5G Observatory Biannual Report

Report of June 2024
(Situation as of 31 March 2024)

Study on "European 5G Observatory phase III" (CNECT/2021/OP/0008)

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NOTE

This is the 20th edition of an independent, biannual summary of developments in the deployment of 5G in the EU, assessing progress towards EU policy goals. Quarterly publications of the European 5G Observatory have been issued since September 2018, under a contract with the European Union and the opinions expressed are those of the contractor and do not represent the official position of the European Commission. Since 2021, the 5G Observatory is run by a consortium of three companies (the contractors) EY, PolicyTracker and LS telcom. Since March 2023 the Reports became biannual.

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List of Acronyms

Table 1: List of acronyms

Acronym	Definition
5G PPP	5G Infrastructure Public Private Partnership
AI	Artificial intelligence
AR	Augmented reality
AWS	Amazon Web Service
CAM	Connected and Automated Mobility
CBRS	Citizens Broadband Radio Service
CEF	Connecting Europe Facility
CEPT	European Conference of Postal and Telecommunications Administrations
CSPs	Communication service providers
D2D	Direct-to-device
DDPP	Digital Decade Policy Programme
DESI	Digital Economy and Society Index
DSS	Dynamic spectrum sharing
EECC	European Electronic Communications Code
EMF	Electromagnetic fields
ETNO	European Telecommunications Network Operators' Association
EU	European Union
FCC	Federal Communications Commission
GDP	Gross domestic product
GHz	Gigahertz
GSOA	Global Satellite Operators Association
GWh	Gigawatt-hour
IPEI-CIS	Important Project of Common European Interest – Cloud Infrastructure and Services
ITU	International Telecommunication Union
KPI	Key performance indicator
MEC	Mobile edge computing
MHz	Megahertz

MNO	Mobile network operator
MS	Member States
MWh	Megawatt-hour
NR	New Radio
NSA	Non-standalone
NTIA	National Telecommunications and Information Administration
NTN	Non-terrestrial networks
QoS	Quality of service
RAN	Radio access network
RSC	Radio Spectrum Committee
RSPG	Radio Spectrum Policy Group
SA	Standalone
SCS	Supplemental Coverage from Space
SNS JU	Smart Networks and Services Joint Undertaking
TB	Terrabyte
V2X	Vehicle-to-Everything
VR	Virtual reality
XR	Extended reality

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1. Latest developments

The current state of play in 5G bands authorisation indicates some progress in this respect compared to the last reporting period, most notably in the 700 MHz and 3.6 GHz bands, which have now been widely assigned across Member States (MSs), while the 26 GHz band has been authorised only in 12 MSs. As such, the authorisation of the 5G pioneer bands, which was supposed to have been completed in all EU Member States by end 2020[1] has not been completely fulfilled yet.

The most recent assignments have taken place in Austria, Bulgaria, and Latvia, with notable auctions in the 3.6 GHz, 700 MHz, 800 MHz, 1800 MHz and 26 GHz bands. There is also a continued strong interest in local spectrum assignment mechanisms across EU MSs, with recent developments in the Netherlands, France, Belgium, and Slovenia.

In terms of EU policy developments, the European Commission published a White Paper on digital infrastructure setting out future policy scenarios to accelerate the deployment and transition of digital infrastructures in Europe, highlighting the need for innovation, efficient investment, and secure networks. Initial reactions to the Commission's digital infrastructure White Paper have been generally positive. The feedback period for the White Paper remains open until 30 June 2024.

Publicly funded 5G initiatives continue to be of interest, with Nokia having announced a significant investment in microelectronics and communications technology in Germany (€360 million) and the European Commission having selected additional projects in the context of the Connecting Europe Facility (CEF Digital) programme.

As far as main commercial developments are concerned, we have observed that the main focus remains on the rollout and expansion of basic 5G networks across the EU, with various operators announcing new 5G coverage milestones. There has also been a continued effort by EU mobile operators to launch more 5G standalone (5G SA) services across the EU, although the deployment of SA services remains limited, and there is little transparency about the extent of operator rollouts.

Major international developments confirm the continued global investment in 5G networks. The ITU reports that 40% of the global population is now covered by 5G (including both SA and NSA 5G coverage). The GSMA predicts that, by 2030, 5G will make up over half of all mobile connections and become the dominant mobile technology. There is also growing interest in the development of non-terrestrial 5G networks (NTN).

1.1.5G spectrum awards

1.1.1. National spectrum awards

Current spectrum assignment status

The 700 MHz and 3.6 GHz bands have now been widely assigned across Member States (MSs), suggesting good progress in the assignment of these two vital 5G pioneer bands, albeit still short of the deadline of end 2020. The 700 MHz band has now been assigned in 25 out of 27 MSs, while the 3.6 GHz band has been awarded in 26 out of 27 MSs. The Netherlands is the only country that has not yet assigned the 3.6 GHz band. However, its auction of the band is will begin on June 25, 2024 and spectrum licences are due to be made available in August this year.

The situation with the 26 GHz band looks different, as the band (at least 1 GHz of spectrum) has not been widely authorised across MSs. In particular, only 12 MSs have authorised spectrum within this band so far, and only Austria did so since the publication of the last 5G Observatory Report in October 2023. This limited interest in the 26 GHz band is mainly attributed to the lack of demand from the mobile industry, which has pointed to the lack of compatible devices. Overall, the 5G pioneer bands are now 73% assigned across the EU.

[1] https://eur-lex.europa.eu/EN/legal-content/summary/european-electronic-communications-code.html

Recent assignments

Over the past six months, three national spectrum auctions have taken place in the EU; in Austria, Bulgaria, and Latvia.

In November 2023, Latvia's Public Utilities Commission (SPRK) auctioned two 25 MHz blocks in the 3.6 GHz band, increasing the total amount of spectrum available in this important 5G pioneer band by 50 MHz. Latvijas Mobilais Telefons (LMT) paid €275,000 for 3750-3775 MHz block. Tele2 paid an equal amount for the 3775-3800 MHz block, resulting in a total auction revenue of €550,000.

In December 2023, Bulgaria held a spectrum award for the 700 MHz and 800 MHz bands. All three winning bidders A1, Vivacom and Yettel were awarded in total two blocks of 2 x 10 MHz. A1 won frequencies in 703-713 MHz/758-768 MHz and 832-842 MHz/791-801 MHz bands. Meanwhile, Vivacom received frequencies in 713-723 MHz/768-778 MHz and 842-852 MHz/801- 811 MHz bands, and Yettel was awarded 723-733 MHz/778-788 MHz and 852-862/811-821 MHz bands.

In March 2024, Austria finished its auction of the 26 GHz band (1400 MHz in total) and a leftover portion of spectrum in the 3.6 GHz band that remained unsold in the country's previous 5G spectrum auction. A1 Telekom and T-Mobile won two 200 MHz blocks in the 26 GHz band, both paying around €4.6m, while Hutchinson won three blocks for €6.9m. Also in March 2024, Latvia finalised an auction in the 1800 MHz band.

1.1.2. Local spectrum awards

There has been a continued strong interest in local spectrum assignment procedures across EU MSs over the past six months.

In October 2023, the Netherlands began accepting requests for local spectrum licences in the 3.6 GHz band. In particular, the country's Ministry of Economics and Climate (EKZ) decided to allow applications for local licences in the lower and upper portion of the 3.6 GHz band, specifically the 3400–3450 MHz and 3750-3800 MHz ranges.

In December 2023, France decided to extend its private spectrum licence trial in the 3.8-4.0 GHz band. Licences awarded will now be valid until the end of 2024, extending the regime for another year. Furthermore, in January 2024, Belgium announced plans to make private spectrum licences available in the 3.8-4.2 GHz band, further cementing the 3.8-4.2 GHz band as a mainstream private 5G network band across Europe.

In March 2024, Slovenia held an unusual auction of private network licences in the 2.3 GHz and 3.6 GHz bands for local municipalities.

