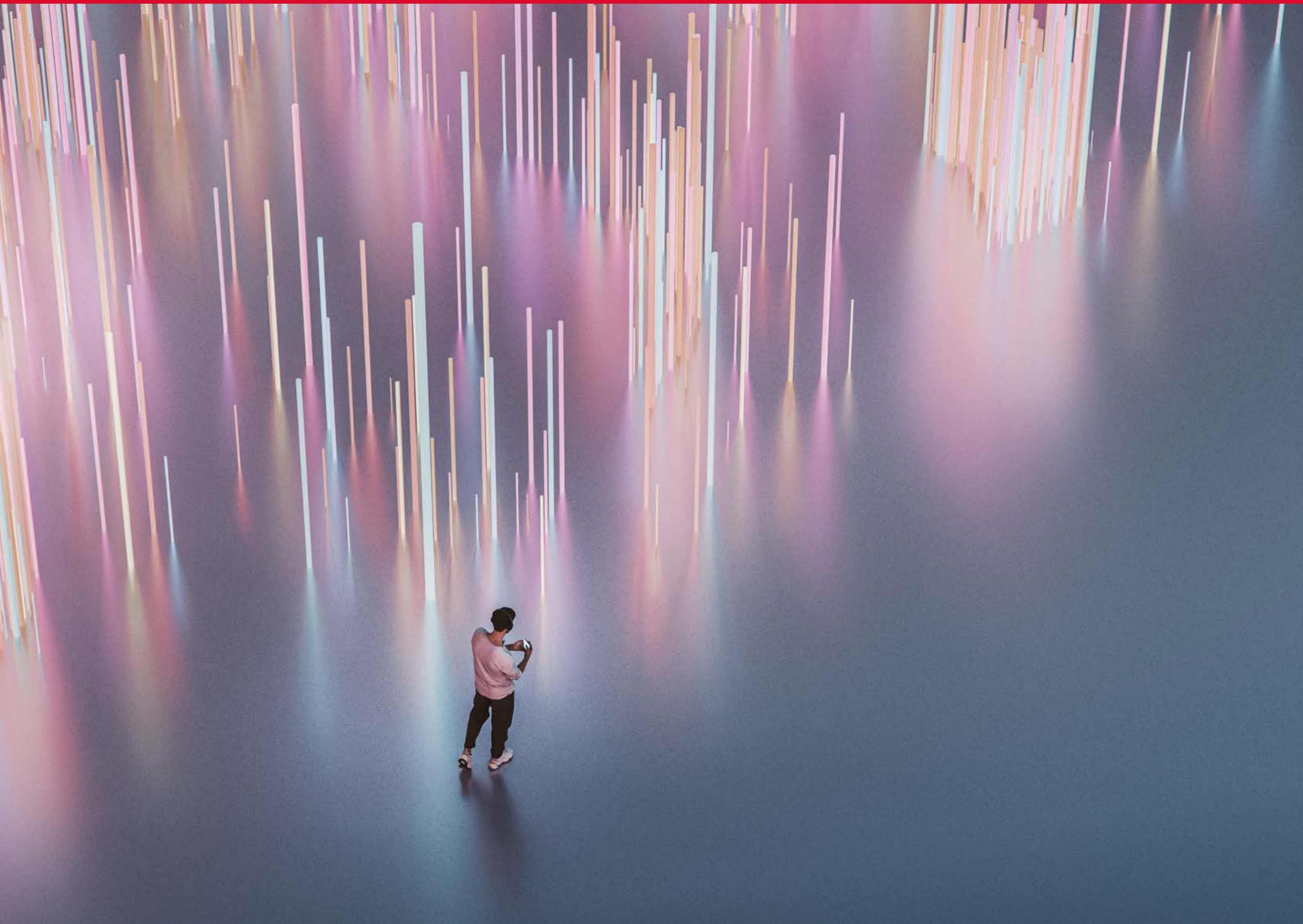
of operator revenue was spent on spectrum costs in 2024

More than
500 LICENCES
to be renewed in 2025–2035

Free spectrum renewals could improve network speeds by up to 23% and could increase Europe's GDP by up to
€75 BILLION

Up to
€30 BILLION
could be saved in spectrum costs in 2025–2035

1. Europe is falling behind the 5G leaders

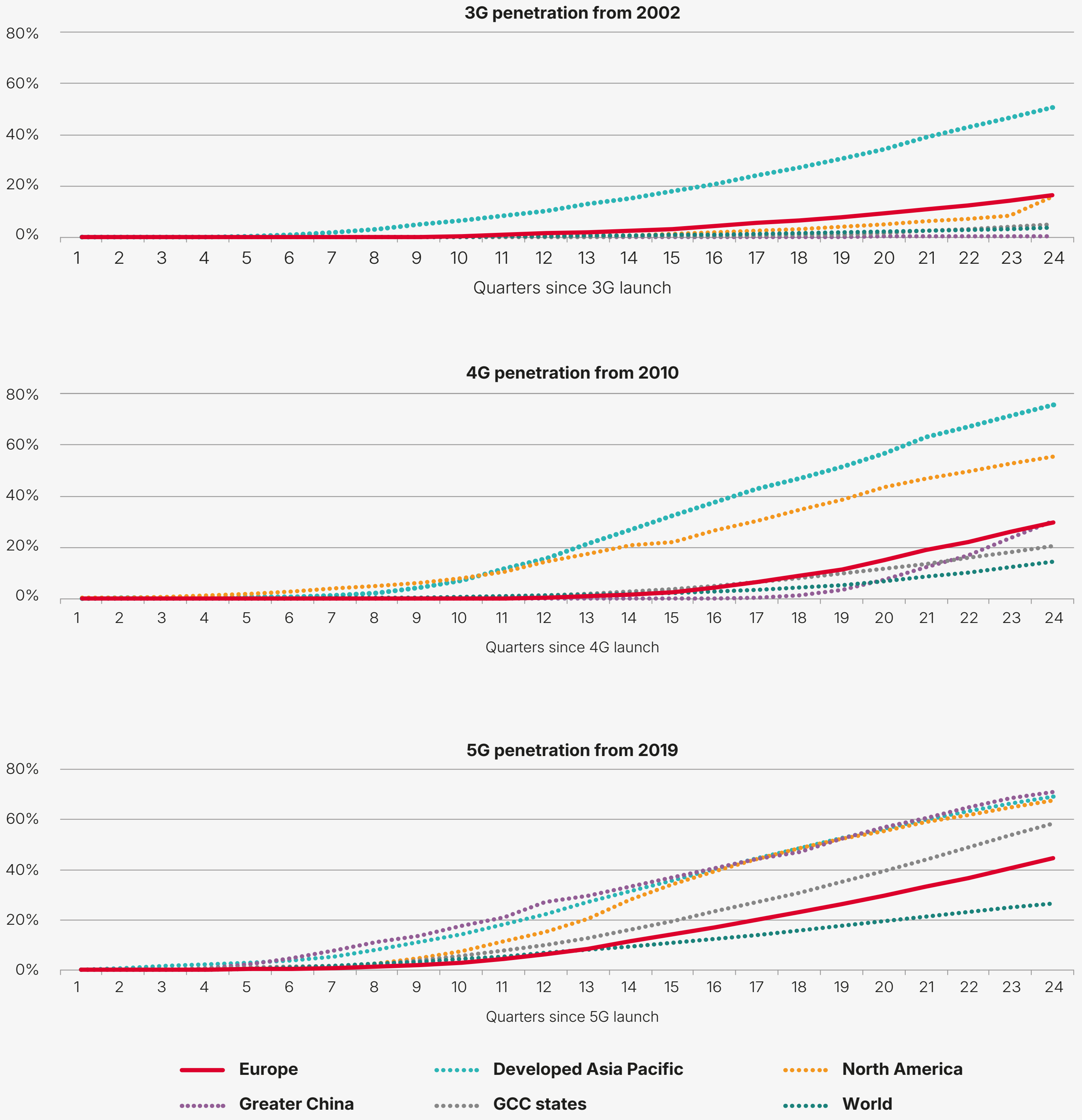


Since the launch of 5G networks in 2019, mobile operators in Europe have invested almost €200 billion, a significant proportion of which was required to upgrade to the latest mobile technology generation. As a result, 5G coverage has expanded to 93% of the population (as of Q3 2025), with 5G penetration reaching more than 50%.

However, despite this progress, Europe is no longer a global mobile connectivity leader, losing the position it had in the eras of 2G, 3G and 4G, as highlighted in Figure 1. In the six years following the first commercial deployment of 3G, Europe had the second highest adoption globally for 3G (after the developed Asia Pacific region, led by South Korea and Japan). It remained one of the leaders for 4G, with adoption only lagging behind developed Asia Pacific and North America. But with 5G, Europe has continued to lag behind the '4G leaders' while also falling behind Greater China and the Gulf Cooperation Council (GCC) states. Governments, operators and consumers in these '5G pioneer' countries have been more proactive in deploying and utilising 5G, driving greater benefits for consumers, businesses and the wider economy.[4]

4 For further details on the economic impact of mobile technology upgrades, see Mobile Technology and Economic Growth, GSMA, 2020; Economic growth and the digital transformation of enterprises, GSMA Intelligence, 2025; and Socioeconomic benefits of high-speed broadband availability and service adoption: A survey, Telecommunications Policy 48, no. 7 (2024): 102808, Wolfgang Briglauer, Jan Krämer and Nicole Palan.

Figure 1
Market penetration of 3G, 4G and 5G since launch[5]



Penetration is calculated by dividing connections by total population. A 3G/4G/5G connection is defined as a 3G/4G/5G SIM card (or phone number, where SIM cards are not used) that has been registered on the mobile network at the end of the period. Connections differ from subscribers in that a unique subscriber can have multiple connections.

Source: GSMA Intelligence

5 In this report, Europe refers to the 27 EU countries plus the UK, Switzerland and Norway. Developed Asia Pacific includes South Korea, Japan, Singapore, Brunei, Australia and New Zealand. North America includes the US and Canada. The GCC states include Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE. Greater China includes mainland China, Hong Kong and Taiwan.

To understand the current state of 5G in Europe, it is important to consider a range of relevant indicators. The majority of operators launched 5G using non-standalone (NSA) technology, which delivers 5G over a 4G core network. However, 5G standalone (SA) is needed for many of the 5G use cases, particularly in the business-to-business (B2B) segment that operators expect to drive revenue growth, but which have not yet achieved scale.

Figure 2a shows that when considering 5G coverage by population, 93% of consumers in Europe now live in an area with a 5G network, which is significantly higher than the global 5G coverage of 54% and comparable to the leading 5G countries (the chart also includes Brazil and India, both of which are large emerging markets with strong recent 5G growth).

However, when considering coverage at the operator level, average 5G population coverage in Europe is 80%, which is notably lower than average 5G coverage for operators in the GCC states, Greater China, North America and developed Asia Pacific. More than one in five operators in Europe had 5G population coverage of less than 70% as of Q3 2025, driven in part by the challenges to achieve widespread coverage with smaller scale.[6] This means that even though overall 5G coverage is high, a significant proportion of consumers and businesses in Europe are not able to access 5G from multiple competing networks.

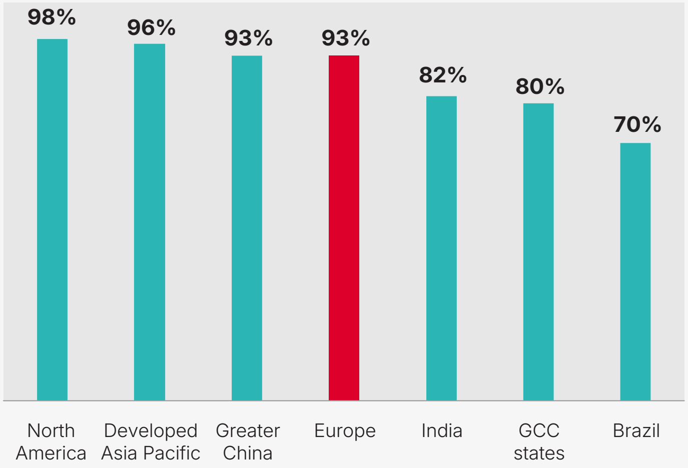
Furthermore, it is important to consider the user experience of coverage outside of residential locations, as mobile is also used in commercial areas and transport links as well as tourist hotspots (and businesses also require connectivity in agricultural and industrial zones). Figure 2c shows the proportion of users with 5G-active devices who spend the majority of their time connected to 5G. In Europe, 60% of consumers with 5G-active devices spend most of their time connected to 5G, which compares well with developed Asia Pacific and the GCC states, as well as Brazil and India. But this is much lower than the equivalent figures for Greater China and North America, which emphasises the need to ensure reliability connectivity outside of residential locations.

Lastly, Figure 2d shows the proportion of 5G connections that are provided over an operator network that has launched 5G SA. It shows that 5G SA deployment is still lagging behind in Europe compared to all other regions considered in the benchmark. It is important to note this does not reflect 5G SA coverage or adoption. Separate data from Ookla shows that the actual utilisation of 5G SA remains very low in Europe at below 2%, compared to almost 77% in Greater China, almost 50% in India and 25% in North America.[7] This reflects the relatively low adoption of 5G SA user equipment, including devices and terminals. This means that the full benefits of 5G cannot be realised, as many use cases – such as network slicing, very low latency and massive IoT capabilities for enterprises – can only be delivered with 5G SA.

6 For further discussion on the impact of scale in the mobile sector, see Competition dynamics in mobile markets, GSMA, 2022

7 These refer to the proportion of Ookla 5G samples that are on 5G SA networks. For further analysis of 5G SA in Europe, see A Global Evaluation of Europe's Competitiveness in 5G SA, Ookla and Omdia, 2025

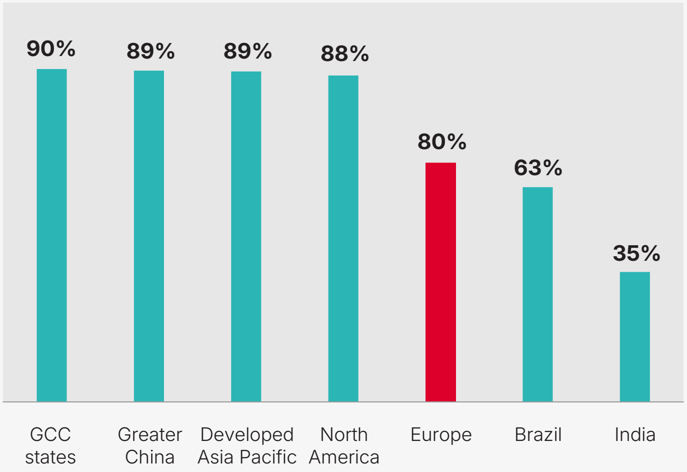
Figure 2a
5G population coverage by region, Q3 2025



Note: Coverage is reported for each country and the chart shows a population-weighted average by region.

Source: GSMA Intelligence

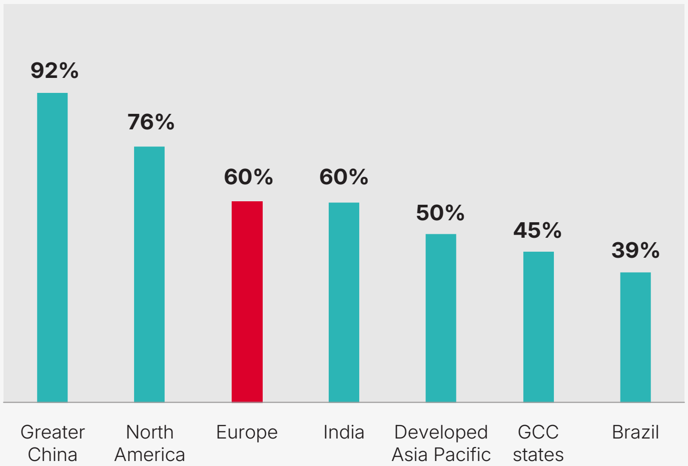
Figure 2b
5G population coverage by operator, Q3 2025



Note: Coverage is reported for each operator and the chart shows a simple operator average by region. The figure for the GCC states is higher than in Figure 2a, because the latter shows a population-weighted average for 5G coverage (rather than an operator-based average that is not weighted by population).

Source: GSMA Intelligence

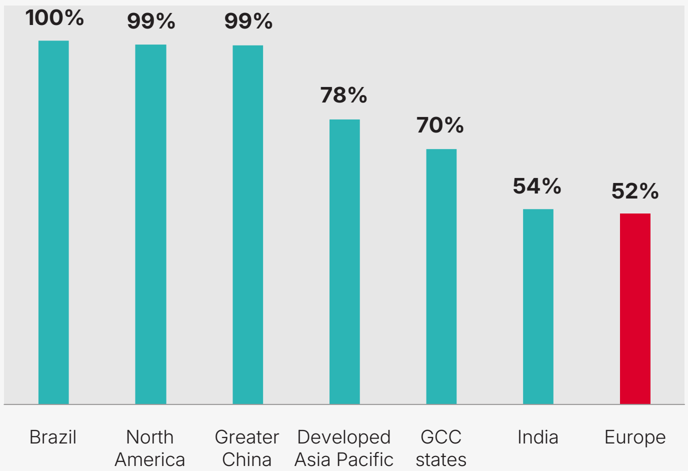
Figure 2c
5G availability by region, 2025



Note: 5G availability is the percentage of users classified into 5G or 5G roaming. To calculate 5G availability, each user with a 5G-active device is classified into the network generation they spend the majority of their time connected to (i.e. 4G or 5G). A device is considered 5G-active if it is known to have reported 5G service in the past six months. Data is based on samples between January and October 2025.

Source: GSMA Intelligence

Figure 2d
Proportion of 5G connections with a 5G SA network, Q3 2025



Note: The percentages in the chart refer to the proportion of 5G connections in each region that are with an operator that have deployed 5G SA. It does not reflect 5G SA coverage or adoption.

Source: GSMA Intelligence

Aside from coverage and availability, it is also important to consider the quality of networks that consumers and businesses experience. Figures 3a and 3b respectively show that median download speeds (across all mobile generations) and median 5G download speeds are lower in Europe than in the leading 5G countries, as well as in India and Brazil. It is notable that Brazil has faster 5G speeds. This is partly because adoption in Brazil (23%) is lower than in other regions, meaning there is more capacity per user in the 5G network. However, Europe also has slower 5G speeds than North America, the GCC states, Greater China and developed Asia Pacific, even though it also has lower 5G adoption (as shown in Figure 1).

In practice, many consumers may not require extremely high speeds (e.g. above 300 Mbps) for the use cases they currently engage in, and so it is more important that they have a consistent level of network quality. Figure 3c shows the proportion of 5G network tests that are above a threshold of 25 Mbps download and 3 Mbps upload. On this metric, Europe is behind most other regions and just slightly ahead of India and North America. More importantly, it shows that more than one in five tests in Europe did not meet the aforementioned download and upload requirements. Separate analysis also shows that when considering all network tests (i.e. all technologies and not just 5G), more than 10% did not meet a threshold of 5 Mbps download and 1 Mbps upload. Figure 3d highlights one of the consequences of this: due in part to the network quality and coverage experienced by European users, average mobile data usage is much lower than in the other regions considered in the benchmarks, apart from Brazil.

Figure 3a

Mobile download speeds, 2025

Mbps

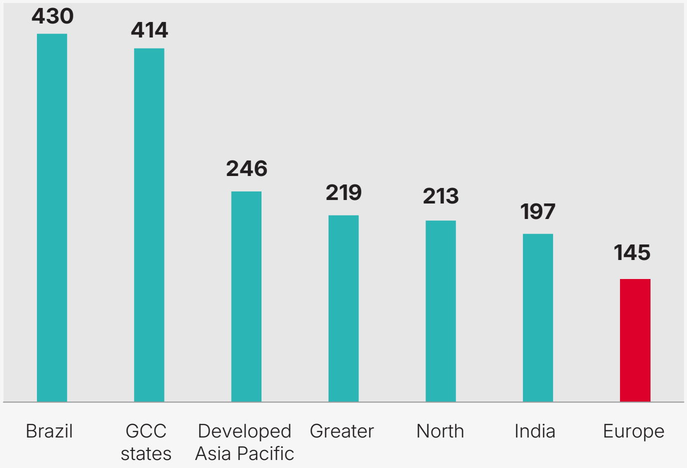
Note: Country-level data was collected on the median download speeds from Speedtest users in the January–October 2025 period. The chart shows population-weighted averages by region.

Source: GSMA Intelligence analysis, based on Speedtest Intelligence data provided by Ookla

Figure 3b

5G download speeds, 2025

Mbps

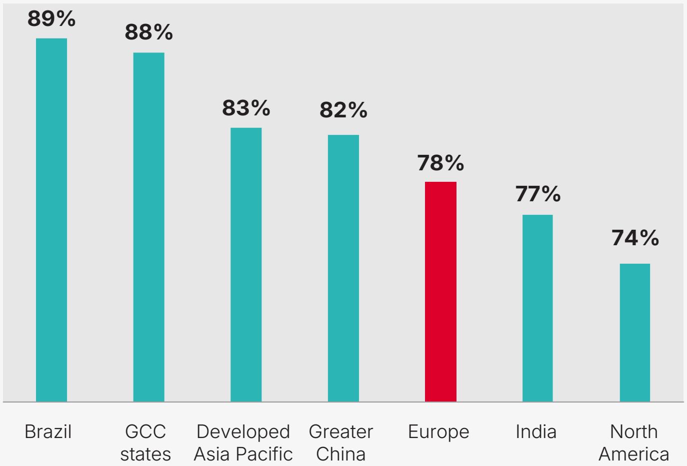


Note: Country-level data was collected on the median 5G download speeds from Speedtest users in the January–October 2025 period. The chart shows population-weighted averages by region.

Source: GSMA Intelligence analysis, based on Speedtest Intelligence data provided by Ookla

Figure 3c

5G consistency, 2025



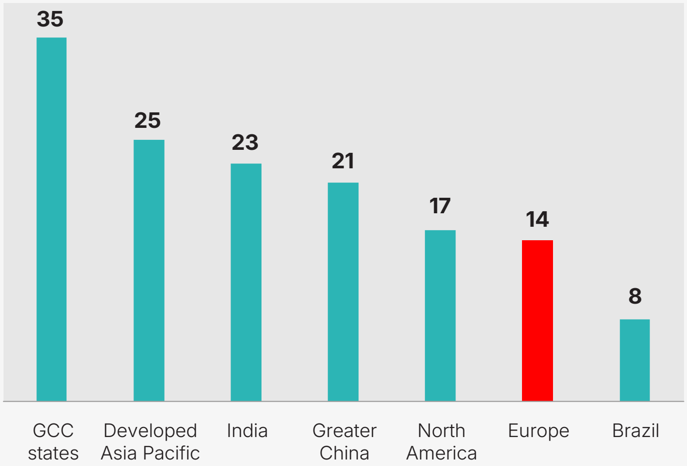
Note: Country-level data was collected on 5G consistency from Speedtest users in the January–October 2025 period. Consistency measures what percentage of a provider's samples equals or exceeds both a download and upload threshold. For 5G, thresholds are 25 Mbps download and 3 Mbps upload. The chart shows population-weighted averages by region.