1.2. Public developments

1.2.1. EU policy developments

In December 2023, the European Commission published the results of its consultation on the future of electronic communications. The Commission highlighted three main takeaways from this consultation: the need for innovation and efficient investment, the need to leverage the single market to boost investment, and the need to increase the security of networks.

Following this consultation, in February 2024, the European Commission adopted its digital infrastructure White Paper. The White Paper outlines several ideas on how to foster innovation, security and resilience of digital infrastructures in Europe. The extensive Paper was generally well received, particularly by the mobile industry, including the GSMA and ETNO. More comprehensive responses to all of the issues raised in the Paper are not yet available; however, more precise orientations are expected as soon as the stakeholders "feedback" period will be closed on 30 June 2024. It is anticipated that the results of this large scale reflection conducted by the Commission, in cooperation with all stakeholders, will provide a solid basis to enable the next Commission to consider major policy reforms, possibly leading to a Digital Network Act as referred to by Commissioner Breton.

Pillar I of the White Paper envisages the creation of a "Connected Collaborative Computing" (3C) Network to set up integrated infrastructures for telco cloud and edge. It notes that computing is becoming more distributed, taking place both on devices, inside traditional data centres, and at the edge (i.e., closer to the end-user). The

White Paper calls for chip manufacturers, electronic communications network equipment providers, and edge and cloud service providers to collaborate closely to facilitate the 3C network and embrace this paradigm shift to ensure economic security and competitiveness. The White Paper suggests several scenarios for policy action to foster the 3C Network. These include large-scale pilots to set up end-to-end integrated infrastructures and platforms for telco cloud and edge, the possibility of a new infrastructure-focussed IPCEI, and different options in order to frame the massive investments required into a simplified and coordinated support framework for a truly digital single market drawing on European and national, public and private investments.

Pillar II of the White Paper concerns the completion of the Digital Single Market by addressing challenges that exist for the convergence of electronic communications networks across the EU. The White Paper argues that barriers to core network centralisation need to be addressed, and the emergence of cloud in telecommunications should be facilitated. The White Paper also calls for a change in radio spectrum policy to better harmonise the release and licencing of radio spectrum for mobile services across MSs.

Finally, Pillar III of the White Paper aims to ensure secure and resilient digital infrastructures for Europe. This involves securing European digital infrastructure from advances in quantum computing and threats towards critical submarine cable infrastructures. The White Paper considers several scenarios, including the promotion of advanced R&I activities across the EU in support of new fibre and cable technologies, a review of available instruments and procurement to leverage private investment to support Cable Projects of European Interest, and the possibility of an equity fund. A joint EU governance system on submarine cable infrastructures is also considered.

The Commission also published recently its second State of the Digital Decade report (June 2024).

1.2.2. Public 5G funding initiatives

The interest in public funding for 5G projects persists. However, there has been a slight decrease in the number of funding initiatives announced by Member States since the last 5G Observatory report of October 2023.

Nokia announced in January 2024 that it would invest €360 million in microelectronics and communications technology in Germany. The project is funded in part by the German Federal Ministry of Economics and Climate Protection (BMWK) and the German states of Baden-Württemberg and Bavaria.

In January 2024, the European Commission selected the winners of its second call under the Connecting Europe Facility (CEF Digital) programme. Agreements were signed with a total of 37 projects that plan deploying 5G infrastructure both for local communities and for major European transport corridors.

In recent months, several previously selected CEF-funded projects have begun deployment, including Telia's 5G trials in Sweden and Cellnex's cross-border project in the Czech Republic and Poland.

In November 2023, the Smart Networks and Services Joint Undertaking (SNS JU) announced the 27 winners of its second call for proposals. The projects cover a wide array of 6G domains, including 6G system architecture, wireless communication technologies, signal processing, infrastructure technologies, experimental pan-EU federated infrastructure, pilots and verticals.

1.3. Commercial developments

1.3.1. 5G coverage developments

The rollout and expansion of 5G networks across the EU have progressed over the past six months. Various operators have announced new 5G coverage milestones in recent months.

In October 2023, Drei Austria announced that its 5G network reached 85% of the population, following a major investment initiative by the company. Tele2 Latvia announced in November 2023 that its 5G network covered 63% of the population.

German MNO Vodafone has focused on improving coverage near railways. The operator announced in November 2023 that it provided 5G SA services to over 50% of the country's railway lines following a deal with Deutsche Bahn.

While 5G population coverage has increased across the EU, previous reports indicated a lack of coverage in the important mid-band frequencies like 3.6 GHz. However, since the last 5G Observatory report, the coverage of 5G in mid-band spectrum has been improved. In particular, Ericsson's latest mobility report (November 2023) estimates that Europe has achieved mid-band coverage of 25%, which is a 10% increase since the last estimate.

1.3.2. 5G standalone progress

There is a continued effort by EU mobile operators to launch 5G standalone (5G SA) services across the EU. 5G SA brings several benefits, including increased performance, improved end-user battery life and the enablement of new features such as 5G network slicing.

Recent announcements include NOS Portugal announcing in December 2023 that it would launch its 5G SA network. In January 2024, Three Ireland began trialling 5G SA with Ericsson.

While many operators have now launched 5G SA configurations, measuring the overall progress of 5G SA across the EU presents a challenge for the 5G Observatory due to the reliance on public announcements and the lack of centralised data on the subject. It can also be unclear how widespread 5G SA is, when operators launch and whether it makes up a significant portion of their overall network.

The GSMA's January 2024 report on global 5G SA progress indicates that most EU MSs feature at least one operator investing in public 5G SA networks, yet the extent of their investments remains unclear.

1.4. Major international developments

Globally, we are observing continued investment in 5G networks. A new ITU report published in November 2023 notes that 40% of the global population is now covered by 5G. This was the first time the ITU had published data relating to 5G mobile coverage, revealing significant growth in the take-up of the mobile technology globally.

The mobile industry body GSMA published a report which predicted that by 2030, 5G will make up over half of all mobile connections and become the dominant mobile technology.

Global investment in 5G is not limited to terrestrial networks, as there is a growing interest in combining satellite and mobile functions in the development of non-terrestrial 5G networks (NTN). More partnerships have been announced in this area, and it is expected to grow in the coming years.

In February 2024, the GSMA announced it would work with the Global Satellite Operators Association (GSOA) to develop technologies that blend satellite connectivity with terrestrial mobile connectivity.