Source: GSMA Intelligence analysis, based on Speedtest Intelligence data provided by Ookla

Figure 3d

Data traffic per connection

GB



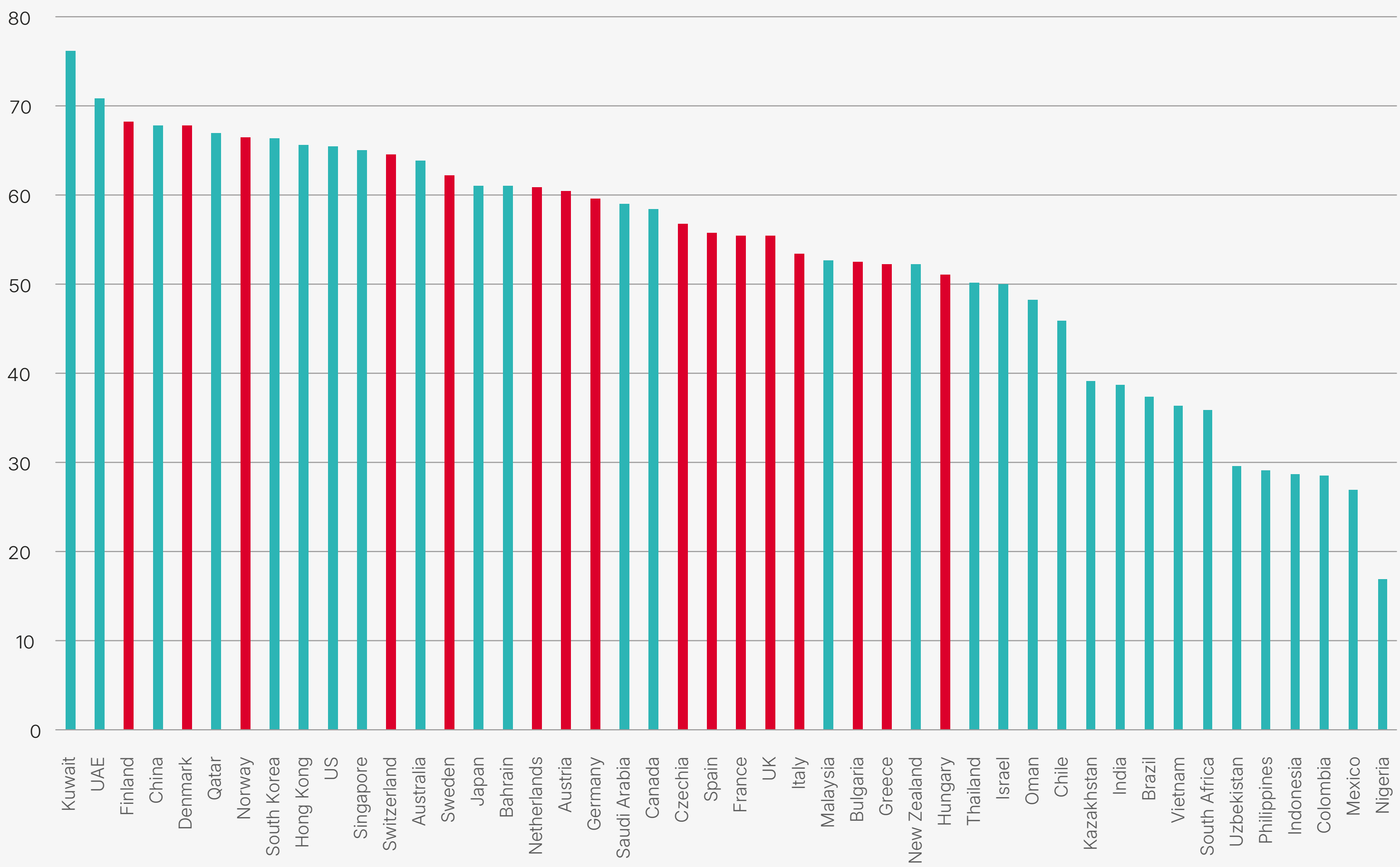
Note: The chart shows country averages by region.

Source: GSMA Intelligence

Of course, regional-level analysis can mask variations by country, especially in Europe. Figure 4 shows the results of the latest GSMA Intelligence 5G Connectivity Index (based on data for Q3 2025), which assesses the level of 5G market development across 46 countries. The index aggregates all of the metrics above as well as other metrics, such as the number of 5G base stations per capita, quality of experience, adoption of 5G fixed wireless access (FWA), adoption of IoT and deployment of RedCap, among others.[8] It shows that some countries in Europe, notably Finland, Denmark and Norway, have advanced 5G markets that are comparable to the leading countries in Asia Pacific, Greater China, the GCC states and the US. Switzerland and Sweden are also not far behind those leaders, but the majority of European markets do not perform as well.

Figure 4

5G Connectivity Index scores, Q3 2025



Source: GSMA Intelligence

8 For further details, see the 5G Connectivity Index

Europe faces a vicious circle of low returns and investment

There are several factors as to why Europe (or most of Europe, outside the Nordic countries) is struggling to achieve the 5G outcomes that are equivalent to those of the leading markets, including competition policy, regulation and demand-side challenges. However, a critical underpinning factor is the challenging investment environment. Compared to leading regions, many European markets have lower returns on investment, which impacts their ability to invest in networks.

Figure 5a shows that the average revenue per user (ARPU) in Europe is much lower than in other high-income countries, driven in large part by the lower levels of mobile usage discussed previously. This is a key factor as to why returns on investment are lower in Europe, as reflected in Figure 5b, which shows that operators in Europe have consistently had lower EBITDA margins than in other high-income countries. This also means a lower return on capital employed (ROCE), with Europe's operator groups seeing a reduction in average ROCE from around 10% to less than 7% between 2015 and 2024. This is lower than for operators in other regions (see Figure 5c) and, in some European markets, operators are earning returns that are below their cost of capital.[9]

The result is that investment per subscriber in Europe has been consistently lower than in other high-income countries over the past 15 years (see Figure 5d),[10] which is a key reason why many European markets are lagging in terms of network quality and the deployment of 5G and 5G SA.

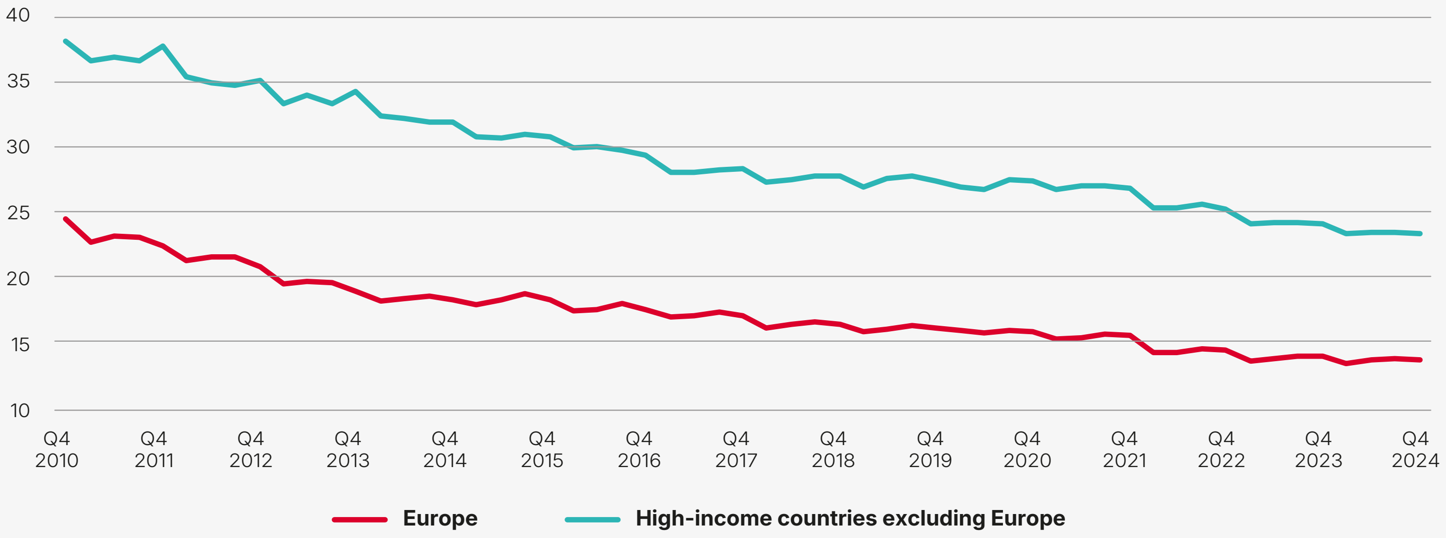
9 See for example State of Digital Communications Report 2025, Connect Europe, 2025 and The future of European competitiveness, EC, 2024

10 An alternative measure of capex intensity is capex as a proportion of revenue. During the past 10 years, European operators have on average invested more as a proportion of revenue (around 17%) than other high-income countries (around 15%). However, the absolute capex per subscriber is a better measure of investment intensity because it is not affected by the fact that ARPU is lower in Europe, which means that operators need to invest more per revenue to compare with other leading regions.

Figure 5a

ARPU in Europe and other high-income countries

USD, 2015 prices

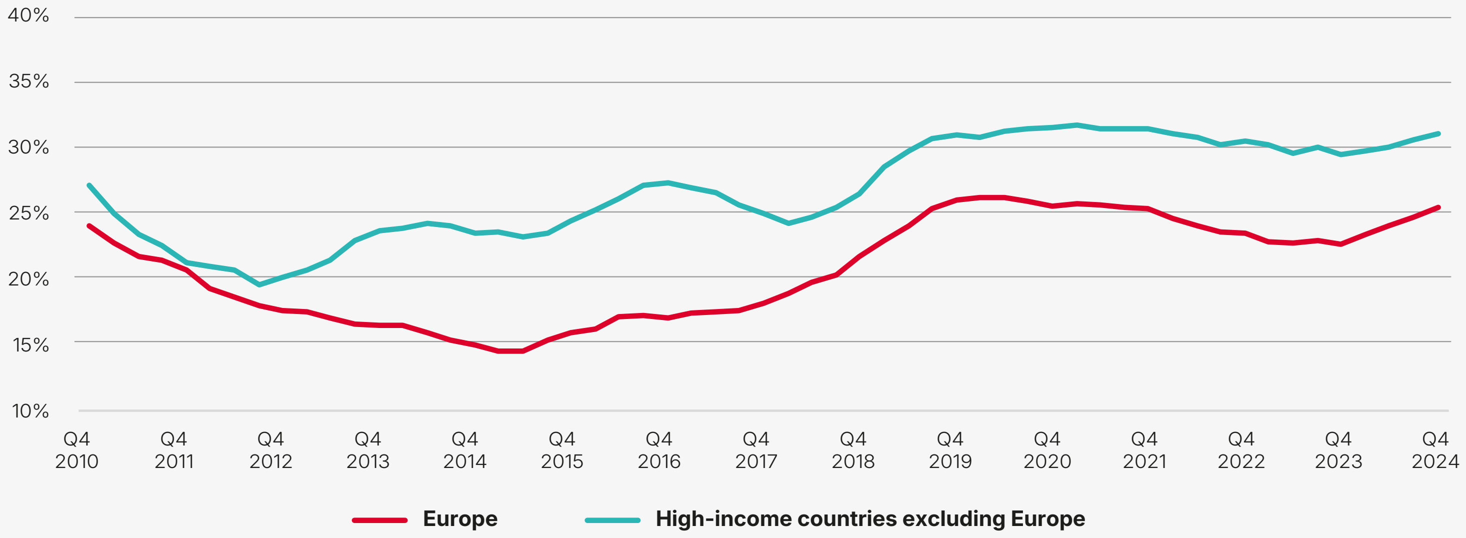


Note: Other high-income countries are based on World Bank income classifications. They include Australia, Canada, Japan, South Korea, New Zealand, Singapore, the US and the GCC states. The chart shows average ARPU.

Source: GSMA Intelligence

Figure 5b

EBITDA margins in Europe and other high-income countries

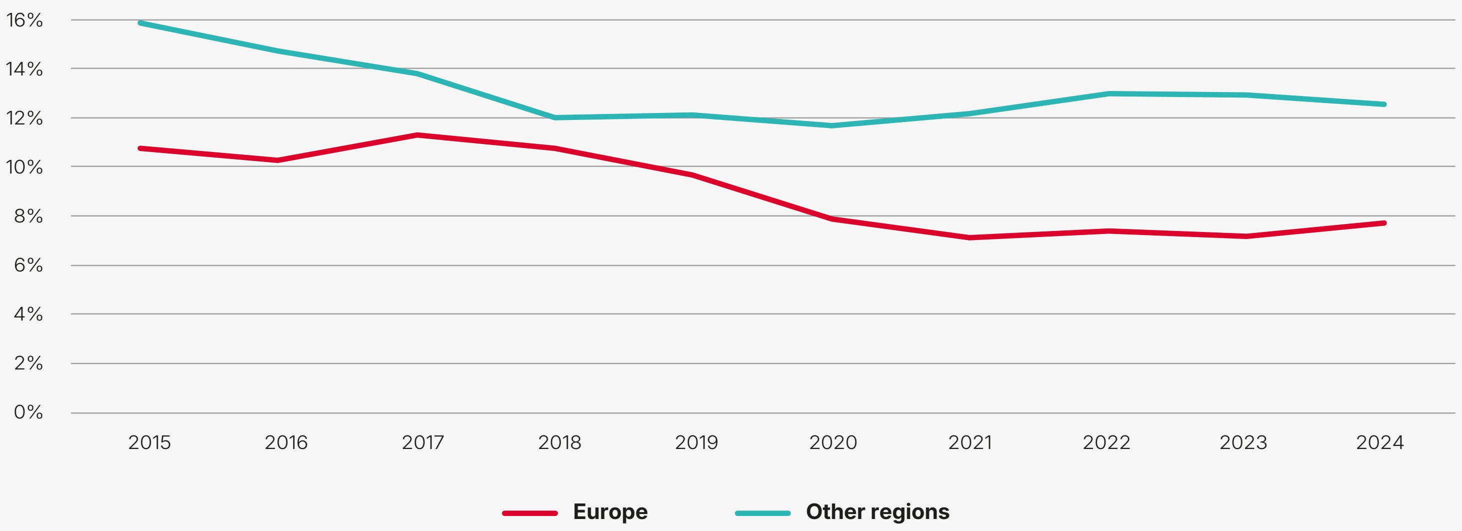


Note: Other high-income countries are based on World Bank income classifications. They include Australia, Canada, Japan, South Korea, New Zealand, Singapore, the US and the GCC states. The chart shows average EBITDA margins by operator for those that report the data, based on a four-quarter moving average.

Source: GSMA Intelligence

Figure 5c

ROCE in Europe and other regions



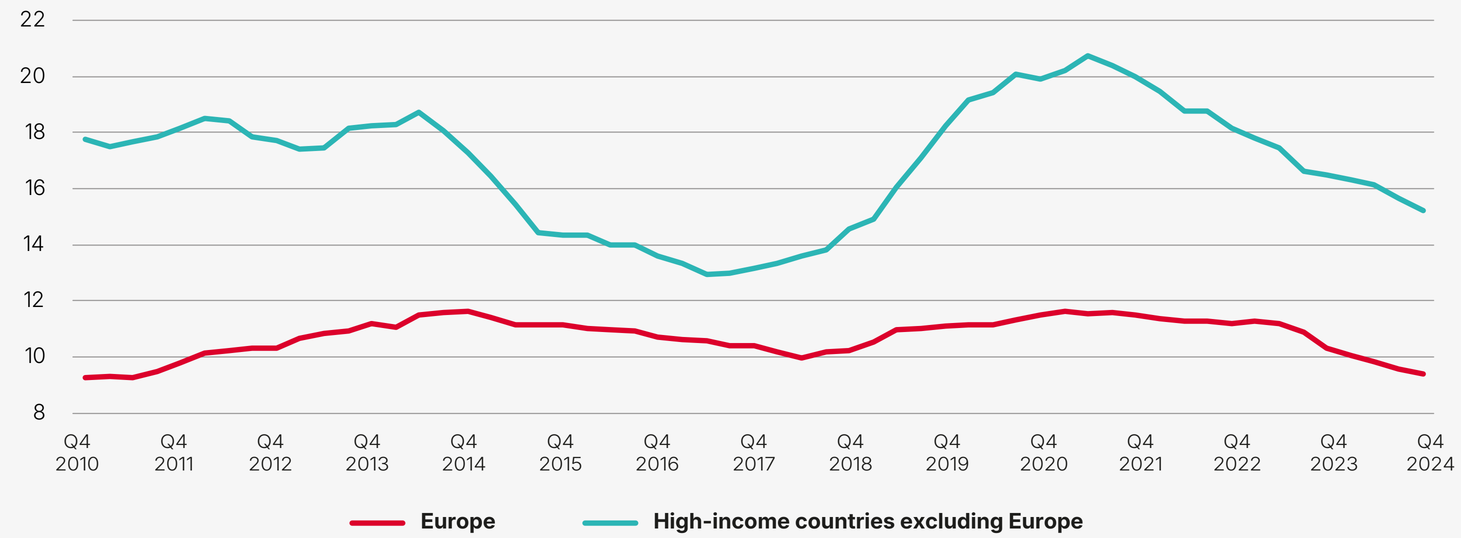
Note: Data shows the average ROCE by operator group based on their headquarter location and for the groups where data was available.

Source: GSMA Intelligence elaborations on data from Frontier Economics

Figure 5d

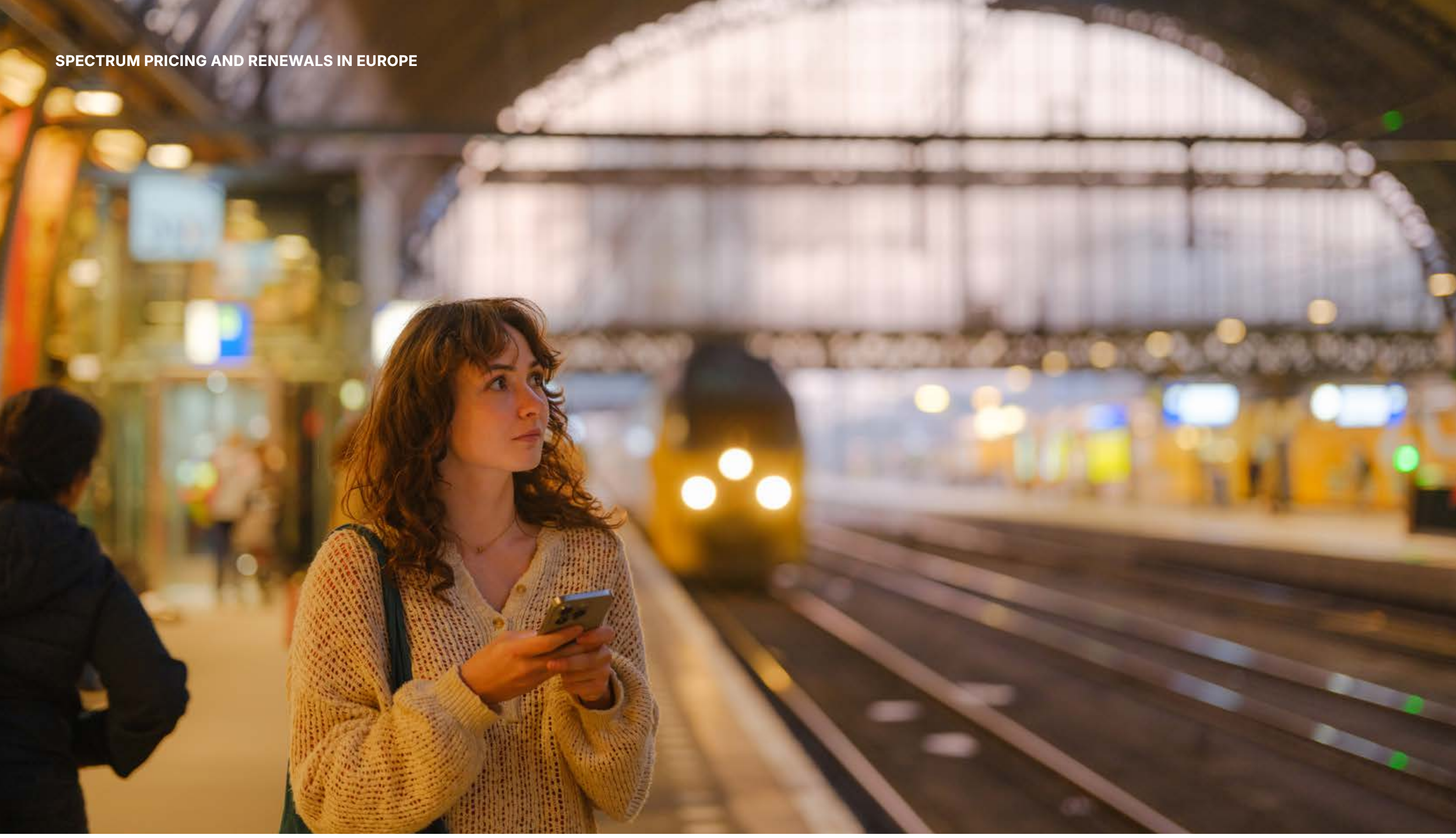
Capex per connection in Europe and other high-income countries

USD, 2015 prices



Note: Other high-income countries are based on World Bank income classifications. They include Australia, Canada, Japan, South Korea, New Zealand, Singapore, the US and the GCC states. The chart shows average capex per mobile connection in 2015 USD prices, based on a four-quarter moving average.

Source: GSMA Intelligence

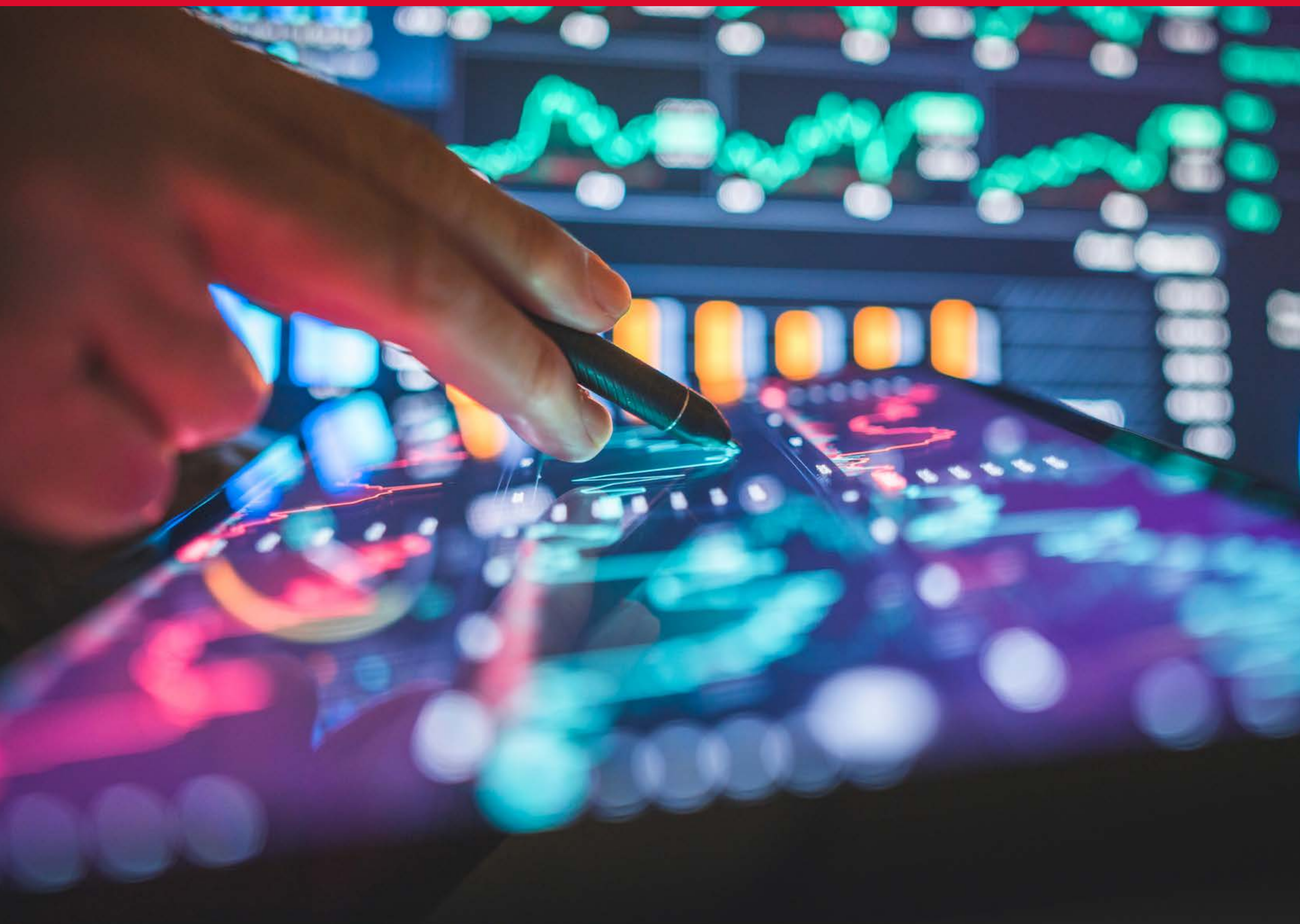


Breaking out of this vicious circle of low returns and lower investment will require policy reforms that improve the ability of and incentive for operators to invest as well as enabling them to more effectively monetise their investments. Many of these reforms have been identified in the Letta and Draghi reports,[11] which cover relevant topics, including competition policy, sector-specific regulation and open-internet regulations (among others). One of the most important areas is spectrum policy, which directly impacts all of the areas mentioned above.

The amount of spectrum available to operators, and the conditions under which they can use that spectrum, impacts the investment needed to deploy radio networks (including the latest technologies) as well as the service quality that consumers and businesses experience (therefore also impacting revenues and returns). The cost of spectrum also has a direct impact on the ability of operators to invest. This report sets out the evolution of spectrum policy in Europe in the past decade and how different scenarios on future spectrum pricing could impact investment, network quality and economic growth in Europe over the next 10 years.

11 See The future of European competitiveness, Mario Draghi, 2024 and Much more than a market – Speed, Security and Solidarity, Enrico Letta, 2024

2. Spectrum trends



Availability of spectrum

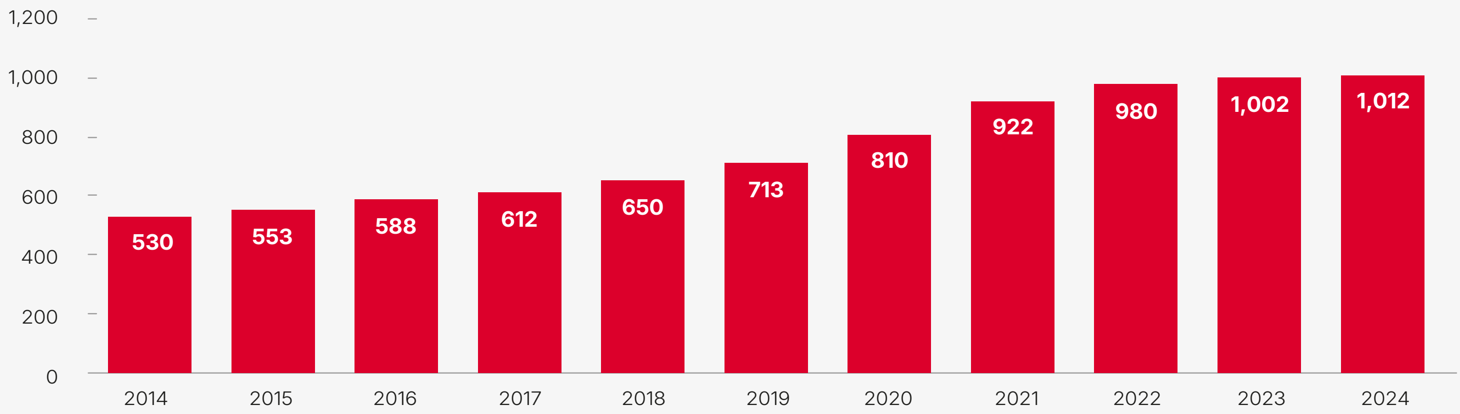
While the latest mobile technologies allow data to be transmitted at a rate tens of times faster per MHz of spectrum, demand for data has grown at an even faster rate. Additional spectrum capacity was necessary for operators to roll out 5G networks and improve the quality of 4G networks.

Most European countries have assigned the majority of IMT bands in the 700 MHz to 3.5 GHz range. On average, operators have acquired access to a combined 1,000 MHz per country in this range, which is comparable to North America and higher than other regional averages (see Figure 6b).

Figure 6a

The increase in the average amount of spectrum assigned to mobile operators in Europe

MHz

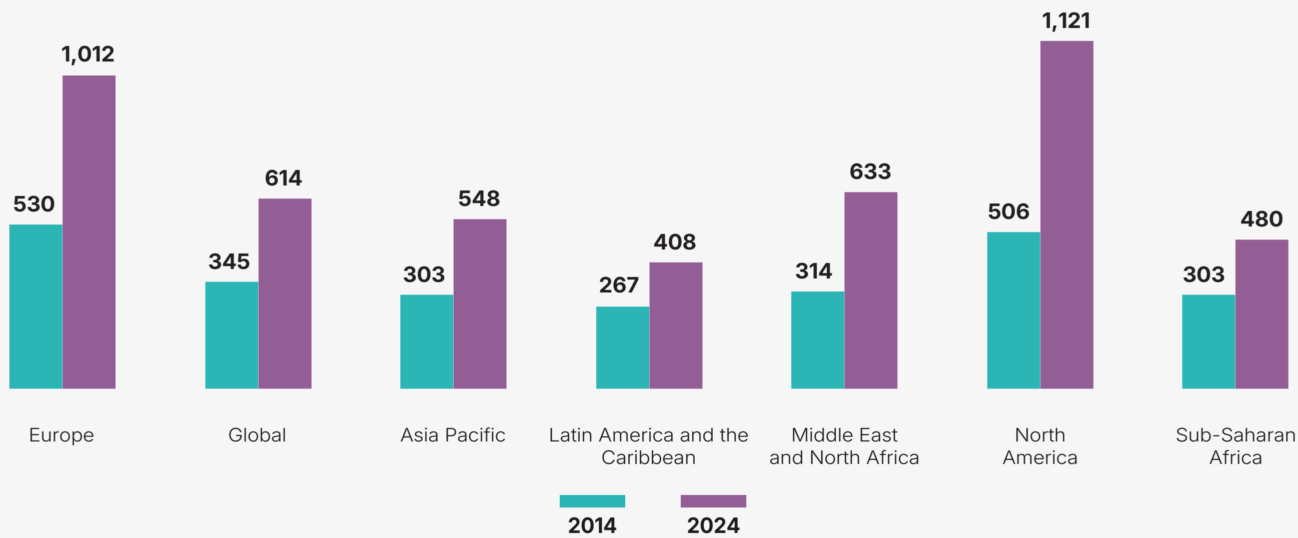


Source: GSMA Intelligence

Figure 6b

Average amount of spectrum assigned to mobile operators by region, 2014 versus 2024

MHz



Source: GSMA Intelligence

Revenue trends

During the same period, mobile market revenues have declined. Measured in per-connection and inflation-adjusted terms, the steady decline means that European operators, on average, generate 33% less revenue from each connection compared to a decade ago. This trend is not specific to Europe and can be seen in all regions (see Figure 7b).

The decline in revenue per connection contrasts with the growing capabilities of mobile networks and the increasing value of new use cases, which go well beyond what original mobile telephony offered. Most of the additional value brought by the latest network generations has in fact been captured by consumers and other digital ecosystem players, such as content and application providers.

This can be attributed to factors such as:

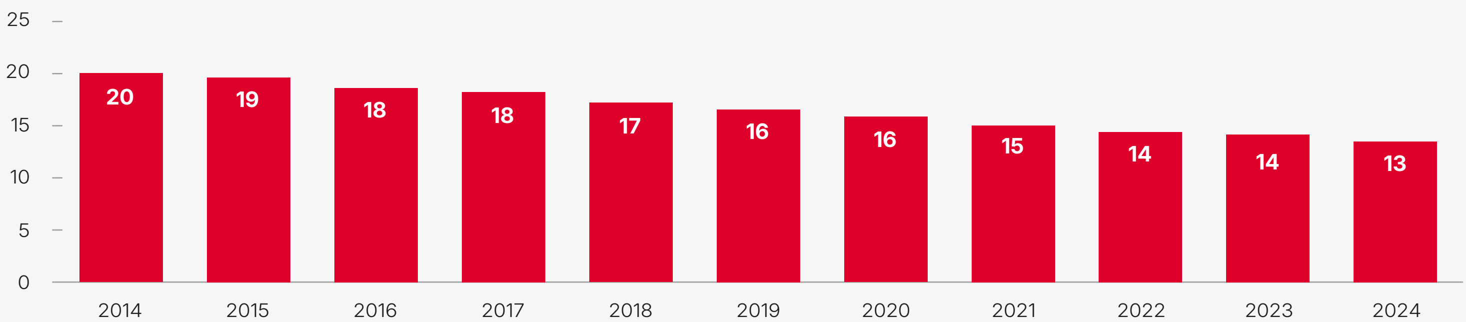
- mobile service becoming a mature market, with high levels of competition driving down prices
- mobile reaching the lower end of the consumer market and providing services to lower-income consumers
- regulatory restrictions and price caps in some countries.

Examining average revenue per GB of mobile data leads to similar conclusions (see Figure 8). Driven by investment in technological progress, operators have been able to offer consumers more mobile data for less. Between 2016 and 2024, average revenue per GB of data declined by 94% in Europe.

Figure 7a

Average revenue per connection in Europe

€ (inflation-adjusted)

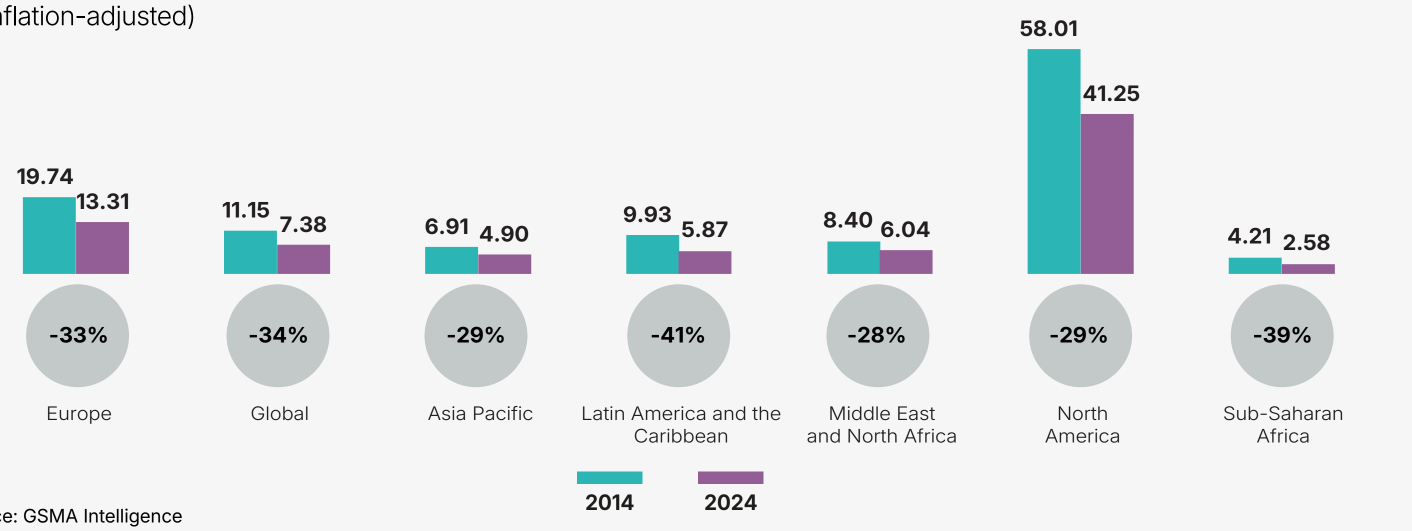


Source: GSMA Intelligence

Figure 7b

Average revenue per connection by region, 2014 versus 2024

€ (inflation-adjusted)

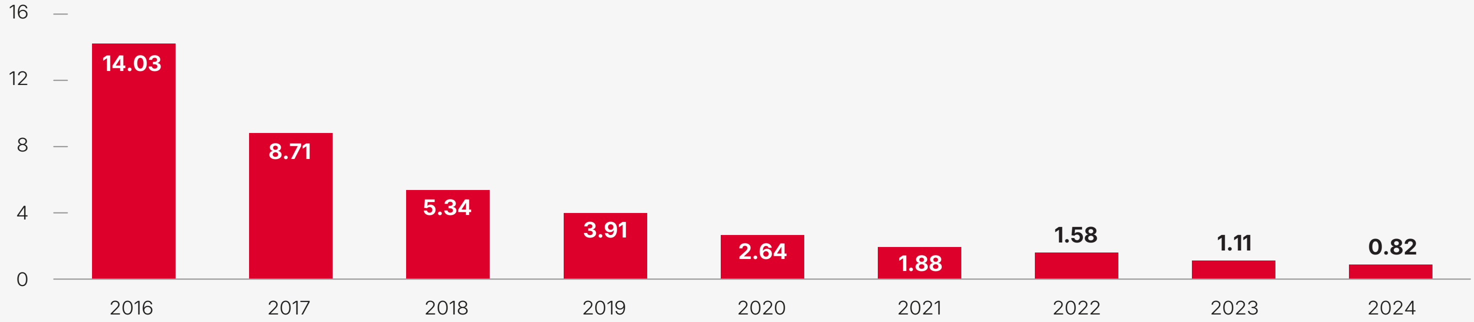


Source: GSMA Intelligence

Figure 8a

Average revenue per GB in Europe

€/GB, 2024 prices

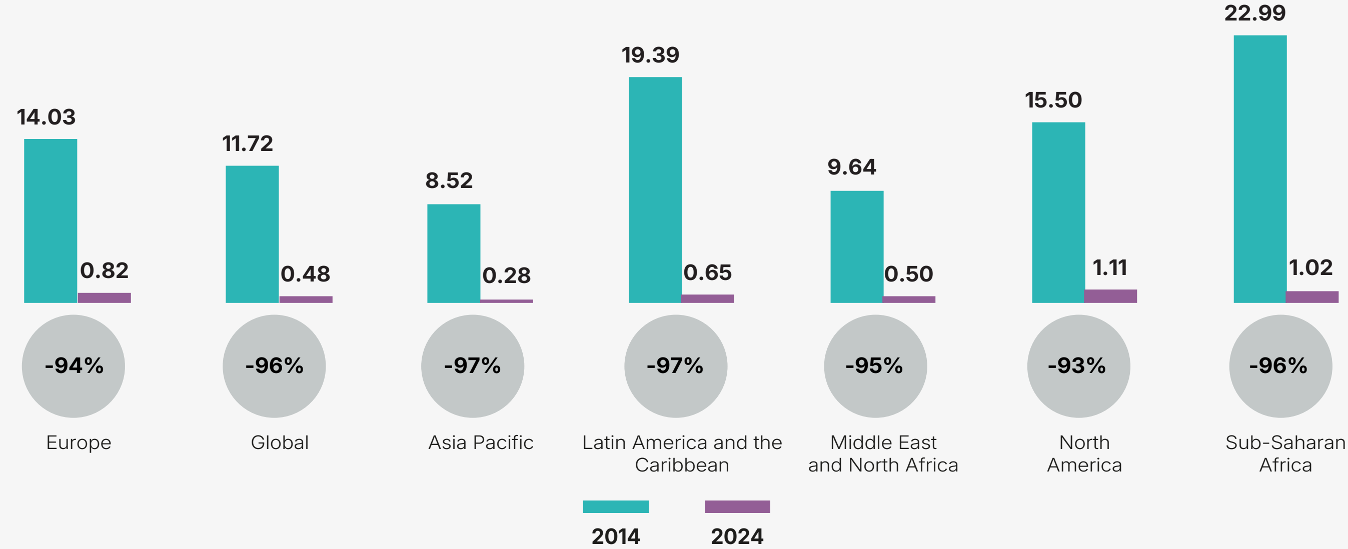


Source: GSMA Intelligence

Figure 8b

Average revenue per GB by region, 2014 versus 2024

€/GB, 2024 prices



Source: GSMA Intelligence

The changing fundamentals of spectrum value

Taken together, the need for larger spectrum holdings to support advanced networks and declining revenues per connection have resulted in a steep decline in the revenue-generating potential of each MHz of spectrum. We find that in Europe, revenue per MHz per connection fell by 54% in the last 10 years. This is similar to the trends seen in other regions (see Figure 9b).

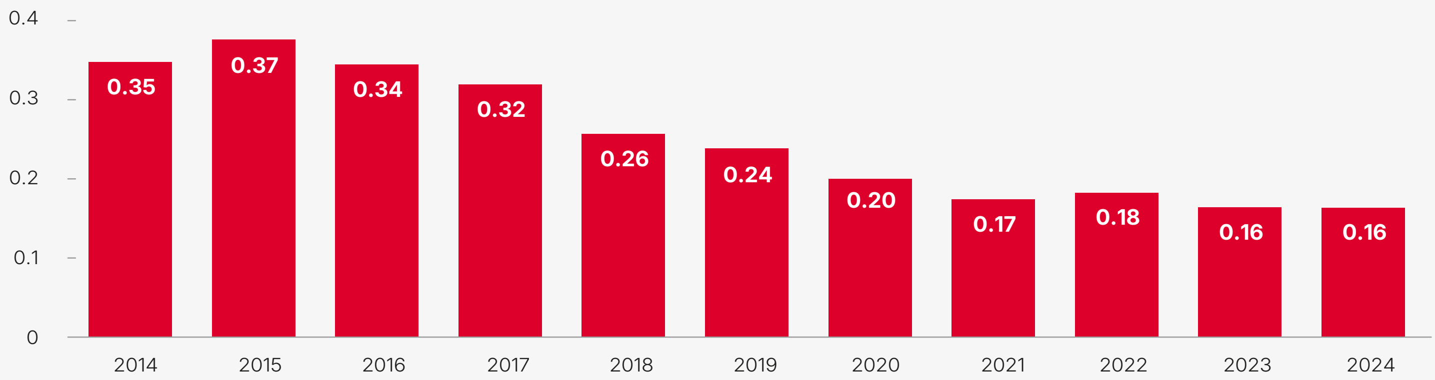
This decline represents a fundamental change in the commercial value of each unit of spectrum:

- The average value of a unit of spectrum to operators has declined in recent years in proportion to the change in market revenue that each MHz can support.
- Prices for spectrum licences should have responded by falling. However, prices paid by operators for spectrum licences are often driven by non-market factors, so this may not have fully materialised.