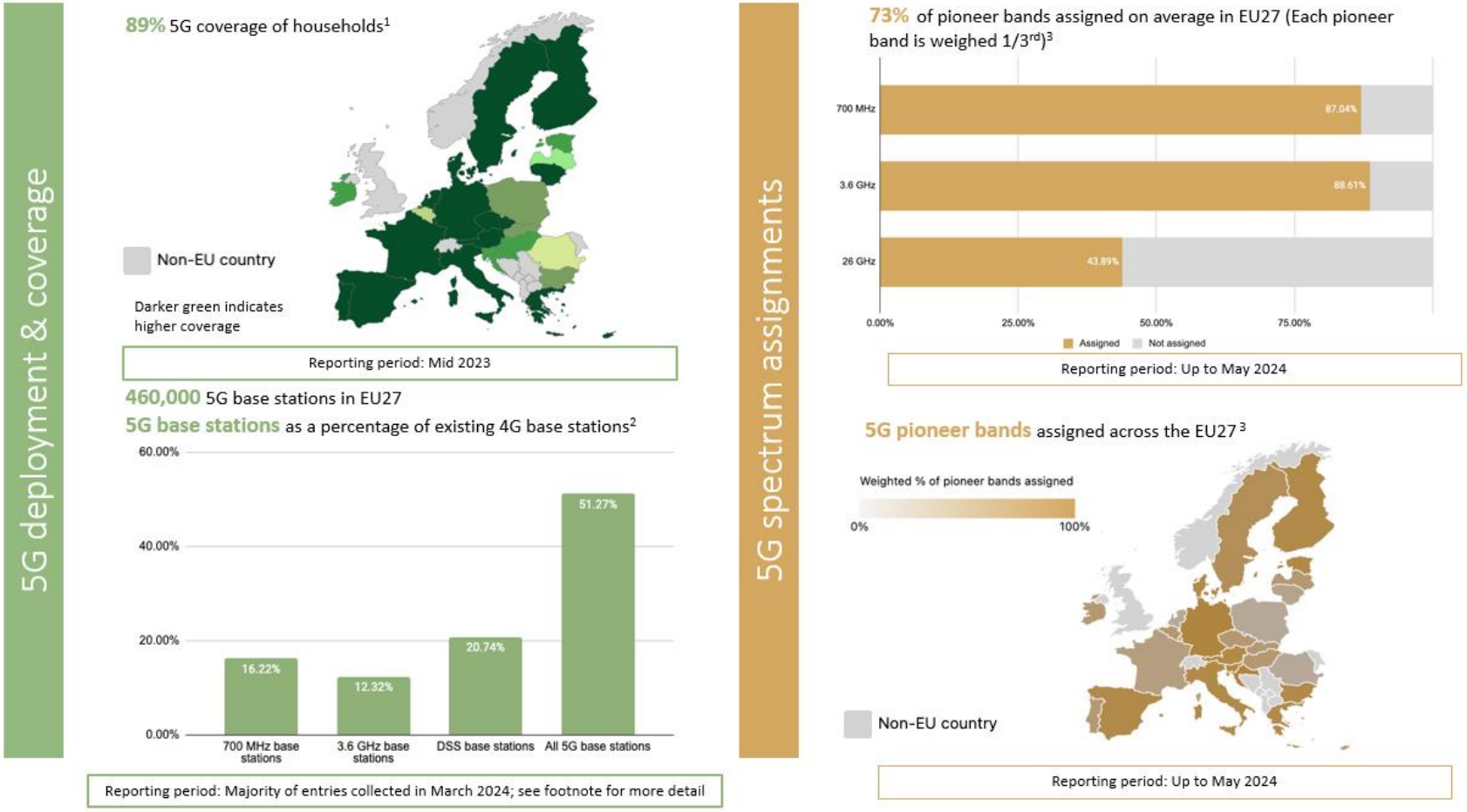
In March 2024, the United States became the first country in the world to develop a regulatory framework for satellite direct-to-device (D2D) connectivity. The Supplemental Coverage From Space (SCS) framework of the US Federal Communications Commission will introduce a footnote in the US frequency allocation table that allows some terrestrial spectrum bands to be re-used by satellite operators.

2. 5G scoreboard

2.1. EU-27 progress so far

The 5G scoreboard summarises the status of 5G commercial launches, spectrum assignments, and of the 5G corridors for Connected and Automated Mobility in EU-27:

- All EU countries now have commercial 5G service available at least in a part of the country (please see the section on Latest Commercial Developments).
- A total of close to 460,000 5G base stations are now active in the EU.
- The most common type of 5G base station makes use of 4G bands in a Dynamic Spectrum Sharing (DSS) configuration.
- Approximately 89% of the EU's population was covered by at least one basic 5G network in mid 2023.

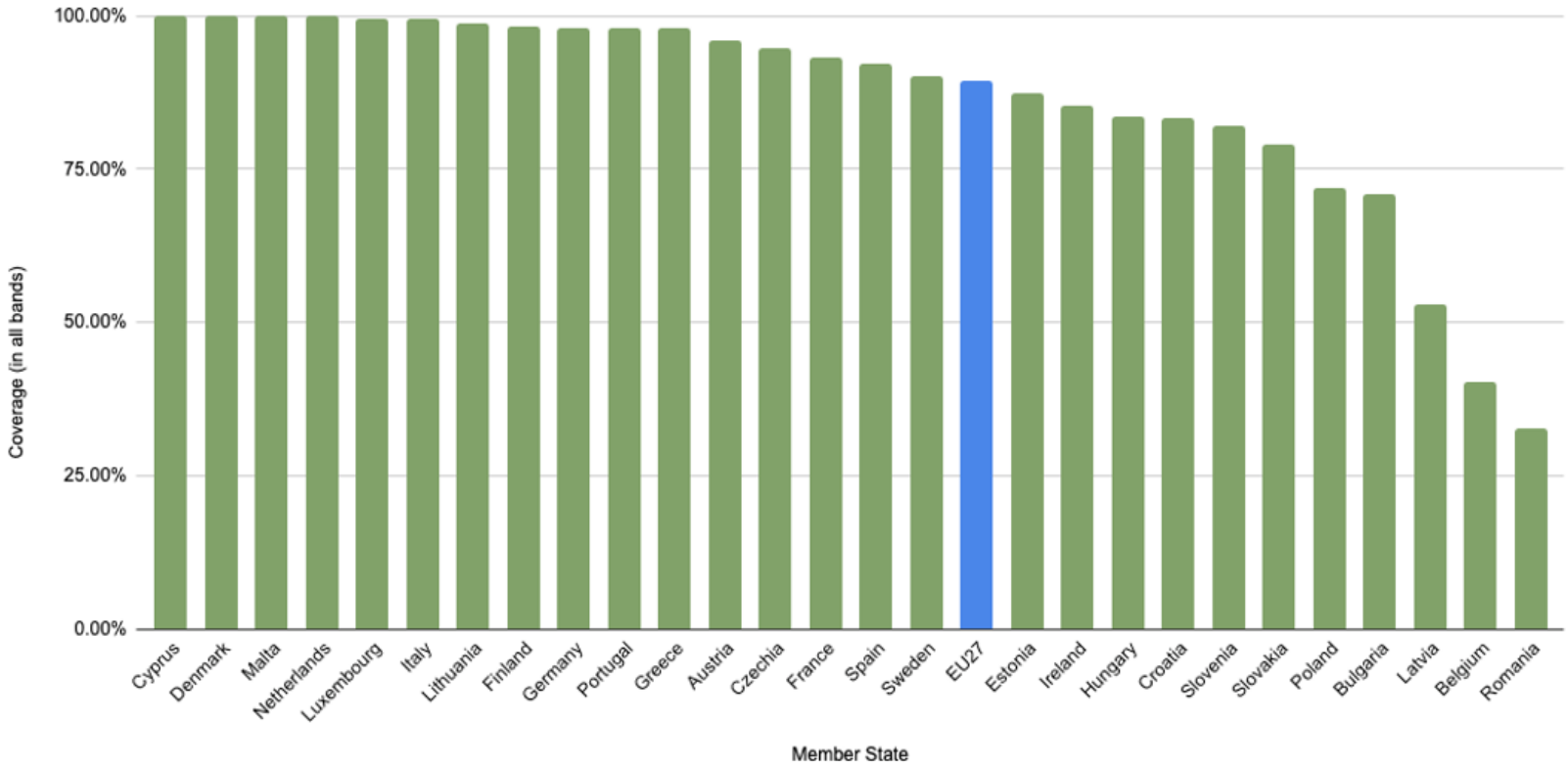


(Source: **Household 5G coverage**: Omdia/Point Topic - Broadband Coverage in Europe 2023, study carried out for the European Commission. Household coverage data is collected through a survey of national regulatory authorities and operators at a regional NUTS3 level; **Base station data** is collected by the European Commission via the Digital Decade Committee through a survey of National Regulatory Authorities and collated by the 5G Observatory consortium; and supplemented with new data from the PolicyTracker Spectrum Database and Auction Tracker; **Spectrum data** is collected from the annual DESI index and supplemented with new data from the PolicyTracker Spectrum Database and Auction Tracker.)

1. EU 5G Coverage: 5G Coverage in all bands is a general indicator that does not presume any particular quality of service measures. All 5G coverage is included, including that using DSS. Location covered by at least one operator.
2. EU 5G Base stations: For some EU countries, only the total number of 5G base stations is known. This means the true total number of base stations in the EU in 700 MHz, 3.6 GHz or DSS bands may be higher. Additionally, some countries use bands that are not included in this chart and do no operate using a DSS configuration. For reporting periods see footnote 23.
3. EU 5G Spectrum: Countries need to assign 60 MHz in 700 MHz; 400 MHz in 3.6 GHz and at least 1000 MHz in 26 GHz to receive a 100% score.

EU 5G progress

5G coverage of households (in all spectrum bands)[1]



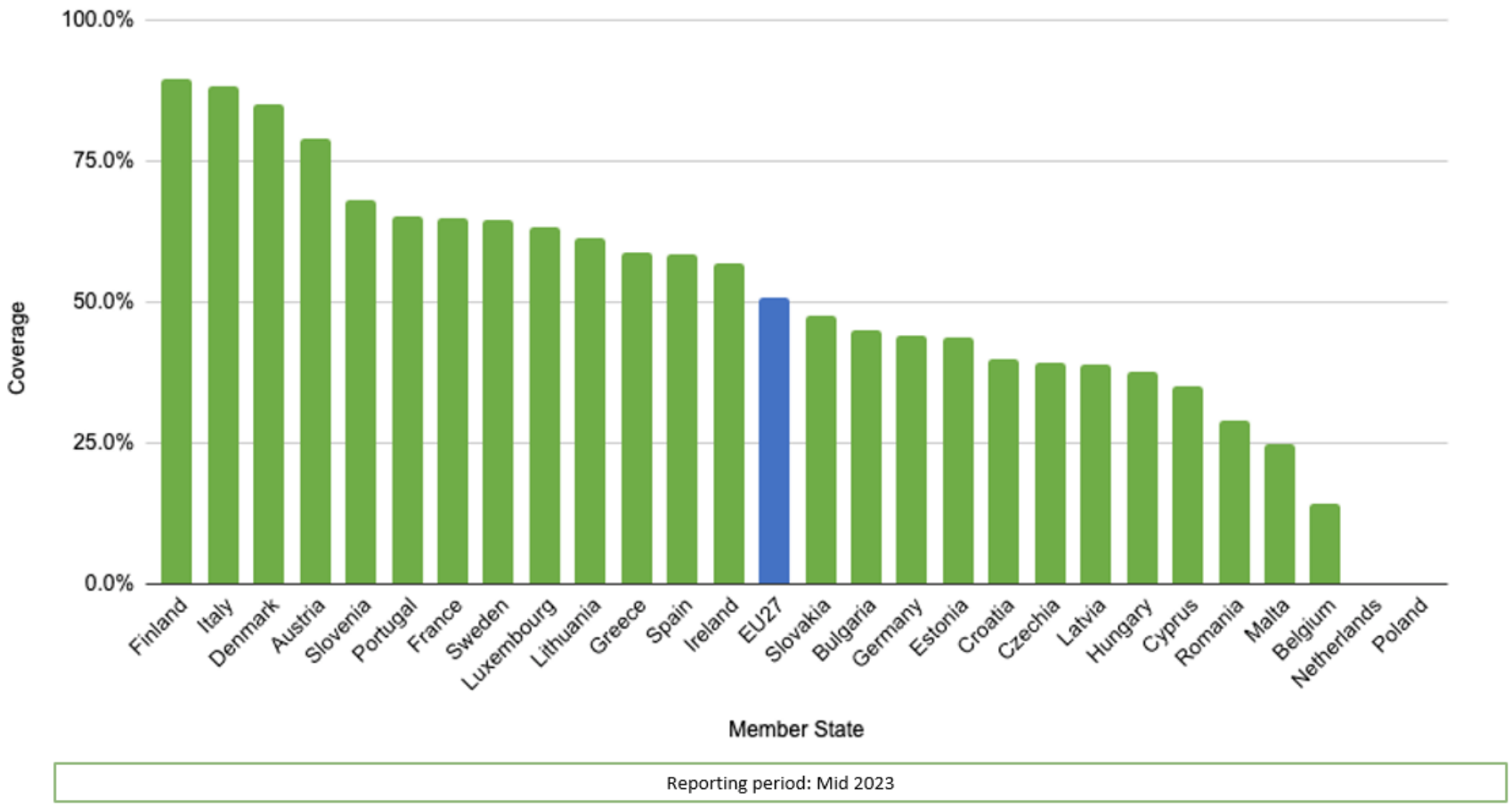
Reporting period: Mid 2023

(Source: Omdia/Point Topic: Broadband Coverage in Europe 2023, study carried out for the European Commission. Household coverage data is collected through a survey of National Regulatory Authorities and operators on a regional, NUTS3 level.)

1- EU 5G Coverage: 5G Coverage in all bands is a general indicator that does not presume any particular quality of service measures. All 5G coverage is included, including that using DSS. Location covered by at least one operator.

EU 5G progress

5G coverage in the 3.6 GHz band

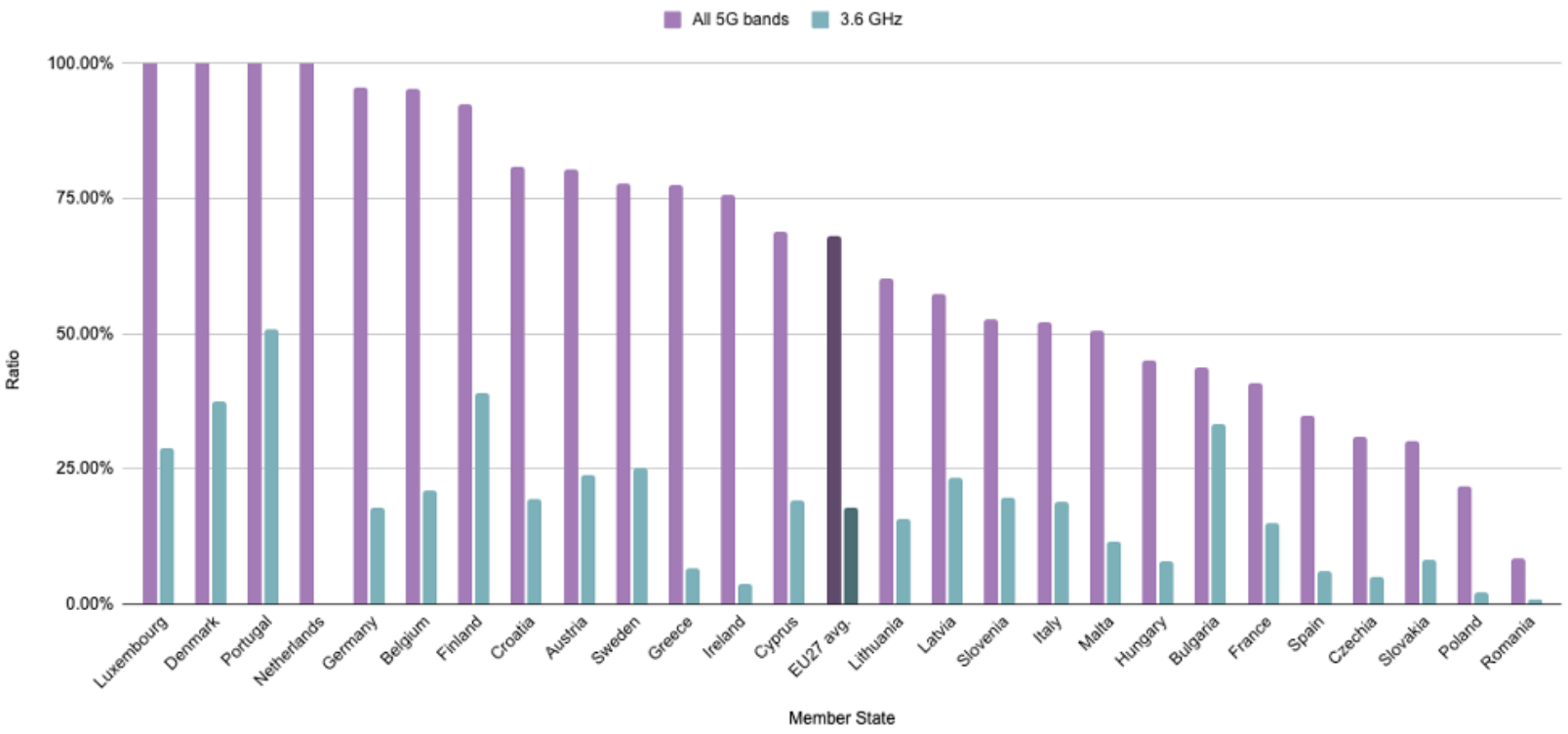


Reporting period: Mid 2023

(Source: Omdia/Point Topic: Broadband Coverage in Europe 2023, study carried out for the European Commission. Household coverage data is collected through a survey of National Regulatory Authorities and operators on a regional, NUTS3 level.)