Figure 9a

Average revenue per MHz per connection in Europe

€/MHz/connection/year, 2024 prices

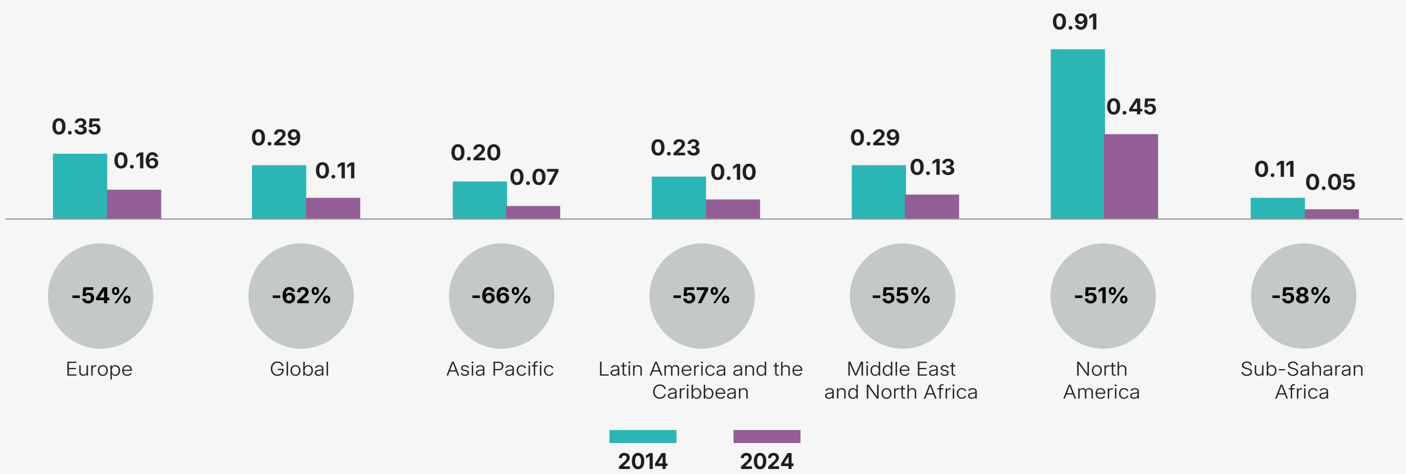


Source: GSMA Intelligence

Figure 9b

Average revenue per MHz per connection by region, 2014 versus 2024

€/MHz/connection/year, 2024 prices



Source: GSMA Intelligence

Why spectrum prices should reflect the changing value of spectrum

Operators acquire spectrum as an input to enhance the coverage and capacity of their networks. The value of spectrum from an operator's perspective is therefore determined by the market value of enhanced network coverage, speeds and capacity that they can sell to consumers and businesses, sometimes called its marginal value. During assignments, operators will be willing to pay up to the spectrum's marginal value.

The marginal value of each unit of spectrum is therefore determined by the following:

- **The technical factor of how much each additional MHz of spectrum adds to capacity.** This is determined by spectral efficiency and the number of base stations. Due to operators' investments in network deployment and research, these have increased the marginal capacity that each MHz of spectrum adds. For example, technological improvements mean that each unit of spectrum utilised by 5G networks can carry over 10 times more data, compared to 2G networks.

- **The demand factors, such as the revenue each additional GB of capacity can generate.** Generally, each incremental GB of data has a lower value to consumers. Hence, the expansion of network capacity and competitive pressures have caused prices of data to rapidly decline, bringing the marginal value of spectrum down. As examined earlier, the average price of each GB of data has declined by 94% over the past decade.

Taken together, these have led to an overall decline in the commercial value of spectrum: the dramatic decline in prices of data has meant that the revenue-generating value of each unit of spectrum has markedly declined, and prices of spectrum should adjust accordingly. However, telecoms regulators sometimes pursue conflicting objectives. This includes intervening in the market to promote digitalisation and lower prices for consumers (which reduces the commercial value of spectrum for operators) while trying to maximise spectrum revenues, such as by reducing the supply of spectrum or not providing clarity on its future (which drives spectrum prices up and reduces network quality).

Artificially high spectrum costs extract the economic surplus, which means that operators are unable to generate the return on capital for their investors. This can lead to inefficient outcomes and underinvestment in networks, as investors withdraw and pursue opportunities in other industries.

Trends in spectrum pricing and its aggregate cost

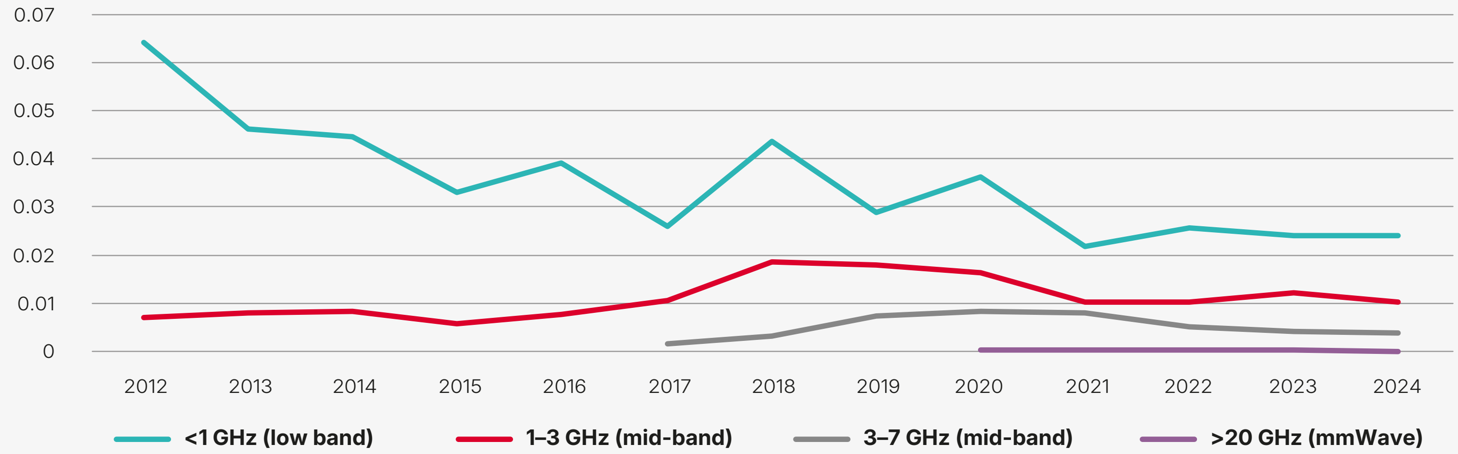
Figure 10 shows trends in the average spectrum unit prices based on licences awarded to mobile operators in Europe. To allow for comparability across countries and various durations, these prices are standardised to per MHz and per year terms, and additionally adjusted by the size of the population or the size of the market. In per unit of population terms, prices of sub-1 GHz bands have markedly declined. Prices of 1–3 GHz bands had initially been increasing, but this trend has reversed from around 2020 and prices have since declined. When expressed in terms of per million of market revenue, the trends appear somewhat different: prices of sub-1 GHz band have remained largely unchanged, while prices of 1–3 GHz bands have increased. This trend of converging prices of sub-1 GHz and 1–3 GHz bands is observed in other regions as well.

In summary, despite some signs of prices adjusting, European price trends signify that prices have not yet fully adjusted to reflect the changing commercial value of spectrum, as proxied by the decline in the revenue each MHz supports.

Figure 10a

Average unit spectrum prices per unit of population in Europe

€/MHz/year/pop, 2024 prices



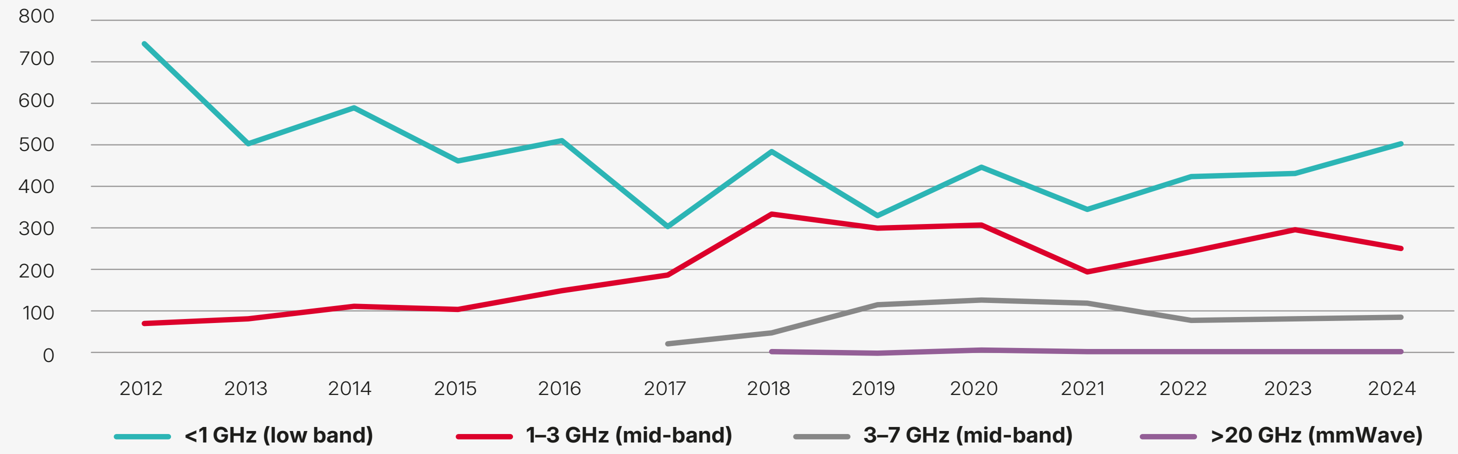
Note: Three-year moving average. Based on licence-level upfront cost amortised over the duration of the licence and adjusted for the cost of capital. Includes all types of licences where upfront cost data were available, including auctions, administrative assignments and renewals. Excludes any additional cost of annual fees if attached to the licence.

Source: GSMA Intelligence

Figure 10b

Average unit spectrum prices per million of market revenue in Europe

€/MHz/year/€ million of market revenue



Note: Three-year moving average. Based on licence-level upfront cost amortised over the duration of the licence and adjusted for the cost of capital. Includes all types of licences where upfront cost data were available, including auctions, administrative assignments and renewals. Excludes any additional cost of annual fees if attached to the licence.

Source: GSMA Intelligence

How to measure spectrum cost accumulation

The spectrum cost burden is measured through the spectrum-cost-to-recurring-revenue ratio (cost-to-revenue ratio (CRR)). This provides an aggregate estimate of accumulated spectrum cost based on all active licences, taking into account upfront fees (amortised over the licence duration) and any annual fees, where applicable. It does not consider any other fees, such as operating licences or the cost of meeting obligations attached to licences.

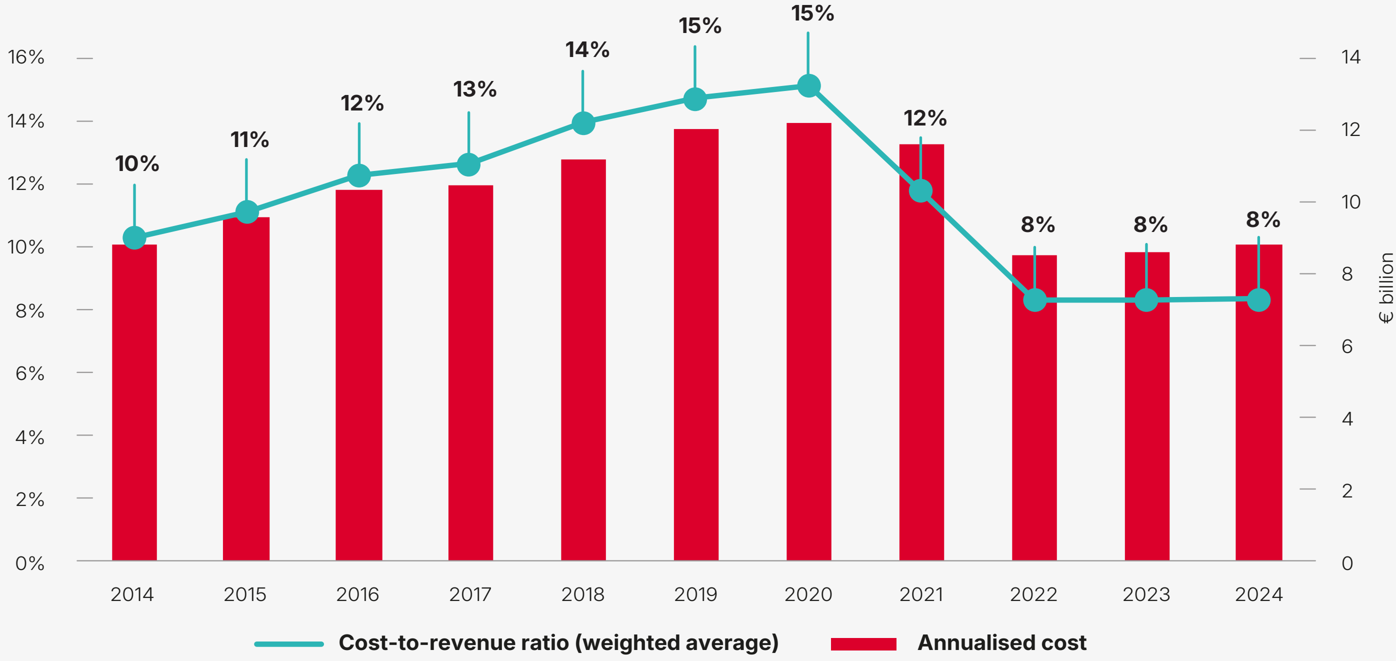
We examine how acquisition of additional spectrum and changing prices have affected the aggregate spectrum cost (see Figure 11).

Total spectrum cost in Europe was initially increasing between 2014 and 2020, before steeply declining between 2020 and 2022, and now stands at 8% of operators' revenue. However, the declining trend in recent years is driven by the expiry of particularly expensive 2.1 GHz licences, many of which have been renewed at lower cost between 2020 and 2022 (particularly in Germany and the UK).

When these licences are excluded from calculation, we find that aggregate spectrum cost related to all other licences has gradually increased over time (see Figure 12), reflecting the acquisition of additional spectrum and decreasing revenues.

Figure 11

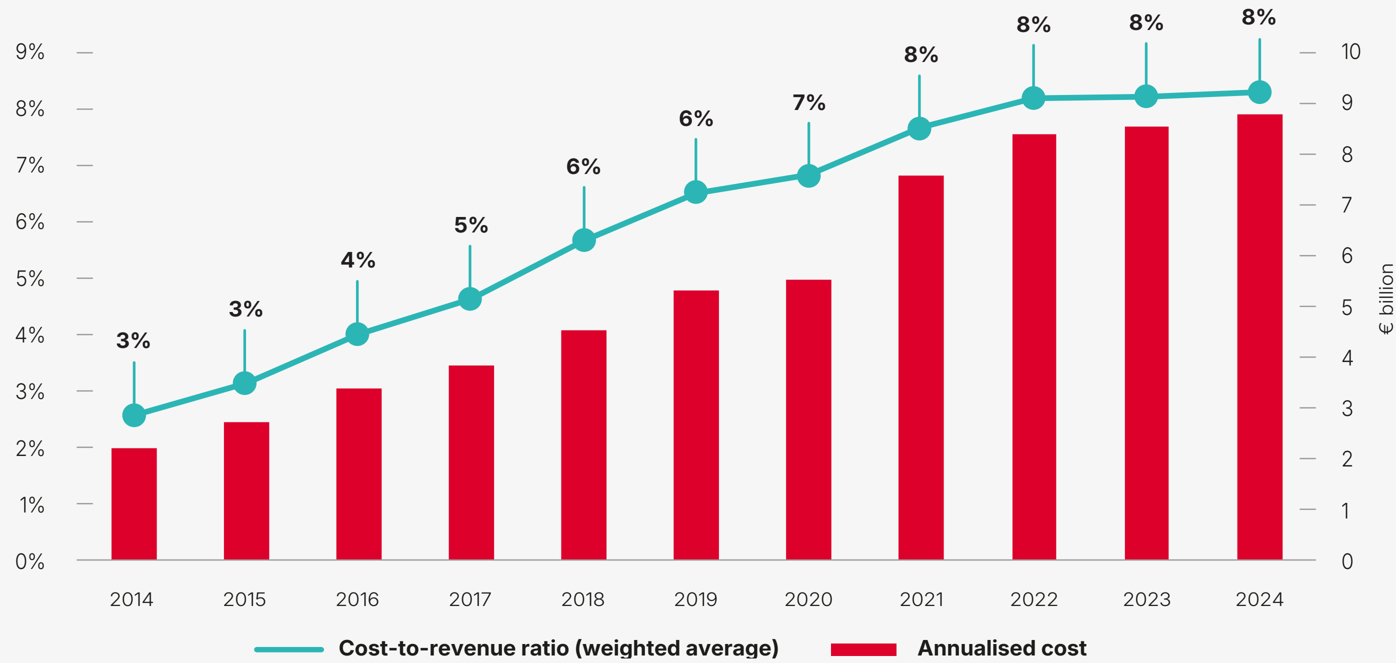
Aggregate spectrum-cost-to-recurring-revenue ratio in Europe



Source: GSMA Intelligence

Figure 12

Aggregate spectrum-cost-to-recurring-revenue ratio, excluding 2.1 GHz licences

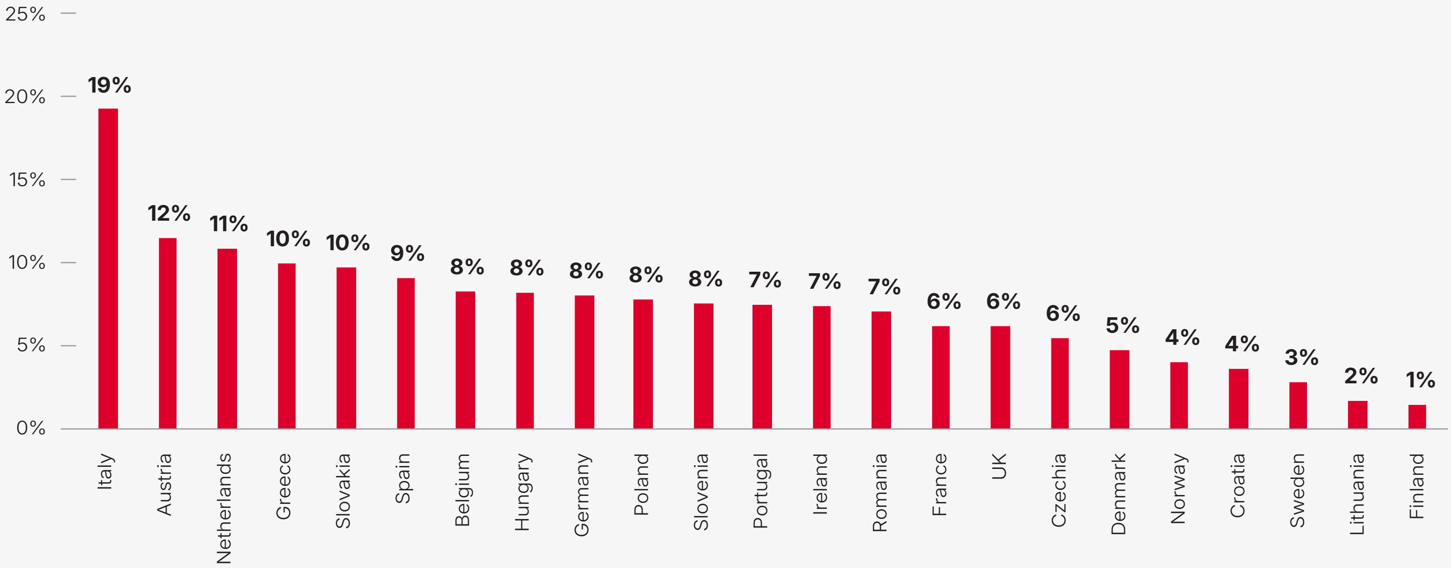


Source: GSMA Intelligence

It is also important to note that spectrum costs vary significantly between European countries (see Figure 13). Certain markets have very high spectrum costs (e.g. Italy, Austria and the Netherlands) and others much lower (e.g. in the Nordic countries). It is worth noting that the latter group all tend to have higher levels of 5G development (as reflected in the 5G Connectivity Index).

Figure 13

Spectrum-cost-to-recurring-revenue ratio in European countries, 2024



Note: Figures presented only for countries where sufficient data could be collected.

Source: GSMA Intelligence

Policy as a driver of spectrum cost

Cross-country differences in total spectrum cost as a share of market revenue can primarily be attributed to different approaches to assignment and pricing. Policy plays a role in determining cost in various ways, even when relying on auctions. Previous research has found that operators tend to pay more for each additional unit of spectrum when current holdings are scarce, while the use of high reserve prices can elevate prices paid during auctions.

Figure 14
Examples of policy choices driving spectrum prices

Pricing and design aspects

We find no material difference in prices between auctions and administrative assignments.

Specific design aspects and regulators' objectives are more influential.

Reserve prices

Reserve prices became final in 37% of the assignments we examined.

Effectively, prices were set by regulators, rather than the market. This can worsen the 'winner's curse'.

Scarcity of spectrum

Operators that own 10% less spectrum than the average paid 10% higher prices for additional spectrum.

Making sufficient spectrum available is an essential part of rational spectrum policy.

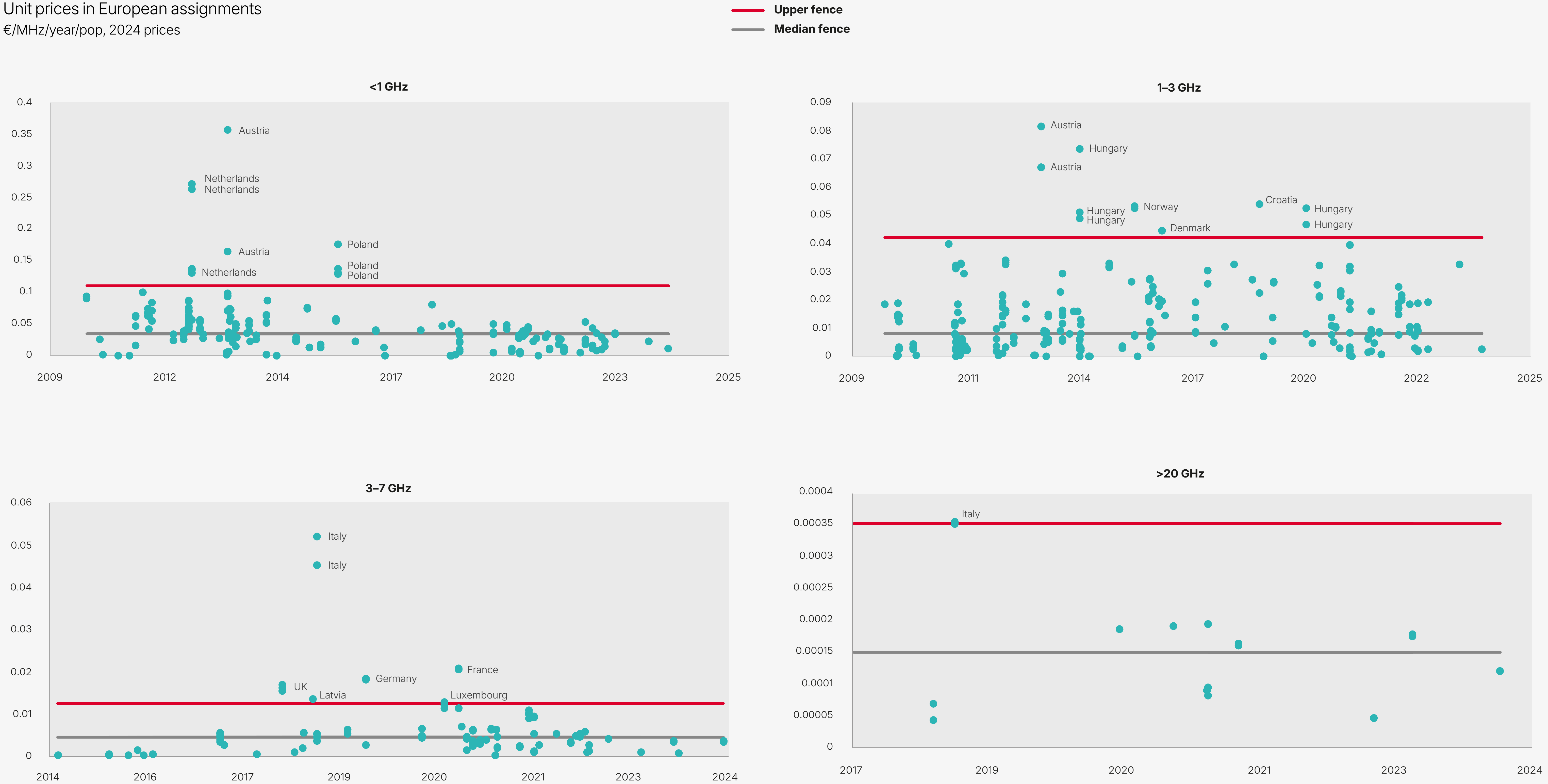
Note: Based on a hedonic analysis of a global dataset of individual spectrum licences.
Source: GSMA Intelligence

In Europe, there are several examples of policy decisions driving prices and contributing to the overall cost of spectrum. As shown in Figure 15, there is a great deal of variation in unit spectrum prices paid in individual assignments. While some of this arises from specific market conditions outside of the remit of regulators, much of the variation stems from policy choices. Thus, many outlier prices can be associated with particular aspects of an assignment that has contributed to high prices (as discussed in the case studies that follow).