EU 5G progress

5G base stations as a percentage of existing 4G base stations in Member States[2]



Reporting period: Majority of entries collected in March 2024; see footnote for more detail

(Source: Base station data is collected by the European Commission via the Digital Decade Committee through a survey of National Regulatory Authorities and collated by the 5G Observatory consortium)

2 – Average: The figure for EU27 represents an average of all EU countries; EU 5G Base stations: For some EU countries, only the total number of 5G base stations is known. This means the true total number of base stations in the EU in 700 MHz, 3.6 GHz or DSS bands may be higher. Additionally, some countries use bands that are not included in this chart and do no operate using a DSS configuration. For reporting periods see footnote 23.

5G Corridors

CEF-Digital funded 5G corridor projects: Call 1 & 2

Study projects

5G Brno – Bratislava
Brno (CZ) to Bratislava (SK)
~ 140 km

5G MELUSINA
Luxembourg (LU) to Metz (FR)
~ 70 km

5G on Track
Mulhouse (FR) to Karlsruhe (DE)
~ 200 km

5GCarolina
Prague (CZ) to Munich (DE)
~ 70 km

5G Gail
Udine (IT) to Villach (AT)
~ 200 km

5G Estuary
Antwerp (BE) to Vlissingen (NL)
~ 260 km

Latest 5GS
Tallin (EE) to Vilnius (LT)
~ 670 km

EUMOB
Bordeaux (FR) to Bilbao (ES)
Perpignan (FR) to Barcelona (ES)
~ 9500 km

5G ADRIA
Koper (SI) to Rijeka (HR)
~ 378 km

5G FREJUS
Fourneaux (FR) to Bardonechchia (IT)
~ 26.5 km

5G HSL EUROLINK
Paris (FR) to Brussels (BE)
~ 468 km

5G-SITACOR
Udine (IT) to Postojna (SI)
~ 275 km

Works projects

5G SEAGUL
Sofia (BG) to Velestino (EL)
~ 473 km

MEDCOR5G
Barcelona (ES) to Montpellier (FR)
~ 548 km

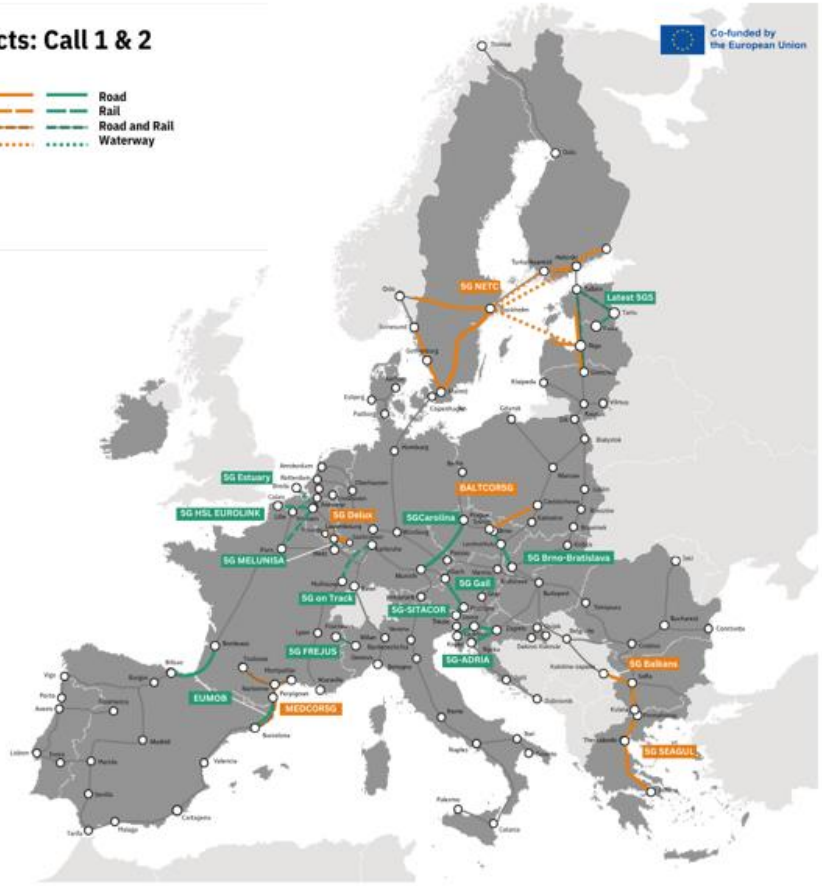
5G DeLux
Frisange (LU) to Saarbrucken (DE)
~ 98 km

5G NETC
Malmö (SE) to Helsinki (FI)
to Riga (LV)
~ 3354 km

5G Balkans
Sofia (BG) to Dimitrovgrad (RS)
~ 135 km

BALTCOR5G
Czestochowa (PL) to Ostrava/Svinov (CZ)
~ 147 km

Road
Rail
Road and Rail
Waterway



6 5G cross border works
12 5G cross border studies

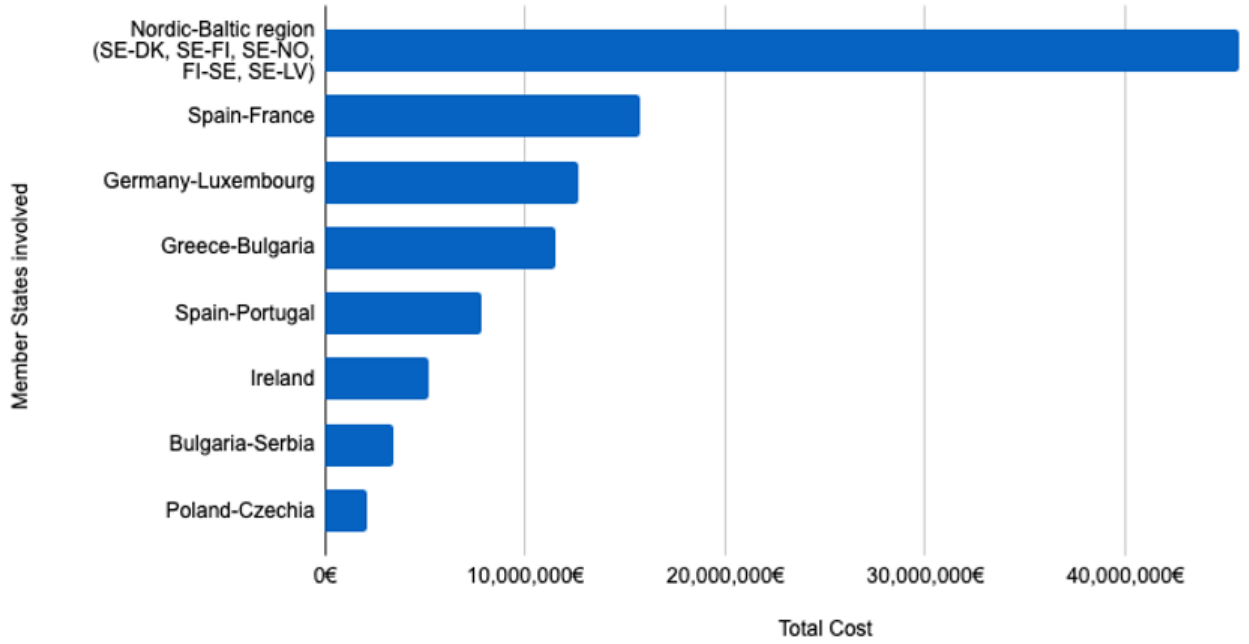
Reporting period: May 2024

(Source: European Commission)

5G Corridors

Committed investment

in 5G cross-border deployment



Reporting period: May 2024

(Source: European Commission data collated by 5G Observatory Consortium)

2.2.International developments

The international version of the scoreboard details the current status of 5G commercial launches and spectrum plans worldwide, including metrics such as "5G base stations per 100,000 inhabitants", which represents the extent of deployment of 5G in each country. The following developments can be highlighted:[2]

- South Korea has the highest number of 5G base stations per 100,000 inhabitants: around six times more than the EU. Meanwhile, China has the second most 5G base stations per 100,000 inhabitants.
- China leads in the number of 5G subscribers, with over 59,690 subscribers per 100,000 inhabitants. South Korea is a close second at 57,915 subscribers per 100,000 inhabitants.
- The United States has awarded the largest amount of high-band spectrum in the mmWave range (26-28 GHz), with a total of 4950 MHz assigned to operators. Following a recent decision to revoke licences, South Korea has only assigned 800 MHz in the band.
- The largest percentage of 5G pioneer bands spectrum already awarded in Europe is located in the mid-band (3.6 GHz), followed by the low band of 700 MHz.

[2] Please notice that there may be discrepancies between the reported figures, as the method for calculating the number of base stations is not standardised between regions.

5G rollout

Comparison of 5G rollout in international markets[4, 5]

	China	South Korea	Japan	USA	EU
Approximate number of 5G base stations*	3,500,000	307,000	146,000	175,000	460,000
Total country population	1,425,700,000	51,800,000	123,300,000	340,000,000	448,400,000
5G base stations per 100,000 inhabitants	245	593	118	51	103
Indicative 5G subscribers*	851,000,000	30,000,000	26,000,000	317,000,000	223,000,000
Indicative 5G subscribers per 100,000 inhabitants	59,690	57,915	21,087	54,750	29,893

Reporting period: 5G base station data collected between July 2022 – May 2024; Population data collected May 2024; 5G subscriber data collected between July 2022-May 2024

(Source: **5G base station data:** USA: Estimate based on Steel in the Air and Wireless Infrastructure Association Report; South Korea: Mk.co.kr citing Ministry data; Japan: Xtech news article citing Ericsson study; China: Ministry of Industry and Information Technology (MIIT). **Population data:** UN via WorldOMeters. **5G subscribers:** USA: Ericsson Mobility Report, includes all of North America; South Korea: Omdia 5G in South Korea 2023 Report; Japan: Omdia Japan forecast; China: Ministry of Industry and Information Technology (MIIT))

4 - International 5G Base stations: This figure is approximate. There may be discrepancies between the reported figures, as the method for calculating the number of base stations is not standardised between regions. The US number of 5G base stations is an estimate based on available information.

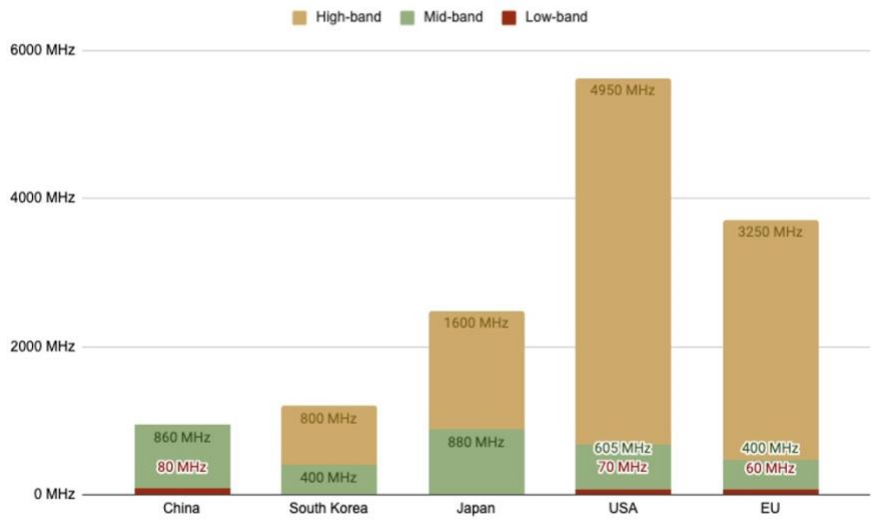
5 - International 5G Subscribers: The US number of 5G subscribers also includes all of North America. 5G Subscriber data in the EU includes all of Western/ Eastern Europe.

5G spectrum

Main bands authorised for 5G in international markets[6]

Country	Low-band (<1 GHz)	Mid-band (1 - 6 GHz)	High-band (>6 GHz)
China	700 MHz	2.6 GHz 3.6 GHz 4.9 GHz	-
South Korea	700 MHz	3.6 GHz	28 GHz
Japan	-	3.6 GHz 3.7 GHz 4 GHz 4.5 GHz	28 GHz
USA	600 MHz	2.5 GHz 3.45 - 3.55GHz 3.5 - 3.7 GHz 3.7 - 3.98 GHz	24 GHz 28 GHz 39 GHz 47 GHz
EU	700 MHz	3.6 GHz	26 GHz

Authorised 5G spectrum in international markets[6]



Reporting period: Up to May 2024

(Source: The PolicyTracker Spectrum Database & FCC 2022 Communications Marketplace Report)

6 - **International 5G Spectrum**: USA data shows all spectrum made available to mobile operators by the FCC. Not all of this spectrum will have been sold to operators so the final amount of spectrum assigned to operators may be slightly lower. For the **EU, spectrum assignments** differ among EU MSs. Because of this, the number used in the scoreboard shows how much spectrum has been harmonised at an EU-level. Some individual countries may have more spectrum assigned for 5G, while some may have less.

3. Progress against monitored targets and strategic implications

The table below presents major strategic implications referring to the overall performance of EU-27 against relevant 5G-related targets. These targets to be monitored in all European 5G Observatory reports have been sourced from EU policy, including the 5G Action Plan,[3] the Digital Decade Policy Programme (DDPP),[4] and the EU 5G Cybersecurity Toolbox.[5] This monitoring exercise will be the basis for a full strategic progress assessment, including relevant roadmaps, to be included in the final report.

[3] https://digital-strategy.ec.europa.eu/en/library/communication-5g-europe-action-plan-and-accompanying-staff-working-document

[4] https://digital-strategy.ec.europa.eu/en/policies/europes-digital-decade; Decision (EU) 2022/2481 of the European Parliament and of the Council of 14 December 2022 establishing the Digital Decade Policy Programme 2030, OJ L 323, 19.12.2022.

[5] https://digital-strategy.ec.europa.eu/en/library/eu-toolbox-5g-security

Table 2: Progress against monitored targets and strategic implications

Targets: 5G AP; Digital Decade; Cybersecurity Toolbox	Performance/status	Bottlenecks identified	Solution/recommendation
All populated areas covered by next-generation wireless high-speed networks with performance at least equivalent to that of 5G.	According to the latest DESI indicators based on the data collected by Omdia/Point Topic[6], the estimated overall 5G coverage in the EU is 89%.[7] With regards to historical data, the baseline trajectory of 5G coverage in the EU was set to reach 97% by the end of 2023 and 99% by the end of 2024 in the European Commission's Communication establishing the Union-level projected trajectories for the digital targets from September 2023.[8]	According to a study by WIK Consult on the investment and funding needs to reach the Digital Decade connectivity targets, a further €33.5 bn of investment is needed for the full coverage of 'full 5G service' in the EU. Meanwhile, providing 'basic 5G service' will entail limited additional investment.[9]	The European Commission has continued to provide funding for digital connectivity, including through the Connecting Europe Facility to strengthen cross-border infrastructures, the Recovery and Resilience Facility,and the Digital Europe Programme.[10] Member States have claimed about €13.6 bn of the Resilience and Recovery Fund in order to speed up the deployment of more energy efficient fixed and 5G broadband networks. However, following the study by WIK Consult, EU funds alone would not be adequate to cover the connectivity gap, and supplementary national and regional, as well as private funding would, thus, be needed.[11] Nevertheless, the current key performance indicator (KPI) used to measure the 5G targets of the Digital Decade only encompasses the percentage of households covered by at least one 5G network regardless of the spectrum band used. As such, the KPI does not specify further the quality or the extent of the performance of the 5G network (both for regular consumers and professional users). Consequently, this may lead to superficial or quasi-complete announcement of 5G coverage. In parallel with the introduction of more 5G indicators in the DESI (i.e. 5G in the 3.4 – 3.8 GHz band, 5G with 80 MHz bandwidth and 5G in the 3.4 – 3.8 GHz band or 80 MHz bandwidth), the KPI can move towards a more layered approach to reflect the different levels of quality of services to be expected for future use cases, instead of a single population coverage indicator.