Figure 15

Unit prices in European assignments

€/MHz/year/pop, 2024 prices



Note: Upper fence is a statistical boundary beyond which data points are considered outliers. It is calculated by adding 1.5 times the interquartile range to the third quartile value. Unit prices refer to individual assignments per operator; therefore where a country is identified more than once, it can refer to the price paid by two or more operators in the country.

Source: GSMA Intelligence.

Spotlight

How poorly designed auctions inflate spectrum costs

The vast majority of countries in Europe have used auctions to price and assign spectrum, particularly for new bands but also for renewed bands in some countries. In principle, auction prices should reflect market value, but in practice they are often determined by spectrum management decisions by the government or regulator, which can artificially inflate prices above the market value. This can happen when governments set high reserve prices, but it can also occur due to auction design, as highlighted in three European case studies below.

Italy's 3.7 GHz auction (2018)

Italy was one of the first European countries to auction part of the 3.5 GHz range for 5G in 2018. However, only 200 MHz was available, as 80 MHz was still in use by the government and the remaining 120 MHz was awarded as WiMAX licences. This meant there were four operators competing for 200 MHz. Furthermore, the spectrum was offered as two lots of 80 MHz and two lots of 20 MHz, which meant only two of the operators could obtain large enough blocks to deliver a competitive 5G service. The artificial scarcity this created resulted in operators paying €4.5 billion, equating to a unit price of €0.05/MHz/pop/year (2024 prices), higher than all unit prices paid in Europe for the band. In the same auction, operators also acquired new spectrum in the 700 MHz and mmWave bands, with all spectrum sold at bids very close to the reserve price. The auction therefore did not allow for price discovery and was primarily determined by the regulator's minimum price. These factors are one of the reasons why Italy has the highest spectrum cost relative to recurring revenue in Europe, at 19%. This is likely to be one factor behind Italy having among the lowest network quality in Europe, ranking fifth from bottom for overall download speeds as well as consistency.

Germany's 3.5 GHz auction (2019)

While many countries have assigned the 3.4–3.8 GHz band for mobile operators, the German regulator, BNetzA, set aside 100 MHz for local vertical use in its 2019 auction, with the intention to create new 5G business cases and support industry users. The impact of this decision was to create scarcity and increase prices, with operators paying €4.2 billion, equating to a unit price of €0.02/MHz/pop/year (2024 prices), which was four times higher than the median price paid for the band in Europe. Additionally, with four operators competing for 300 MHz of spectrum, none of them were able to secure the 100 MHz that was set out in the IMT-2020 vision. This is likely to have contributed to 5G speeds in Germany being the second lowest in Europe. The outcome of the auction also means that more spectrum is available for local use than is available to any of the four mobile operators. Spectrum for local use is also not subject to the same efficiency test and made available at a fraction of the cost and without any rollout obligations. Furthermore, due to the licensing model chosen by BNetzA, set-aside applications are outside of the urban areas where the spectrum is most needed by mobile operators,[12] creating inefficiencies in spectrum use.[13]

12 GSMA Intelligence analysis of data provided by Ookla Cell Analytics in 2025 shows that more than 70% of mobile traffic in Germany is in urban areas.

13 For further details, see The Impact of Spectrum Set-Asides on 5G: Germany, GSMA, 2023 and An Industrial 5G Spectrum Policy for Europe, Vodafone, 2019

The Netherlands' multi-band auction (2010 and 2012)

The Netherlands auctioned most of the 2.6 GHz band in 2010 and then in 2012. The regulator sold new spectrum frequencies in the 800 MHz band as well as renewing existing 900, 1800 and 2100 MHz bands. At the time, there were three incumbent operators and the regulator reserved 2×10 MHz spectrum in 800 MHz for a new entrant (Tele2). This contributed to a very competitive auction, with existing operators competing intensely for the remaining 40 MHz of spectrum in the 800 MHz band, which was needed as a coverage layer to deploy 4G. The set-aside created scarcity for the non-reserved spectrum, with KPN and Vodafone each paying around five times more than Tele2 for the same amount of spectrum. The 2012 auction subsequently raised €3.8 billion, with unit prices for 800 MHz among the highest in Europe. However, while the objective of bringing in a new entrant was achieved, Tele2 never established a significant position and its market share never exceeded 7%. It was subsequently acquired by T-Mobile in 2019, bringing the country back to a three-player market. During the six years it was active in the market, Tele2 never made use of the reserved 2.6 GHz spectrum it acquired in 2010 (the auction included tight spectrum caps that effectively reserved spectrum for new entrants, including Tele2 and Ziggo, which also never made use of its spectrum). This is an example of a regulator using spectrum policy as a tool to address a competition concern, but which was ultimately poorly designed and did not meet its objective in the long run. Furthermore, the decision meant that spectrum prices were artificially inflated and contributed to the Netherlands having the third-highest spectrum cost relative to recurring revenue in Europe today, at 11%.

3. Spectrum licence renewals

Renewal activity and pricing approach

Renewals of existing licences provide regulators and policymakers an opportunity to address some of the spectrum cost challenges over the next decade. A number of spectrum licences will be expiring in Europe, allowing for an opportunity to choose the optimal approach to pricing. Around 350 licences are due for renewal by the end of 2030 and another 200 licences between 2031 and 2035, when many European countries are expected to start deploying 6G. Figure 16 provides an overview of this by country and spectrum band.

The renewal activity will peak at around 2029 and 2030, when licences of the greatest value are due to expire. Their past upfront cost amounted to billions of euros, making them significant contributors to the overall spectrum cost (see Figure 17). Therefore, the pricing approach during the renewals will determine the level of spectrum cost in Europe for years to come.

Figure 16

Timeline for the expiry of over 500 licences in Europe

Licences expiring in 2025–2035 highlighted in red

	700 MHz	800 MHz	900 MHz	1500 MHz	1800 MHz	2100 MHz	2300 MHz	2600 MHz	3400–3800 MHz
Austria	2044	2029	2034	2044	2034	2044		2026	2039, 2044
Belgium	2042	2033	2042	2043	2042	2042		2032	2040
Bulgaria	2038	2038	2031, 2034		2031, 2034	2035		2041	2042
Croatia	2036	2039	2044		2044	2044		2044	2036
Cyprus	2041	2028, 2031, 2034	2028		2028	2028		2028, 2031, 2034	2041
Czechia	2036	2029	2029, 2044		2029, 2044	2041		2029	2032
Denmark	2040	2034	2034		2032	2042	2041	2030	2042
Estonia*	Not applicable								
Finland	2033	2033	2033		2033	2033		2029	2033
France	2035	2032	2031, 2034		2031, 2034	2030, 2031, 2032		2031	2026, 2035
Germany	2033	2030	2033		2030, 2033	2040		2030	2040
Greece	2030, 2035	2030	2027		2027, 2035	2036		2030	2035
Hungary	2035	2029	2029, 2037		2029, 2037	2027, 2035		2029	2034, 2035
Ireland	2042	2030	2030		2030	2027, 2042	2042	2042	2032
Italy	2037	2029	2029	2029	2029	2029		2029	2029, 2037
Latvia	2042	2033	2026, 2030	2042	2026, 2030	2027, 2030	2027	2028	2028, 2043
Lithuania	2042	2030	2032		2032	2026	2029	2027, 2030	2042
Luxembourg	2035	2027	2027		2027	2033		2027	2035
Malta		2033	2026		2026	2026		2033	2036
Netherlands	2040	2029	2030	2040	2029, 2030	2040		2029, 2030	2040
Norway	2039	2033	2033		2028, 2033	2032		2042	2042
Poland	2040	2031	2026, 2029, 2038		2027, 2029, 2037	2037		2031	2038
Portugal	2041	2027	2027, 2033, 2042		2027, 2033, 2041	2033, 2041		2029, 2041	2041
Romania	2047	2029	2029		2029	2029, 2031		2029	2047
Slovakia	2040	2028, 2048	2025, 2026, 2048		2025, 2026	2026, 2048		2028, 2048	2025, 2045, 2048
Slovenia	2036	2029	2031	2036	2031	2036	2037	2029	2036
Spain	2041, 2061	2041	2035, 2040		2038, 2040	2040		2040	2040, 2048
Sweden	2040	2035	2025, 2048		2027, 2037, 2054	2025, 2050	2045	2025, 2050	2045
Switzerland	2034	2028	2028	2034	2028	2028		2028	2034
UK**	2041	2033					2038	2033	2037, 2038, 2041

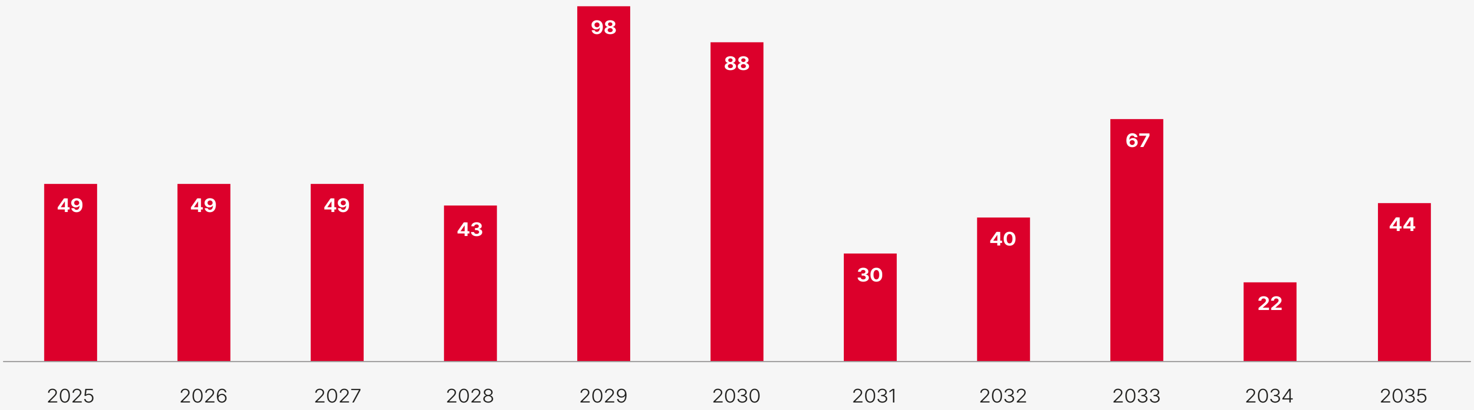
* Estonian frequency licenses are issued for one year by law and must be renewed annually, which includes the payment of a state fee for renewal each year. The regulator does not have the right to refuse to renew the licence unless there is a legal basis for refusal. Mobile licences are therefore valid for an indefinite term unless there is a basis for refusal.

** UK licences are generally indefinite. There is an initial licence term (usually 20 years), after which recurring annual fees are paid. The UK dates in the table refer to when annual fees may be payable after the initial term of the indefinite licence.

Source: GSMA Intelligence

Figure 17a

Number of licences expiring in Europe between 2025 and 2035

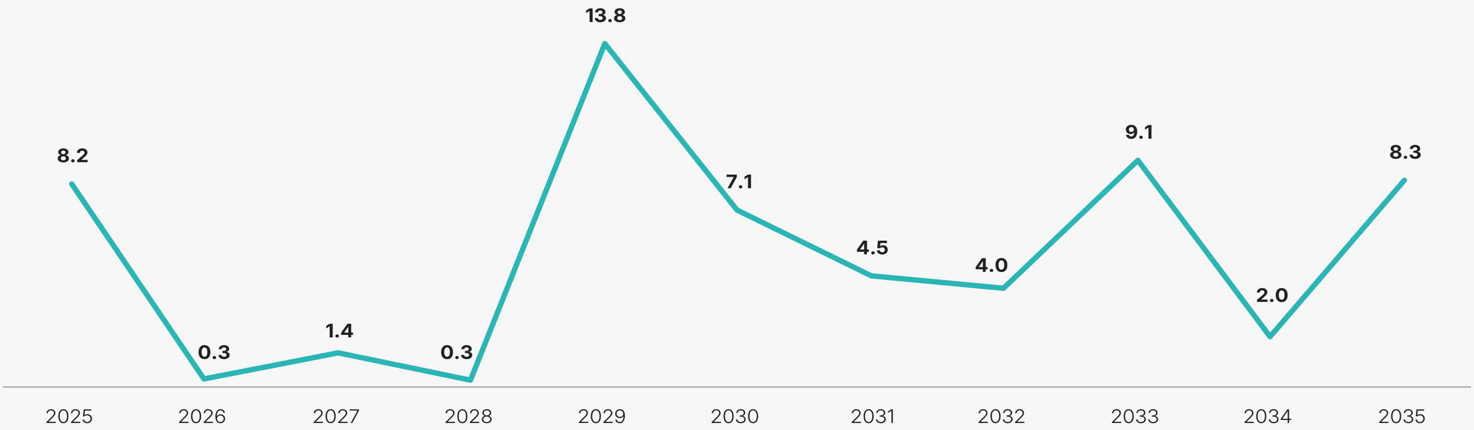


Source: GSMA Intelligence

Figure 17b

Historical upfront cost of licences in Europe by expiry year

€ billion, 2024 prices



Source: GSMA Intelligence

Regulators can choose from a variety of potential options when setting the pricing approach for the upcoming renewals. We list some of these in Figure 18, providing a brief description and rationale, as well as an assessment of how such an approach typically drives spectrum cost.

These approaches can be used exclusively for pricing only, but frequently they are combined with other aspects of regulation. For example, free-of-charge renewals and renewals at reduced fees have in the past been used alongside investment obligations.

Figure 18
Potential approaches to spectrum pricing during licence renewals

Approach to licence renewals	Description and rationale	Spectrum cost
Renewal at historical prices	This maintains the high cost of spectrum. Prices do not reflect the new reality of spectrum value, hindering network improvements. High ongoing spectrum costs are likely to limit operators' ability to fund network expansion or reduce prices. This approach would typically be pursued as a way of maximising direct government revenue, but overlooks the negative consequences on network quality and the risk of returned (and therefore unused) spectrum.	Very high
Renewal using an international benchmark based on recent assignments	This reflects more recent lower prices but is still backward-looking. In some countries this means lower prices and in other countries this means higher prices. The approach can partially reflect the recent trends in the value of spectrum, but can still risk elevating cost and returned spectrum as benchmarks do not reflect the specific conditions of a local market.	High
Re-auctioning of licences	Regulators could seek to re-auction existing licences to determine the most efficient users and reveal updated values. However, the resulting cost is heavily dependent on the auction design and format, as well as reserve prices, and so could lead to higher costs. Furthermore, re-auctioning spectrum that is currently being used to provide services that are the basis to operations and maintaining revenues risks significant disruption, high prices and inflated spectrum costs. This would have a significant impact on investment and operators' ability to provide competitive 5G (and eventually 6G) services	Uncertain but likely to be high/ very high
Prices adjusted in line with declining revenue per MHz per connection	This approach aligns spectrum cost with operators' reduced revenue per unit of spectrum. A gradual decline in spectrum cost leads to improved investment incentives. However, the past trends in revenues may not be a good proxy of the future value of spectrum. Hence, some risk remains of artificially inflating spectrum cost.	Medium
Pricing at the opportunity cost of spectrum	This approach sets the renewal fee to the estimated value of the next-best use of the spectrum (e.g. broadcasting for low bands). This reflects an efficient allocation based on true economic cost. However, the opportunity cost can be difficult to establish if it is based on the economic value driven by the alternative use. Another option could be to set the renewal at an equivalent price to other users in comparable bands (e.g. broadcasters or satellite users). This ensures that access to spectrum is provided on equal footing and would typically reduce the cost of spectrum to mobile operators.	Medium to low
Free-of-charge renewals or conversion to perpetual licences	This would result in a more rapid decline in spectrum cost. It could potentially be offered in exchange for investment commitments to ensure incentives for operators to prioritise connectivity goals. While the approach forgoes government revenue generation, it can spur further investment and economic benefits. It is also important to note that free-of-charge renewals still mean that operators pay the historical costs of bands not being renewed as well as, in some countries, annual spectrum fees.	Low

Source: GSMA Intelligence

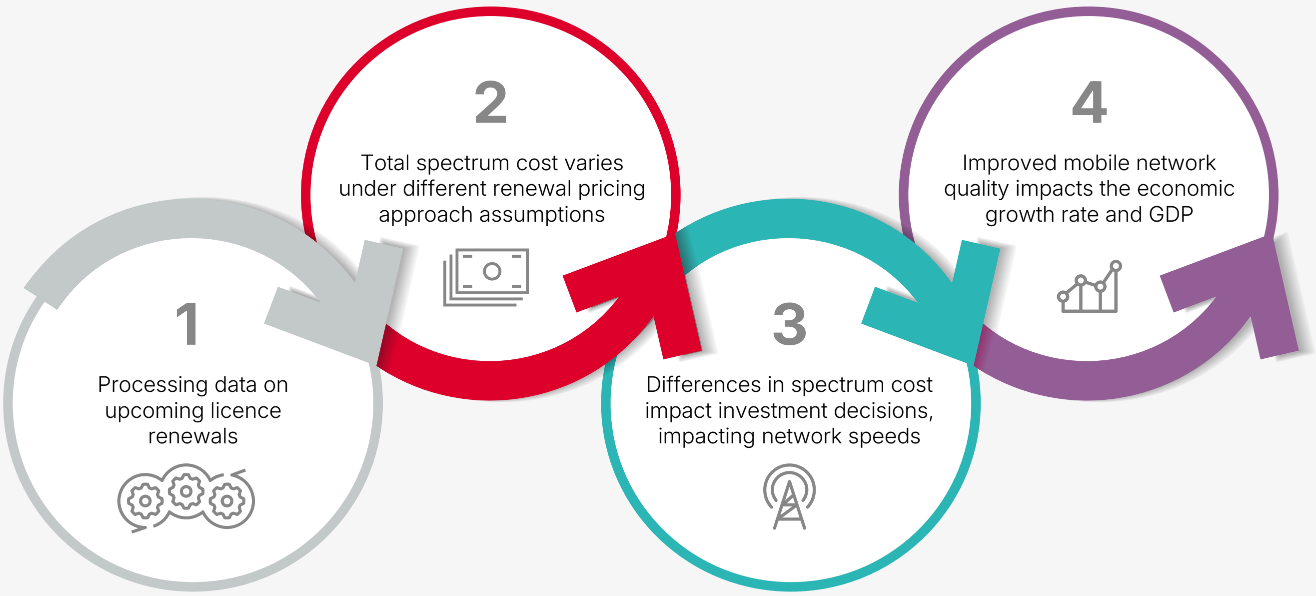
The economic impact of different pricing scenarios

We apply economic modelling to examine how different approaches to pricing could affect the quality of infrastructure in Europe, and how this could translate into economic impacts throughout the wider economy. This exercise is based on bespoke analysis in four steps (see Figure 19), initially establishing spectrum cost projections under different pricing approaches. In the steps that follow, we calculate the impact of spectrum cost on network quality. In the last step, we calculate the impact of improved network speeds on economic growth. More details on the modelling approach are available in the appendix.

We focus modelling on four illustrative scenarios where assumptions on pricing can be straightforwardly defined and which are aligned to the costs identified in Figure 18. We assume the same licence length that applies to existing licences would also apply to the renewals. A longer licence length would improve certainty and the amortised cost would be lower, but it is difficult to quantify by how much. We also focus on renewals only and do not make any assumptions on the cost of additional spectrum that will likely be made available over the next decade, such as the upper 6 GHz band.

Figure 19

Modelling: approach in four steps



The results of the modelling show that the policy options drive significant differences in the spectrum costs paid by operators (see Figure 20). In line with the renewal activity peaking at around 2029, the difference in spectrum cost between the scenarios becomes more apparent from 2030 onwards.

A high cost of spectrum constrains operators' ability to invest in further network improvements. Our projections show that renewing licences based on past prices (scenario 1) means that operators would incur €104 billion in spectrum costs in the 2025-2035 period, while free-of-charge renewals (scenario 4) would result in aggregate costs being nearly €30 billion lower, reducing the spectrum burden by around 28%. To put this figure into context, it represents more than triple the investment that is needed to upgrade to 5G SA across all 5G networks in Europe. Hence, low-cost licence renewal cost could allow operators to fund the necessary capital expenditure to deploy 5G SA.