[6] Since 2023, and in line with the Digital Decade Policy Programme 2030, the DESI indicators are integrated into the State of the Digital Decade report and used to monitor progress towards the digital targets.
[7] DESI 2024
[8] https://digital-strategy.ec.europa.eu/en/library/communication-establishing-union-level-projected-trajectories-digital-targets
[9] Full coverage of 'basic 5G service' or the upgrading of existing 4G base stations and operating 5G core network on top is estimated to entail a further €11.5 of investment. High quality or 'full 5G service' requires the installation of more base stations and small cells to enable wider bandwidths and more reliable connectivity. Source: https://digital-strategy.ec.europa.eu/en/library/investment-and-funding-needs-digital-decade-connectivity-targets
[10] https://digital-strategy.ec.europa.eu/en/activities/digital-programme
[11] https://digital-strategy.ec.europa.eu/en/library/investment-and-funding-needs-digital-decade-connectivity-targets

Targets: 5G AP; Digital Decade; Cybersecurity Toolbox	Performance/status	Bottlenecks identified	Solution/recommendation
Digital technologies, including 5G at the core of new products, new manufacturing processes and new business models	The rollout of private local 5G networks is growing across the EU, with more than 20 new deployments identified by the Observatory team since the last 5G Observatory report. Germany leads in terms of the number of identified deployments, while Belgium, Italy, and Spain, among others, continue with the trend observed in the previous period in private 5G network deployment. 5G verticals seem to be particularly developed in ports, for instance, in Belgium, Estonia, Germany and Spain. Meanwhile, 5G verticals are still at an earlier phase in other industries (e.g. healthcare, transport), and most vertical industry trials are occurring within private networks.	The lack of consensus on spectrum policies for private local networks can be a potential bottleneck. 5G verticals can either use spectrum already assigned to mobile operators or rely on dedicated spectrum licences issued by governments. MSs with a higher number of deployments, such as France and Germany, are benefiting from this dedicated 5G spectrum licences for private networks, while other MSs may not have the same licensing model available. Similarly, an increasing number of MSs have designated a dedicated spectrum for 5G verticals, although the exact portions of the spectrum used for these licences vary depending on standardisation efforts. For example, Germany offers the upper part of the 3.6 GHz band (3.7-3.8 GHz), while France is awarding licences in the 3.8-4.0 GHz.	Recommendations on the optimal licensing regime for local 5G authorisation regimes could help harmonise deployment and cross-border 5G projects. Regarding spectrum consistency, the European Commission published a mandate to the CEPT to develop technical conditions regarding the shared use of the 3.8-4.2 GHz band for wireless broadband systems providing local-area network connectivity in December 2021.[12] The study is still ongoing but nearing completion and will feed into the mandate to harmonise the 3.8-4.2 GHz band to help resolve the lack of spectrum consistency.
Authorising 5G spectrum bands	On average, 73% of pioneer bands have now been assigned in the EU-27. The 3.6 GHz band remains the most widely assigned one, with 26 out of 27 MSs having assigned at least 50% of the targeted spectrum in this band. The 700 MHz band is still the second most popular band, which has been assigned by 25 out of 27 MSs, with Bulgaria being the latest addition. The 26 GHz remains the least popular band, which has only been assigned at least 50% of the targeted spectrum in 12 MSs following Austria's auction of the band.	There is a lack of demand for the 26 GHz band in Europe. Spectrum assignments may differ amongst EU MSs. Consequently, a harmonised approach to spectrum sharing for local networks needs to be further developed.	Specifically for the 26 GHz band, there have been differences in the way the band has been made available, suggesting there is no *"universal formula"*. Most approaches, such as Germany's local licenses or Finland's licenses, take into account the use of the band for industrial applications and 5G verticals.[13] The identification of additional band/capacity for 5G should be initiated in a timely fashion to anticipate the expected growing business demand. The RSPP 2.0 legislative initiative to update the previous programme was expected in Q3 2023, for which the promotion of spectrum sharing, a better harmonisation of spectrum bands and the continuous development of technologies relying on the use of spectrum were recommended to be the focus of the new spectrum strategies.[14] Regarding local 5G networks, the European Commission has mandated CEPT to assess technical conditions for the

[12] https://digital-strategy.ec.europa.eu/en/library/radio-spectrum-cept-mandates

[13] From a technical perspective this is very much a band used to serve congestion in high-capacity density networks as well which implies the need for a balanced approach.

[14] https://www.europarl.europa.eu/legislative-train/carriage/new-radio-spectrum-policy-programme/report?sid=7801

Targets: 5G AP; Digital Decade; Cybersecurity Toolbox	Performance/status	Bottlenecks identified	Solution/recommendation
			3.8-4.2 GHz band, for which the study was scheduled to conclude in March 2024. This mandate may help resolve the existing lack of spectrum consistency.[15]
Promoting pan-European multi-stakeholder trials[16]/ Developing Pan-European deployment of 5G corridors	Twelve pan-EU network of 5G cross-border corridors have been established to accommodate live tests of 5G infrastructure to enable Cooperative Connected and Automated Mobility (CCAM).[17] In addition, at least eight Member States refer to the European deployment of 5G corridors along TEN-T networks in the interest of Single Market and cohesion in their recovery plans.[18] After the launch of 15 corridor deployment projects (seven works and eight inception studies) selected under the first CEF Digital call in 2022, the second call followed with the selection of seven projects, consisting of three work projects and eight studies to enable Connected and Automated Mobility (CAM) along transport corridors as of January 2024.[19]	At the moment, 19 MSs are involved in the existing 12 5G cross-border corridor trials, while a total of 21 MSs are involved in corridor deployment work projects and studies funded under the first and second CEF Digital calls.	Upcoming projects (including under the support of the CEF Digital framework) and commitments of MSs in their recovery and resilience plans are expected to bridge existing gaps. Following the first and second CEF digital calls, the third call for proposals was closed for submission in February 2024. The call includes the topic of 5G coverage along transport corridors, and additional projects and studies are expected in the future following the process.
5G security toolbox implementation	The NIS Cooperation Group published its second report on MSs' progress in implementing the 5G Cybersecurity toolbox in June 2023.[20] There have been no major developments regarding the progress since the last report. SM01, which concerns strengthening the role of national authorities, has been adopted by 23 MSs. Meanwhile, SM06 on strengthening resilience at the national level, has only been adopted by three MSs.	Although a significant increase in the number of MS implementing the strategic measures is denoted for SM02, SM04 and SM05, there are still differences in the state of implementation of each measure. Some measures, including SM05, to ensure the diversity of suppliers for individual MNOs through appropriate multivendor strategies, and SM06 are difficult to implement due to the interdependency on transnational operators and the small size of the market/country.	NIS Cooperation Group's report includes specific recommendations for each strategic measure, highlighting areas of improvement to be addressed for the next phases of the Toolbox implementation and monitoring (both at the EU and national level). A specific NIS report on open RAN architecture was published in May 2022[21] and is the subject of implementation discussions with MSs.