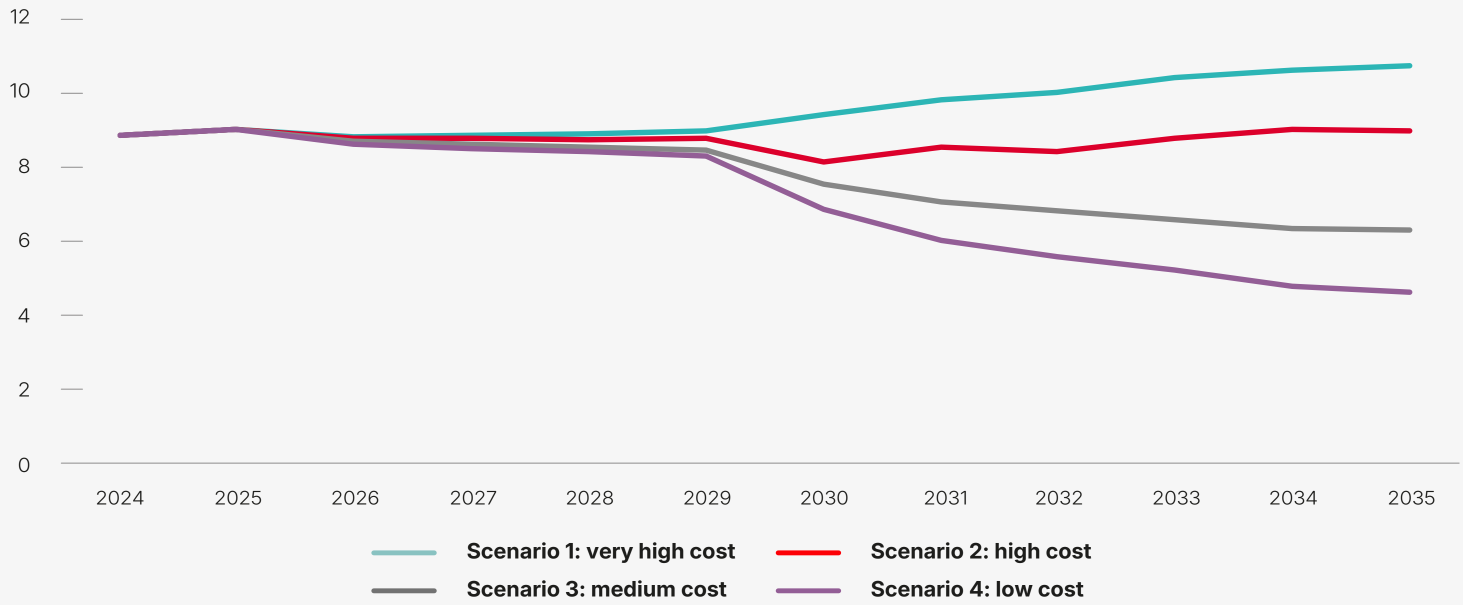
Nevertheless, under the low-cost scenario (with no cost attached to licence renewals), operators will still incur €75 billion in spectrum costs during the 2025–2035 period due to payment of ongoing licences prior to renewal, as well as annual spectrum fees (see Figure 20c). Further investment could therefore be unlocked by reducing or removing annual fees, which amount to €17 billion over the next 10 years in the low-cost scenario.[14]

14 In our modelling, annual spectrum fees are assumed to be maintained at their current levels in scenario 1. In other scenarios, they are reduced by the same percentage as total amortised costs.

Figure 20a

Modelling results: annual spectrum cost estimates in Europe

€ billion, 2024 prices



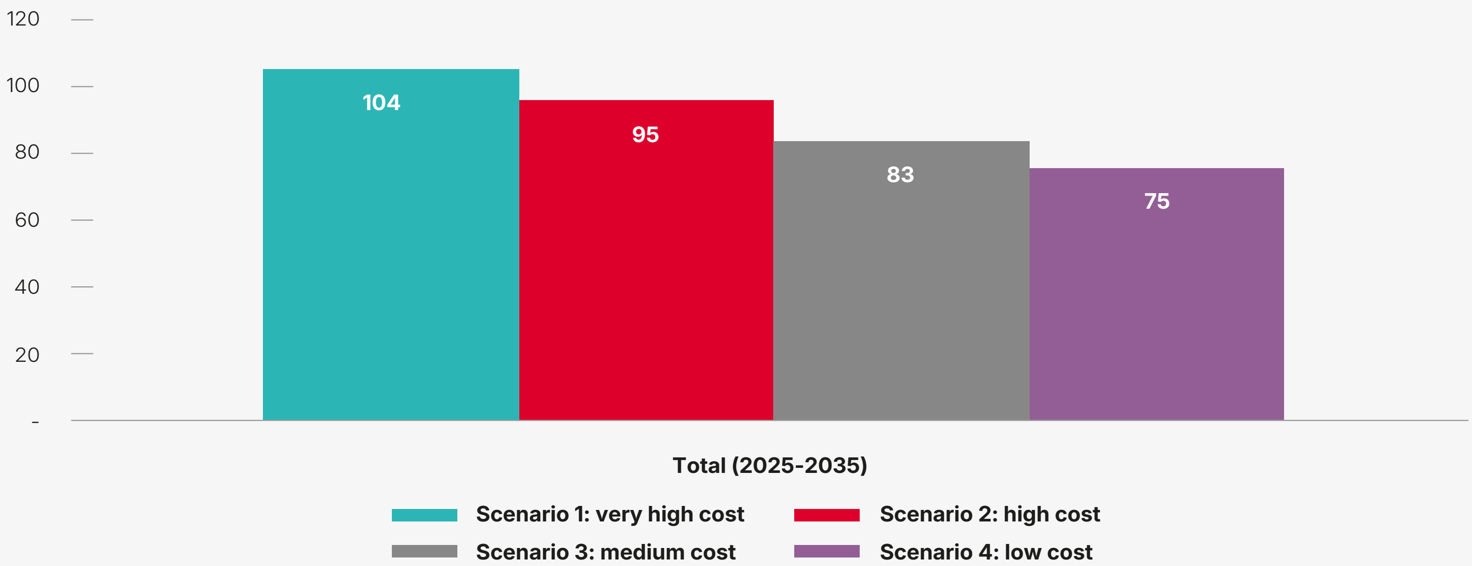
Note: Excludes cost in countries where reliable data could not be obtained (Bulgaria, Estonia, Latvia, Luxembourg and Switzerland).

Source: GSMA Intelligence estimates

Figure 20b

Modelling results: cumulative spectrum cost estimates in Europe

€ billion, 2024 prices



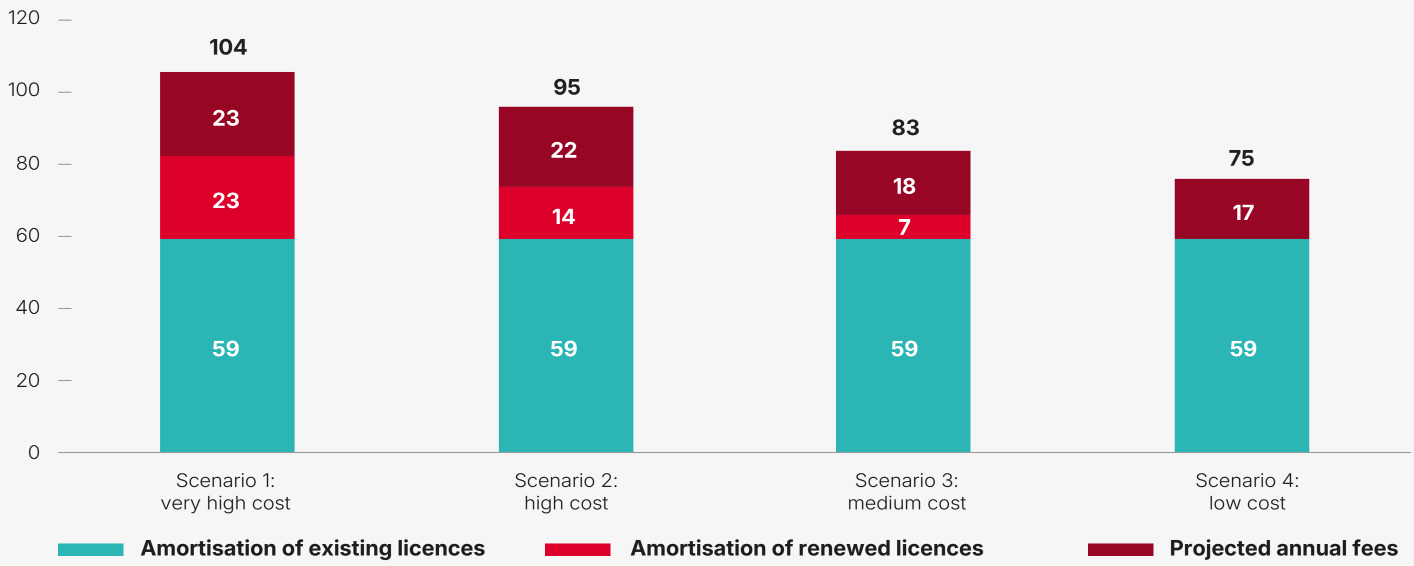
Note: Excludes cost in countries where reliable data could not be obtained (Bulgaria, Estonia, Latvia, Luxembourg and Switzerland).

Source: GSMA Intelligence estimates

Figure 20c

Breakdown of cumulative spectrum cost estimates in Europe

€ billion, 2024 prices



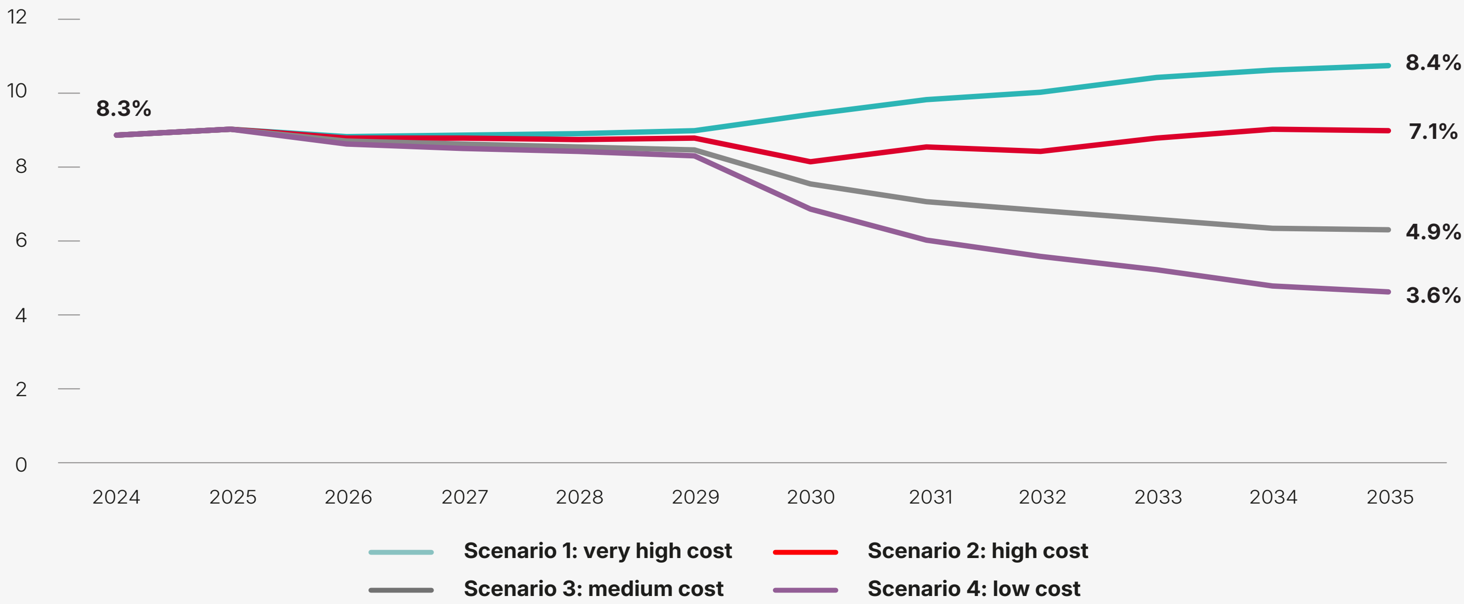
Note: Excludes cost in countries where reliable data could not be obtained (Bulgaria, Estonia, Latvia, Luxembourg and Switzerland). Due to rounding, the total costs may not be equal to the sum of the cost breakdowns.

Source: GSMA Intelligence estimates

In line with the evolving spectrum cost, we estimate spectrum cost as a share of operators' revenue based on GSMA Intelligence revenue forecasts. As shown in Figure 21, in the scenario of very high cost (scenario 1), the European weighted-average spectrum cost would remain unchanged at over 8% of operators' revenue by 2035. A scenario allowing for partial adjustment based on recent benchmarks (scenario 2) would reduce the cost to around 7% of operators' revenue. Under medium-cost and low-cost scenarios (scenarios 3 and 4), operators would pay 4.9% and 3.6% of their revenue to meet spectrum costs, respectively. Under the low-cost scenario, which assumes free-of-charge licence renewals, spectrum cost does not decline to zero because even by 2035, some existing licences will remain active, so their upfront cost will continue to be amortised.

Figure 21

Modelling results: spectrum-cost-to-revenue estimates in Europe



Note: Figure excludes cost in countries where reliable data could not be obtained (Bulgaria, Estonia, Latvia, Luxembourg and Switzerland).

Source: GSMA Intelligence estimates

Leveraging the evidence on the impact of spectrum cost on network quality[15] we find that lowering spectrum cost could meaningfully impact network infrastructure, as measured by download speeds (see Figure 22). For each scenario, we estimate impacts as a range of values to reflect the uncertainty. All impacts are expressed in relation to the very-high-cost scenario.

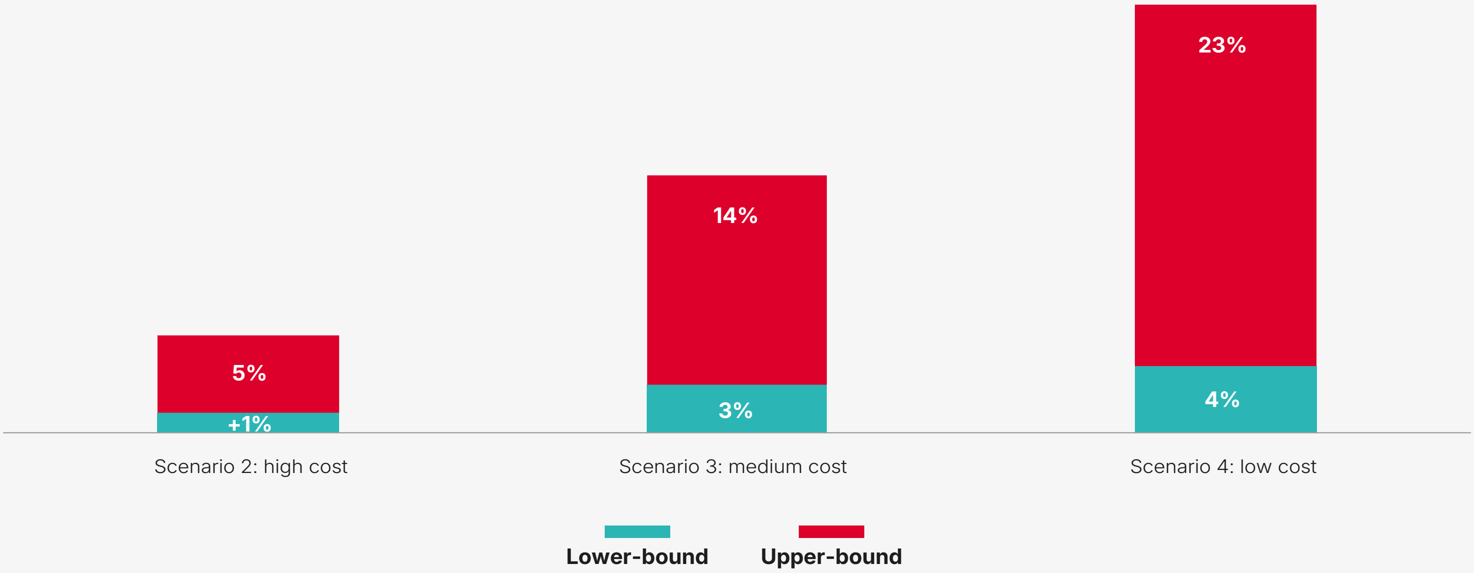
We find the following:

- Partial adjustment to spectrum cost (high-cost scenario) could improve speeds by between 1% and 5%.
- Adjustment of renewed licences in line with the decline in revenue per MHz (medium-cost scenario) could improve speeds by between 3% and 14%.
- With free-of-charge renewals (low-cost scenario), we estimate that network speeds could improve by between 4% and 23%.

Figure 22

Modelling results: the impact on average network speeds in 2035 compared to scenario 1 (very high cost)

Europe weighted average



Note: For each scenario, figures are presented as a range to indicate the uncertainty arising from the choice of parameters used in modelling. The range reflects lower and upper bounds based on the empirical literature that quantifies the impact of spectrum costs on network quality. Based on countries where reliable spectrum cost data could be obtained.

Source: GSMA Intelligence estimates

15 Further details on this evidence are provided in the Appendix.

As a result of improved network speeds, we estimate the wider economic benefits of improved connectivity (see Figure 23). Given the estimated range of impacts on network quality, we also estimate the economic impacts as ranges and in reference to the very-high-cost scenario. We find that the total impacts throughout Europe would amount to the following in each scenario:

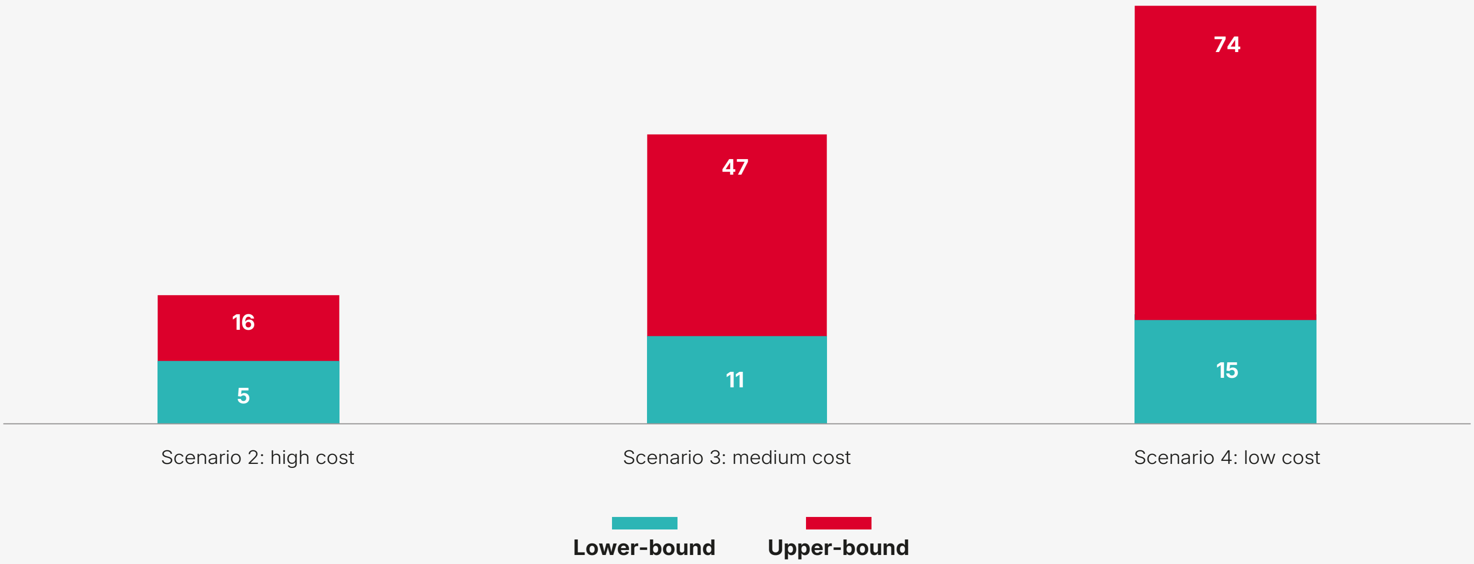
- **High-cost scenario:** This would bring a moderate increase in GDP of up to €16 billion.
- **Medium-cost scenario:** This would increase the impact on GDP by up to €47 billion.
- **Low-cost scenario:** This would drive the greatest economic benefits, by up to €74 billion.

These impacts illustrate the economic opportunity offered by adjusting spectrum pricing and avoiding a build-up of spectrum costs. Many regulators in Europe and other regions have recognised this and have approached spectrum licence renewals with an objective to promote investment and expand high-speed mobile coverage within their markets. Examples of this are provided below *(Spotlight: Enabling investment with renewals and longer licence durations)*. Some regulators have also adopted innovative market-based approaches to achieve certain coverage and service-quality targets, which are more efficient than traditional licence obligations that are attached to spectrum awards. An example of this is provided below *(Spotlight: Austria's approach to coverage obligations)*.

Figure 23

Modelling results: cumulative 2025–2035 GDP impact of improved network quality compared to scenario 1 (very high cost)

€, 2024 prices



Note: For each scenario, figures are presented as a range to indicate the uncertainty arising from the choice of parameters used in modelling. The range reflects lower and upper bounds based on the empirical literature that quantifies the impact of spectrum costs on network quality. Based on countries where reliable spectrum cost data could be obtained.

Source: GSMA Intelligence estimates

Spotlight

Enabling investment with renewals and longer licence durations

The analysis presented above highlights the magnitude of spectrum cost savings that could be achieved if renewed spectrum licences were either adjusted to operator revenues per MHz or offered free of charge. A number of countries have recognised this and have focused on increasing investment as part of spectrum renewals.

France's 'New Deal' in 2018

In 2018, the French regulator, ARCEP, renewed licences for 900, 1800 and 2100 MHz that were due to expire between 2021 and 2024. Given the regulator's concerns over low availability of 4G in rural areas, it agreed with operators to trade the licence renewal fee for the acceleration of 4G rollout and provide nationwide, high-quality mobile coverage for everyone in France. The government and local authorities identified areas that needed improved coverage in order to bolster regional development. The commitments included providing mobile coverage in selected 'white zones', accelerating the pace of transport corridor coverage and improving reception quality nationwide, particularly in rural areas. The regulator tracked operator progress and found that, after five years, the share of the population covered by 4G across all four operators had almost doubled (from 45% to 88%) and the share living outside of a 4G network had declined from 20% to 11%. Meanwhile, almost two thirds of the population now had access to 30 Mbps services or higher (up from 37%). This example shows how reducing or removing spectrum costs as part of the licence renewal process can increase investment in coverage and network quality, driving greater social and economic value.[16]

Spain's approach to licence renewals

In 2022 the Spanish government, seeking to align domestic regulation with the European Electronic Communications Code (EECC), approved the General Telecommunications Law. This included a provision stating that existing spectrum licences can be extended. Following a consultation in 2023, the extension was approved in 2024 and brought older spectrum licences in line with the most recent Spanish licence awards. Spain awarded 700 MHz and 26 GHz licences in 2021 and 2022 respectively, with terms that enable the operators to keep their licences for at least up to 40 years. The initial 20-year licence will be extended by another 20 years, with no additional upfront cost, as long as the operators meet their coverage requirements, use spectrum efficiently and foster the development of new wireless technologies. Further extensions beyond the initial 40 years are possible, subject to an assessment, before expiration. The licence extension applied to 3.5 GHz as well as previously assigned bands in 800 MHz, 900 MHz, 1.8 GHz, 2.1 GHz and 2.6 GHz frequencies. The extensions ensured the most efficient use of spectrum while minimising administrative costs. The government expected that the cost-free renewals would mean more investment for network deployments. Besides cost savings, extensions provide certainty of access, allowing long-term planning to carry out new investments involving spectrum bands on expiring licences. This was especially important for bands expiring before 2030. Many of these bands are expected to be refarmed for use by 5G networks. 5G coverage had reached 95% of Spain's population by Q3 2025, while the country also has the highest utilisation of 5G SA in Europe.[17]

16 For further details, see https://www.arcep.fr/cartes-et-donnees/suivi-du-new-deal-mobile.html

17 A Global Evaluation of Europe's Competitiveness in 5G SA, Ookla, 2025

Indefinite licences and spectrum trading in the US

The US provides a valuable case study on how long-term spectrum certainty can be enabled through indefinite licences. The Federal Communications Commission (FCC) has awarded licences with a right of renewal, which means they are effectively indefinite. In order to ensure spectrum remains efficiently utilised, the country has made spectrum trading a key policy since the early 2000s. The FCC established a framework for secondary markets, allowing both full transfers (sales) and leasing of spectrum rights. This flexibility has supported rapid expansion of mobile broadband and 5G networks, with the US among the leading 5G markets worldwide (including one of the highest 5G FWA adoption rates). Spectrum holders such as satellite operators and smaller rural operators have been able to lease or sell unused spectrum to major mobile network operators, enabling faster deployment of services without requiring new spectrum auctions. The recent acquisition of spectrum in the 3.45 GHz band by AT&T from EchoStar and UScellular,[18] as well as T-Mobile US's sale of 800 MHz spectrum,[19] highlights how this can work effectively in practice.

18 See "AT&T acquires EchoStar spectrum assets for $23B", Mobile World Live, August 2025 and "AT&T scores spectrum from UScellular in $1B cash deal", Mobile World Live, November 2024

19 See "T-Mobile US to sell-off 800MHz spectrum", Mobile World Live, March 2025

Spotlight

Austria's approach to coverage obligations

While the majority of countries continue to utilise auctions to assign new spectrum bands, and in some cases existing bands that are up for renewal, some regulators have taken new approaches to expanding coverage and improving quality of service in underserved locations (typically rural and remote populations, as well as transport corridors). The most common approach taken by regulators historically has been to attach coverage and/or quality-of-service obligations to licences. However, by bundling obligations with a spectrum licence, there is a risk of conflating two objectives that may not align, namely ensuring spectrum is put to its most efficient use and extending coverage to populations and areas that are not economically viable for the market to provide (i.e. addressing a market failure caused by positive externalities). There is also a risk that onerous and costly obligations can result in spectrum being unsold.

Some regulators have therefore unbundled licences from service-level obligations to ensure these are met efficiently. One option is to separate the two completely by using direct procurement outside the spectrum auction to expand coverage expansion, which several countries do using universal service funds. An alternative is to unbundle within the auction design.

Austria's multi-band auction (2020)

In 2020, the Austrian Regulatory Authority for Broadcasting and Telecommunications (RTR) held an auction for the 700, 1500 and 2100 MHz bands. It combined multiple approaches to ensure widespread coverage in the country. There were also band-specific deployment obligations; for example, winners of spectrum in the 700 MHz band had to deploy at least 500 base stations by the end of 2022 and 1,500 base stations by the end of 2023. And there were band-specific coverage obligations; for example, winners of spectrum in the 2100 MHz band had to use the spectrum to cover 75% of the population by the end of 2023 with a 5G service that provided 30 Mbps download and 3 Mbps upload speeds. Obligations were also set for coverage in large cities and on roads, motorways and railways. Additionally, there was a reverse auction that extended coverage to underserved communities.

The final result of the auction was the award of all available spectrum for around €200 million, and coverage was procured for 1,702 of the underserved communities (81% of the 2,100 defined). Almost half of these (802) were assigned in the reverse auction. A key lesson from the auction was recognition that coverage obligations for the most difficult-to-reach areas represent a significant additional cost associated with acquiring the spectrum licence. If obligations are bundled with a spectrum award but are too onerous, the spectrum award may fail, meaning spectrum is not put to efficient use and the obligations are not met. The Austrian auction addressed this by using a market mechanism (reverse auction) to decouple spectrum awards from specific coverage obligations in high-cost communities. The importance of this is demonstrated by the fact that one operator, Telekom Austria, did not acquire any 700 MHz spectrum but acquired obligations to cover 349 communities in the reverse auction stage. This reflects the possibility that one operator can put a band to optimal use across a country, while another is better placed to deploy in hard-to-reach areas at lower cost.[20]

20 For further details, see Auction results, Austrian Regulatory Authority for Broadcasting and Telecommunications, n.d.

4. Assignment and pricing of new spectrum bands

While the approach to pricing and licensing of existing spectrum bands will be critical for operators, it is equally important for regulators in Europe to ensure that additional spectrum is made available to meet future demand and that it is licensed and priced efficiently. With the mobile industry looking ahead to 6G, which is expected to be deployed from 2030, there is a need to identify potential new spectrum requirements so operators can plan investments and governments can develop long-term spectrum roadmaps.

The GSMA's report on 6G-era spectrum needs[21] shows that in order to meet demand for current and new use cases, a total of 2 GHz to 3.1 GHz of mid-band spectrum[22] will be needed in Europe in high-density areas, such as cities. In very-high-demand countries, such as in the Nordic countries and the Baltics, mid-band requirements could potentially reach up to 3.9 GHz.

The key policy implication from the study is that at least 2 GHz of mid-band spectrum is required for mobile by 2030 to ensure mobile networks do not become congested, while more spectrum may potentially be required to cope with additional traffic demand in the longer term. Building on recent spectrum identifications at the World Radiocommunication Conference 2023 (WRC-23), and also looking ahead to WRC-27 discussion items, the primary mid-bands currently under consideration for additional mobile spectrum are from within the:

- 3.8–4.2 GHz range, which could provide an additional 200–400 MHz of mid-band spectrum
- 4.4–4.99 GHz range, which could provide an additional 400–600 MHz
- upper 6 GHz range (6.425–7.125 GHz), which could provide an additional 700 MHz
- the 7.125–8.4 GHz range, which could provide an additional 600–1275 MHz.

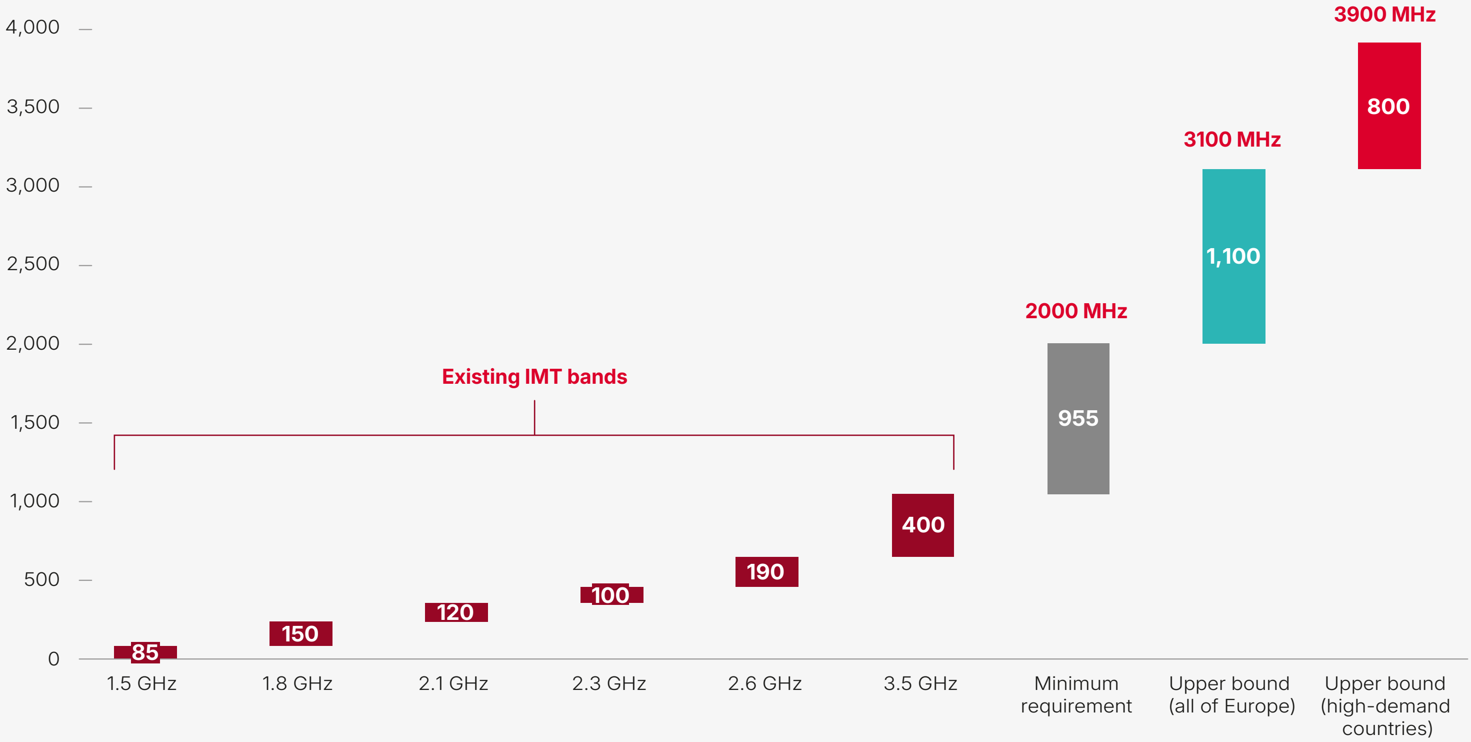
There is a clear pathway to ensure that the minimum requirement of 2 GHz of mid-band spectrum is available by 2030 by assigning the upper 6 GHz band plus 300 MHz in the 3.8–4.2 GHz range (these frequencies combined would provide the additional 1 GHz of spectrum needed). Assigning these bands would bring Europe in line with other leading countries such as the US, China and India, with the US identifying an additional 800 MHz of mid-band spectrum[23] and China and India having identified the full upper 6 GHz band for licensed mobile. Beyond that, the 4.5 GHz and 7–8 GHz bands can offer solutions to the longer-term requirements that could materialise in the 2030s.

21 Vision 2040: Spectrum needs for the future of mobile connectivity, GSMA, 2025
22 Mid-band spectrum refers to frequencies between 1 GHz and 10 GHz.
23 The recent One Big Beautiful Bill Act (OBBBA) mandates the auction of at least 800 MHz of spectrum for use by terrestrial cellular networks, with all auctions to be completed by 2034.

Figure 24

Existing IMT mid-bands and future spectrum requirements

MHz



Note: The 1.5 GHz and 2.3 GHz frequencies are not fully harmonised and so several countries in Europe have not yet made these available for mobile use.

Source: GSMA Intelligence

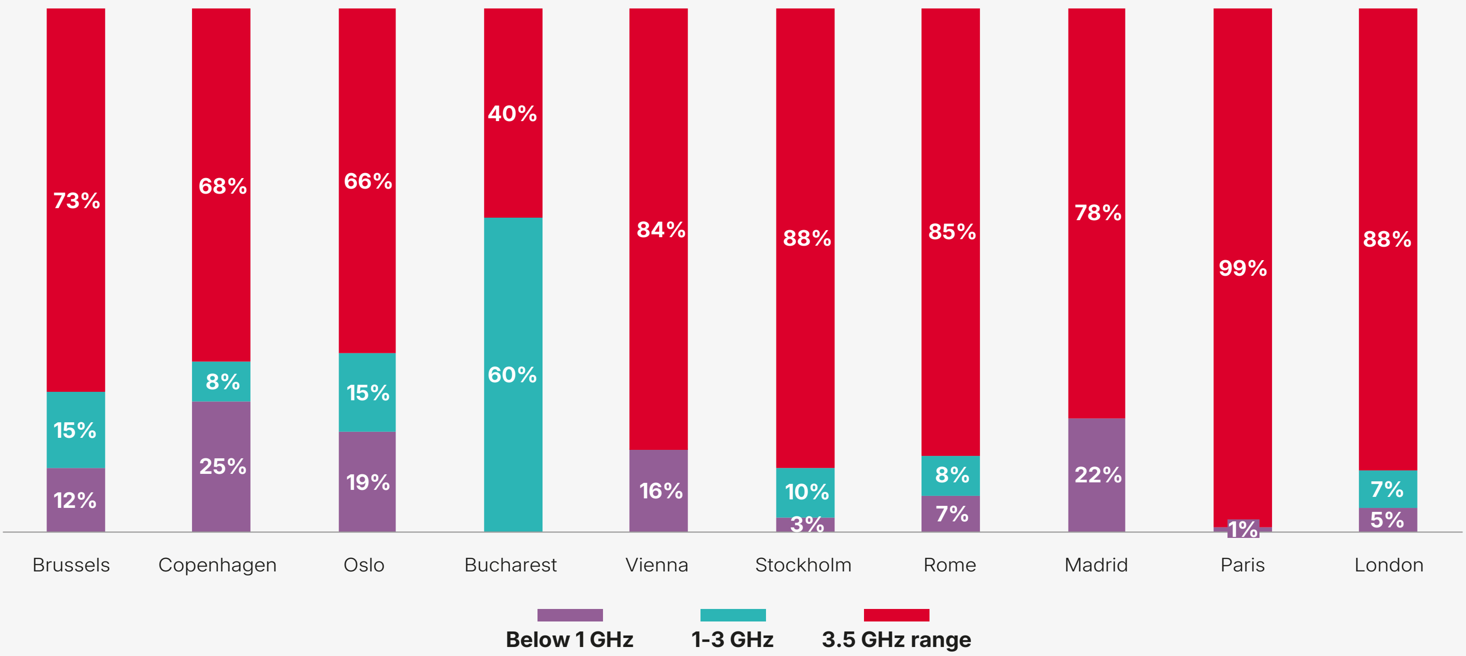
Assigning the upper 6 GHz band for licensed mobile will maximise the economic benefits in Europe

Following the conclusion of WRC-23, countries representing 60% of the global population sought inclusion in the identification of the upper 6 GHz band for licensed mobile. Since then, China, India, Vietnam, the UAE and Brazil have all confirmed that the entire band will be used for mobile, while Australia will assign 580 MHz for mobile.

Assigning the upper 6 GHz band for mobile will help to address future capacity constraints and will also drive the greatest benefit for Europe's economy. Operators have efficiently deployed 3.5 GHz spectrum for 5G and would do the same for the upper 6 GHz band for 6G. Trials have shown that 6 GHz can deliver comparable indoor and outdoor coverage to the 3.5 GHz range.[24] Across 10 of Europe's biggest cities, the majority of 5G use (both indoors and outdoors) is on the 3.5 GHz band (see Figure 25), which provides speeds that are up to eight times faster than on low bands (sub-1 GHz) and lower mid-bands (1–3 GHz).

Figure 25

Proportion of indoor 5G scans by spectrum band



Note: Data is provided on coverage scans from Speedtest Android users, which include information on indoor/outdoor location, connection type (4G/5G), spectrum band and signal strength. Data collected for March 2025.

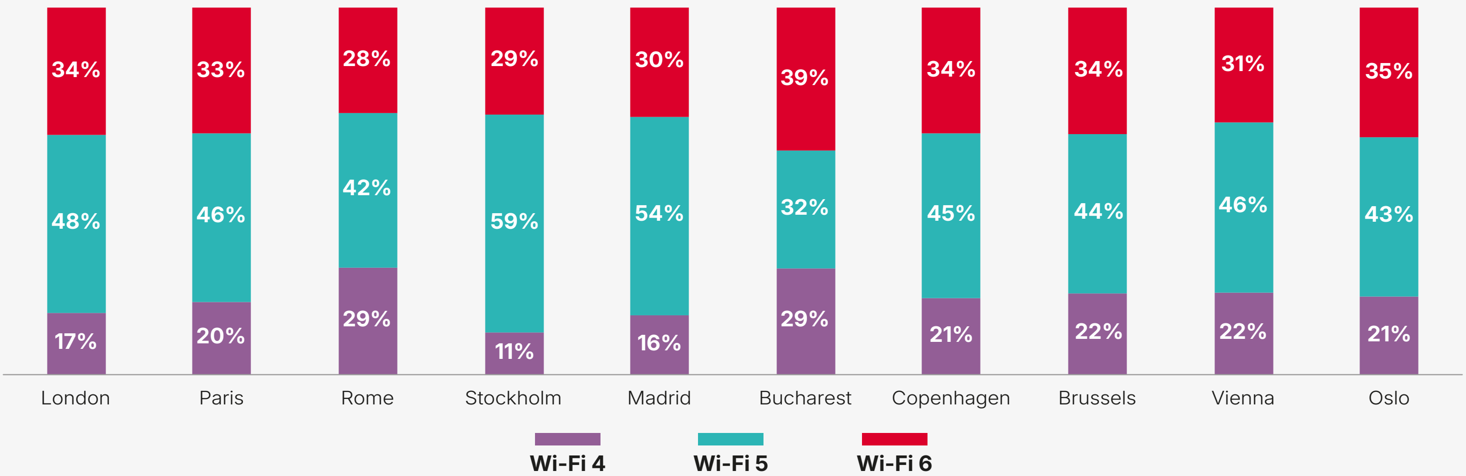
Source: GSMA Intelligence analysis of data provided by Ookla

24 For examples of trials that have shown 6 GHz can deliver comparable indoor coverage to the 3.5 GHz range, see Mobile Evolution in 6 GHz, GSMA, 2024 and Exploring Upper-6 GHz and mmWave in Urban 5G Networks: A Direct on-Field Comparison, Morini et al, 2025

By contrast, the majority of Wi-Fi use in Europe is on older Wi-Fi 4 and Wi-Fi 5 technologies (see Figure 26), meaning there is scope to improve Wi-Fi speeds by upgrading equipment to Wi-Fi 6, as well as optimising indoor deployments (e.g. with additional access points, mesh network solutions and using Wi-Fi boosters).[25] Furthermore, where Wi-Fi 6/6E is used, the lower 6 GHz band that has been assigned for unlicensed use in Europe remains underutilised (see Figure 27). This means that the lower 6 GHz band can still be used for capacity expansion going forward. Analysis by GSMA Intelligence shows that when considering licensed and unlicensed options for the upper 6 GHz band, the former drives the greatest benefit because mobile is much more likely than Wi-Fi to be capacity constrained.[26]

Figure 26

Proportion of Wi-Fi scans by technology

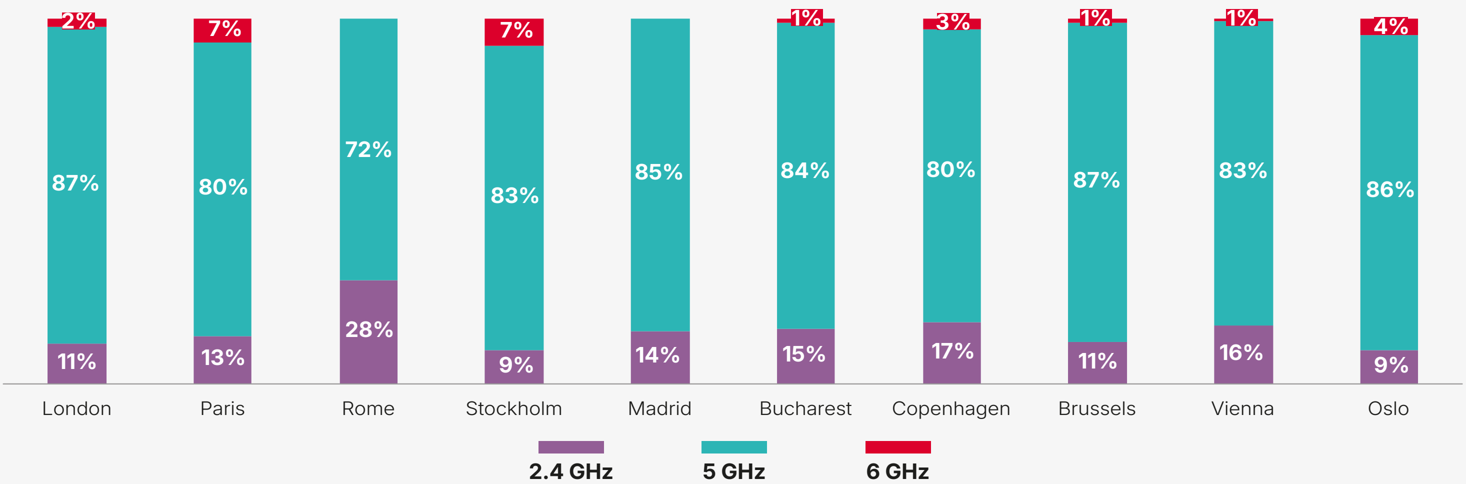


Note: Data is provided on Wi-Fi scans from Speedtest Android users, which include information on indoor/outdoor location, technology and frequency. Data collected for March 2025.

Source: GSMA Intelligence analysis of data provided by Ookla

Figure 27

Proportion of Wi-Fi 6/6E scans by frequency

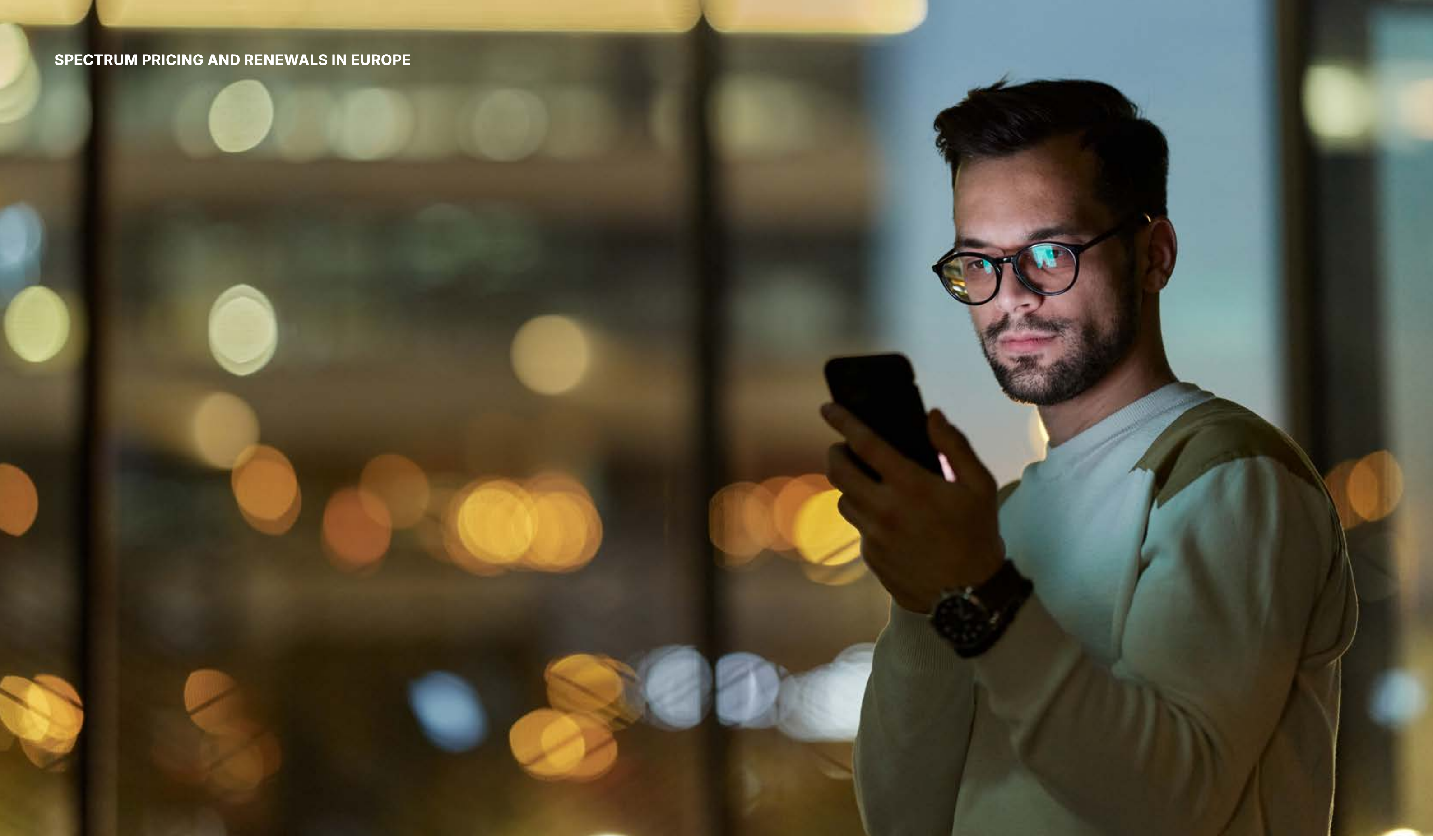


Note: Data is provided on Wi-Fi scans from Speedtest Android users, which include information on indoor/outdoor location, technology and frequency. Data collected for March 2025.

Source: GSMA Intelligence analysis of data provided by Ookla

25 For further detail on ways to improve Wi-Fi spectral efficiency, see Mobile Evolution in 6 GHz, GSMA, 2024

26 See Mobile Evolution in 6 GHz, GSMA, 2024



Spectrum in the 3.8–4.2 GHz band could be more efficiently used by mobile

In addition to the upper 6 GHz band, regulators in Europe should consider extending the 3.5 GHz range for high-powered mobile into the 3.8–4.2 GHz band. This frequency has been identified for low- or medium-power local vertical applications in many European countries, with protection for incumbent fixed-satellite service. However, empirical evidence shows that setting spectrum aside for localised use has no significant impact on the digitalisation of enterprises, but it does reduce the quality of public mobile networks, which has an adverse impact on both consumers and businesses.[27]

The lack of association between set-asides and the adoption of private networks can be explained by the availability of alternative options for spectrum access. In particular, enterprises can access complete private network solutions (including spectrum) from public mobile network operators. A further option for enterprises is to power their private networks using spectrum available through sharing frameworks or spectrum leasing. Similarly, the lack of association with IoT adoption indicates that set-asides do not enhance the ability of enterprises to access these services beyond what alternative spectrum access modes offer.

An in-depth analysis of how the 3.8–4.2 GHz band is licensed for local use in the UK shows that reserving 400 MHz in a prime mid-band can result in an inefficient use of the spectrum, as it becomes underutilised, as outlined below *(Spotlight: Enhancing the utilisation and efficiency of the 3.8–4.2 GHz band in the UK)*. There is therefore a strong case for rethinking the current approach and making better more efficient use of the 3.8–4.2 GHz band in Europe to support 5G and future 6G, improve network quality for consumers and businesses and drive wider economic gains.

27 See The impact of spectrum set-asides on private and public mobile networks, Jakub Zagdanski, Pau Castells, and Kalvin Bahia, Telecommunications Policy (2025): 102991.

Spotlight

Enhancing the utilisation and efficiency of the 3.8–4.2 GHz band in the UK

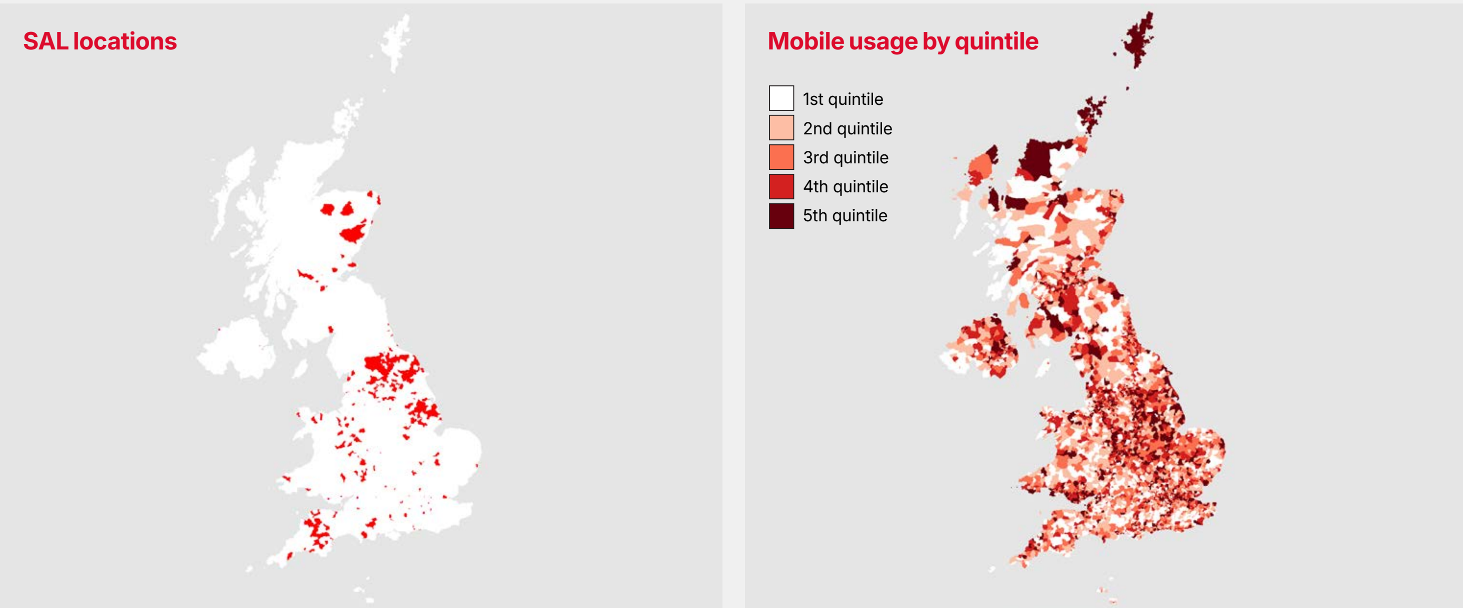
The UK operates a licensing framework for the 3.8–4.2 GHz spectrum band under its shared access licence (SAL) scheme. This spectrum has been available for shared and private network use since 2019, targeting wireless connectivity at different sites, including businesses or industrial users.[28] At the end of 2024, there were 569 live SALs, meaning they were not widespread across the UK. SALs were in use in only 3% of postcode sectors,[29] meaning just over 300 postcode sectors have at least one SAL of medium or low power.

When analysing the distribution of mobile data usage, drawing on data provided by Ookla, it was found that 96% of mobile data traffic is located in postcode sectors without any SALs. Figure 28 provides a visual illustration of the distribution of mobile network traffic in the UK, based on data sourced from Ookla, as well as the location of SALs. It shows that 3.8–4.2 GHz spectrum is not being utilised in most of the country, yet could provide a valuable resource for operators to expand capacity in high-demand locations. Furthermore, an Analysys Mason study showed that existing SALs could meet their current requirements with 100 MHz of spectrum instead of 400 MHz.[30]

This underutilisation of spectrum in the 3.8–4.2 GHz band, six years since the SAL framework was put in place, represents a missed opportunity to significantly improve mobile network performance in the UK. If this spectrum were made available to mobile operators, it could enhance network capacity and provide better service to consumers. Analysis by GSMA Intelligence found that the improvement in network performance from allowing mobile operators to utilise 200–300 MHz in the band could result in a cumulative GDP increase of £3–5 billion in the UK from 2025 to 2030.

Figure 28

SALs distribution and mobile usage across the UK



Source: GSMA Intelligence analysis, based on Cell Analytics™ data provided by Ookla

28 A more detailed review of how the band is currently used can be found in Review of the use of spectrum in the 3.8–4.2GHz band in the UK, Analysys Mason, 2025

29 The UK is administratively split into around 1.8 million geographic postcodes, which can be aggregated into approximately 10,000 postcode sectors. For example, SE1 9HA is a full postcode, while the relevant postcode sector is SE1 9 (meaning the sector includes all postcodes that are prefixed with SE1 9). The postcode sector boundaries we use in this analysis are sourced from Harper Collins.

30 Review of the use of spectrum in the 3.8–4.2GHz band in the UK, Analsys Mason, 2025

Assigning the full upper 6 GHz and 3.8–4.2 GHz bands will allow Europe to meet its mid-band requirements and ensure spectrum costs remain sustainable

Europe's Radio Spectrum Policy Group (RSPG) has published an Opinion which states that either 665 or 700 MHz of spectrum within the 6.425–7.250 GHz range will be designated for mobile use.[31] Specifically, under the RSPG's Opinion, 540 MHz (6.585–7.125 GHz) is designated for priority mobile use, with an additional 160 MHz (6.425–6.585 GHz) or 125 MHz (7.125–7.250 GHz) to be confirmed after WRC-27. This is important because assigning less than this amount would pose two significant risks for Europe.

First, it would be very challenging for mobile operators to gain access to the minimum 2 GHz mid-band requirement by 2030 without the full upper 6 GHz band, as there is insufficient spectrum available in the 3.8–4.2 GHz band alone and the 4.5 and 7–8 GHz bands are unlikely to be ready for mobile use by 2030.

Second, past experience shows that restricting the amount of spectrum available artificially inflates spectrum prices, which increases cost and results in lower investment, slower deployment of new technologies (e.g. 5G-Advanced and 6G) and poorer network quality.[32] This was seen in the aforementioned cases of the Italian and German auctions in 2018 and 2019 respectively, where no operator was able to obtain 100 MHz of spectrum (as recommended by the ITU[33]), but they paid significantly higher prices compared to operators in other countries in the same band. Repeating the same mistake for the upper 6 GHz band, which is designed to operate with 200 MHz carriers, would ultimately lead to the same, or even worse, outcome for 6G that Europe is currently experiencing with respect to 5G.

31 Opinion on Long-term vision for the upper 6 GHz band, European Commission Radio Spectrum Policy Group, November 2025

32 See Global Spectrum Pricing, GSMA, 2025

33 The ITU minimum technical requirements to meet 5G performance requirements identify at least 100 MHz channel per operator

5. Policy recommendations

A key component of the European Commission's Digital Decade is the development of secure and sustainable digital infrastructure, including the aim for all populated areas and transport corridors to be covered by 5G. This study has shown that there are more than 500 spectrum licence renewals set to occur in Europe over the next 10 years, providing an opportunity for regulators to ease financial pressure on operators and stimulate greater investment in the sector. This will better enable countries to meet their Digital Decade targets and allow consumers and businesses to access mobile networks that are comparable to those in the leading 5G regions, including developed Asia Pacific, the GCC states, Greater China and North America.

Empirical evidence has clearly established that high spectrum costs reduce the ability of operators to invest in their networks, which results in lower network coverage and quality. Applying this evidence in Europe, where spectrum costs currently account for 8% of operator recurring revenues, regulators have the opportunity to reduce spectrum costs over the next 10 years and potentially unlock €24 billion in new investment, which could improve network quality by up to 23% and bring an additional €75 billion in additional GDP.

Given this evidence, a number of policy implications can be drawn. In particular, Europe's regulators should consider the following actions:

- **Prioritise enhancing certainty and investment incentives in renewal assessments.** Regulators should ensure spectrum renewals create the conditions for the industry to invest in networks, ensuring long-term certainty and viability of operations.

- **Simplify and optimise the renewal process by applying administrative extensions.** While well-designed auctions provide an important tool to assign spectrum when demand is greater than supply, particularly for new bands, existing bands have already been assigned through a competitive process. Another auction would create uncertainty that can be avoided through an administrative renewal, and any changes in the optimal distribution of existing bands can be achieved through spectrum trading.

- **Automatically renew licences with an indefinite duration.** An indefinite duration provides regulatory certainty for operators to invest in network expansion and modernisation on existing bands, removing the risk that their spectrum holdings will significantly change, and also allows them to amortise spectrum-related investments over a longer time period when the life of the asset is longer than the life of the licence. At a minimum, licences should have a duration of at least 40 years. To ensure that spectrum is assigned to the most efficient users over time, regulators should facilitate spectrum trading and leasing, which would be incentivised by the implementation of indefinite licences.

- **Do not set aside spectrum for a new entrant or for localised use.** Regulators should be very cautious about using renewals (and auctions of new bands) to promote a new entrant in the mobile market. Europe's past experience has highlighted the risk that a new entrant may not be sustainable in the long run, combined with the likelihood of artificially inflating spectrum costs (thereby reducing investment). Similarly, setting aside spectrum for local use has not been shown to produce any benefits in terms of enterprise digitalisation, but it has reduced quality on public mobile networks. Unless regulators are able to produce new and robust evidence to the contrary, they should avoid reserving or setting aside spectrum in IMT bands. Spectrum reservations would artificially reduce the spectrum available for mobile networks, therefore increasing the spectrum prices in auctions, reducing the efficiency of network deployments and impacting their coverage and quality

- **Renew licences well in advance of the licence expiry date.** It is important for regulators to provide operators with long-term regulatory certainty for licence renewals. Without this clarity, there will be a risk that operators could lose access to some of their existing spectrum. This would require a significant reconfiguration of networks and could result in a loss of customers and revenue, which will impact investment incentives. Furthermore, if there is a risk that an operator will need to pay a high price for spectrum renewal (or in an auction), it will need to reserve funds that could otherwise be invested in the network. Given that 2030 represents a key point at which the European Commission hopes to achieve its Digital Decade targets, as well as the date when 6G deployments are expected to begin, any uncertainty related to licence renewals in the 2025–2035 period could mean that Europe will fall further behind countries that have provided operators with long-term spectrum certainty.

- **Engage with the mobile industry to meet well-defined and achievable connectivity targets where they are needed.** Empirical evidence shows that higher returns on investment in Europe's mobile industry drives higher investment and network quality for consumers. Therefore, any reduction in spectrum costs would be reinvested back into the sector. However, regulators may prefer operators to provide a firm and measurable commitment to certain network investments if they reduce or remove fees for renewed spectrum. Mobile operators stand ready to engage in such discussions, as happened for example in France and the UK. It is important, however, that such commitments are economically and financially sustainable and can be easily measured and monitored. Alternatively, regulators can consider market-based approaches to meet obligations, such as reverse auctions, that are detached from licence renewals. If governments require coverage or service obligations beyond what is feasible with these tools, then public subsidies will be needed.

- **Ensure that mobile operators have at least 2 GHz of mid-band spectrum by 2030 to deploy 6G.** Given existing IMT assignments in Europe, which currently stand at around 1 GHz, the short-term priority should be to assign the full upper 6 GHz band for licensed mobile, as well as allowing high-power use by operators in the 3.8–4.2 GHz band. This will provide operators the spectrum needed to meet 5G demand, deploy 6G and promote investment by ensuring future spectrum costs are not artificially inflated as they have been in the past. If regulators use an auction when assigning new bands, they should set modest reserve prices, use auction formats without unnecessary complexity and ensure mobile operators have the opportunity to acquire the full spectrum they need.

Appendix: methodology

Scenario definition

We build spectrum cost scenarios based on licence-level data from the GSMA Intelligence Spectrum Navigator database. We assume different renewal pricing approaches as defined in the scenario assumptions table in Chapter 4. To calculate amortised cost of licences and benchmarks for unit prices, we rely on adjustment for the weighted average cost of capital (WACC).

Adjustment for the WACC reflects the time value of money when operators are required to pay upfront for a licence with a given duration. The WACC adjustment amortises the cost of a licence over its duration, taking into account the cost of capital required to make an upfront payment (or a given schedule of instalments).

The WACC-adjusted annualised payment is calculated using a formula converting the present value of a lump-sum payment into an equivalent annuity with payments over the duration of the licence.

Equation 1

Adjustment of upfront cost based on the cost of capital

$$\text{WACC adjusted annualised licence cost} = \frac{\text{Upfront cost}}{\dfrac{1 - \left(\dfrac{1}{1 + \text{WACC rate}}\right)^{\text{Duration in years}}}{\text{WACC rate}}}$$

Equation 2

Formula of spectrum-cost-to-revenue ratio

$$\text{Spectrum cost to recurring revenue ratio} = \frac{\text{WACC adjusted annual upfront cost of all active licences} + \text{Annual spectrum fees}}{\text{Annual recurring revenue}}$$

Hence, the present value (discounted value) of the annualised cost is equal to the present value of the lump sum.

We rely on the spectrum-cost-to-revenue ratio as a measure of the total cost of spectrum from all active licences owned by an operator. For each operator, we calculate the spectrum cost-to-revenue ratio as specified in Equation 2.

The WACC-adjusted annualised spectrum cost for each active licence is calculated as outlined above. The cost of licences that started or expired during a particular year is attributed in proportion to the number of days the licence remained active in a given year. For example, if a licence ended on the 100th day of the year, only 100/365 of the annualised cost of the licence was attributed to that year.

Annual recurring revenue historical data and projections have been sourced from the GSMA Intelligence database.[34] Recurring revenue is defined as revenue from mobile subscriptions, excluding other streams such as sales of devices.

34 https://www.gsmaintelligence.com/

Impact modelling

The impact model is a parameterised calculator tool incorporating inputs on spectrum cost and baseline economic projections. The baseline projections regarding key economic and mobile-sector projections are obtained from GSMA Intelligence and the IMF. We then use parameterised equations to estimate impacts, initially to calculate how a difference in spectrum cost will impact improvements to network quality, and in turn how changes to these will impact economic growth. We rely on the following key pieces of evidence. To measure the impact of spectrum cost on 5G rollout and network speeds, we parameterise the relationship between spectrum cost and network speeds based on the empirical relationship between spectrum cost and speeds estimated by GSMA Intelligence. To reflect the uncertainty on the magnitude of the effect we rely on a range of parameters, which varied depending on the econometric model and the measure of spectrum cost:

- Lower spectrum-cost-to-revenue ratio is associated with higher network speeds. We estimate a non-linear relationship, which evaluated at 7% cost-to-revenue ratio shows that halving of spectrum cost improves network speeds by 10%.
- Lower spectrum-cost-to-revenue ratio is associated with higher network speeds. We estimate a non-linear relationship, which evaluated at 7% cost-to-revenue ratio shows that 10 percentage points lower spectrum-cost-to-revenue ratio results in 8.4% higher network speeds.[35]
- Lower spectrum-cost-per-connection is associated with higher network speeds, with halving of spectrum cost per connection boosting speeds by 24%.[36]

We apply these impact parameters to the estimated cost-to-revenue ratios under different scenarios. For each scenario we obtain a percentage difference in network speeds relative to scenario 1 (very high cost).

In the last step, we estimate the impact of improved mobile speeds. There are a number of studies that demonstrate faster broadband speeds (for both fixed and mobile technologies) can drive improved macroeconomic outcomes.[37] For this study, we assume that a doubling of broadband speeds can contribute 0.3% to GDP growth. We calculate this effect on the basis of a difference in speeds in a given year in relation to scenario 1, our reference scenario. For example, in any given year, 10% higher speeds would translate into a boost to GDP level of . The baseline GDP forecast in monetary terms is based on the IMF WEO database, which provides forecasts of GDP up to 2030. To extend these forecasts to 2035, we extrapolate the last available year's growth rate. To calculate the impact on GDP in monetary terms, we apply the % increase in GDP to the baseline monetary GDP forecast. For example, if in a given country and year we estimated that higher speeds will boost GDP by 0.03% and the baseline GDP forecast for the country amounts to €1 trillion, the estimated monetary GDP boost amounts to 0.03%×€1 trillion=€300,000,000. We assume no compounding of the GDP impact over previous years – each year's impact is based on the estimated difference in speeds in the given year.

35 Global Spectrum Pricing, GSMA, 2025

36 Ibid.

37 See for example Does broadband speed really matter as a driver of economic growth? Investigating OECD countries, International Journal of Management and Network Economics 5 2, no. 4 (2012) 336-356, Rohman, Ibrahim Kholilul, and Erik Bohlin; The economic impact of mobile broadband speed, Telecommunications Policy 46, no. 5 (2022): 102351, Edquist, Harald; and; Quality of communications infrastructure, local structural transformation, and inequality, Journal of Economic Geography 24, no. 1 (2024): 117-144, Acosta, Camilo, and Luis Baldomero-Quintana.

A full list of papers is provided in Socioeconomic benefits of high-speed broadband availability and service adoption: A survey, Telecommunications Policy 48, no. 7 (2024), Wolfgang Briglauer, Jan Krämer and Nicole Palan

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