[15] https://digital-strategy.ec.europa.eu/en/library/radio-spectrum-cept-mandates
[16] The original 5G AP target Source: https://digital-strategy.ec.europa.eu/en/policies/5g-action-plan can be linked to the Digital Decade reference to Multi-Country Projects (MCPs): large-scale projects facilitating the achievement of the targets for digital transformation of the Union and industrial recovery.
[17] https://digital-strategy.ec.europa.eu/en/policies/cross-border-corridors
[18] CZ, ES, IT, LV, EL, LT plans. Source: Commission Staff Working Document
[19] https://digital-strategy.ec.europa.eu/en/news/5g-corridors-call-2-selected-project-overviews
[20] Second report on Member States' progress in implementing the EU Toolbox on 5G Cybersecurity | Shaping Europe's digital future (europa.eu)
[21] Cybersecurity of Open Radio Access Networks | Shaping Europe's digital future (europa.eu)

The table below presents the most recent data[22] on the number of base stations per MS and band type. Empty cells in the table mean it was not possible to gather the data per band type but only as a total number of base stations. "n/a" means that no recently updated numbers are available. In addition, Annex II features the general number of 5G base stations per country, while this section only reports recent updates on the numbers.

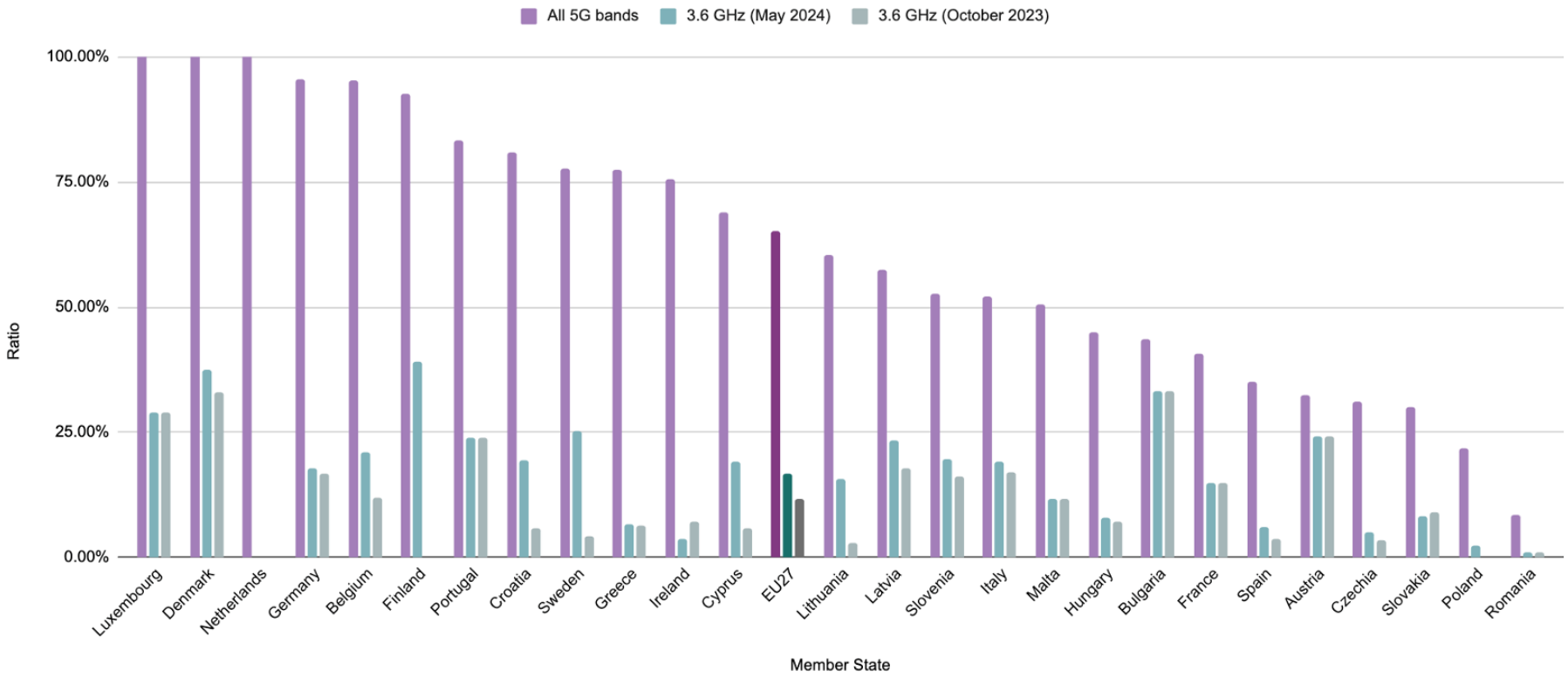
Table 3: Number of base stations per Member State and band type

Indicator	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LV	LU	MT	NL	PL	PT	RO	SE	SI	SK
Number of operating 5G base stations	16,049	10,966	3,697	1,346	13,879	97,710	13,022	n/a	9,819	46,772	22,200	39,502	4,300	5,276	24,066	63,710	2,769	2,175	887	440	15,987	30,750	9,099	4,211	16,072	2,041	3,490
700 MHz band	3,578	4,327	0	910	4,107	27,905	3,306	n/a	966	22.424	12,800	14,826	2,611	2,772	4,134	18,337	1,537	871	0	0	11,379	14	3,413	0	4,512	849	63
3.4-3.8 GHz band	4,747	2.424	2,808	374	2,278	18,173	3,845	n/a	853	8,156	9,400	14,457	1,033	937	1,204	23,307	724	891	164	102	0	3,234	4,024	501	5,210	760	966
in 4G spectrum bands (using dynamic spectrum sharing, DSS)	822	337	884	62	7,494	51,632	0	n/a	8,000	15,665		10,219	656	1,567	18,728	21,714	508	349	723	338	4,593	27,480	1,662	3,710	6,348	207	2,461
in dedicated non-pioneer bands (other than the above)	6,902	3,878	5	0	0	0	5,871		0	527			0	0	0	352	0	64			15	22	0	0	2	225	0

Notes: the calculated total of the 5G base stations may differ from the summing of the indicators for each considered band. That is because both 700 MHz and 3.5 GHz can be used in one 5G base station. Consequently, summing these indicators, including the use of DSS, might give inaccurate results.

[22] Reporting period: Estonia excluded due to lack of data; Data for Austria, Cyprus, Czechia, Germany, Denmark, Greece, Spain, Finland, Croatia, Hungary, Ireland, Italy, Lithuania, Latvia, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia collected in March 2024; Data for Belgium collected in February 2024; Bulgaria collected in September 2023; France collected in August 2022, Sweden collected in October 2023; Luxembourg collected in December 2022 and Malta collected in March 2023.

Figure 1: Percentage of 5G base stations compared to existing 4G base stations (including 3.6 GHz change since last report in October 2023)[23]



[23] Reporting period: Estonia excluded due to lack of data; Data for Austria, Cyprus, Czechia, Germany, Denmark, Greece, Spain, Finland, Croatia, Hungary, Ireland, Italy, Lithuania, Latvia, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia collected in March 2024; Data for Belgium collected in February 2024; Bulgaria collected in September 2023; France collected in August 2022, Sweden collected in October 2023; Luxembourg collected in December 2022 and Malta collected in March 2023.

4. Deployment of edge cloud in mobile networks

4.1. What is edge cloud computing?

Beyond speed improvement, the enhanced functionalities of 5G are seen as a driving force for profound transformation across various sectors and verticals – including manufacturing, healthcare, transportation and logistics and gaming, among others. Bringing higher reliability and ultra-low latency together, as well as enabling massive IoT and machine-to-machine type communications, were some of the key expectations of 5G: edge computing is a feature of these 5G enhanced capabilities (alongside virtualised RAN and others), and it will play a significant role in realising the full 5G benefits.

Edge computing in telecommunications – often referred to as Mobile Edge Computing (MEC) or Multi-Access Edge Computing – is a concept that involves bringing computing infrastructure closer to end-users and/or applications (the "edge" of the network) by deploying computing solutions within the vicinity of where data is generated and consumed. In other words, edge computing means more of the heavy lifting happens on, or near, the end device.

This approach aims to address the surge in demand for real-time data processing and analysis across diverse technological domains, such as robotics, Augmented and Virtual Reality (AR/VR) and connected vehicles. By moving data processing and analysis closer to the point where the data is captured, there are also improvements in network performance and bandwidth optimisation, major reductions in response time and enhancement in security. The primary distinction lies in latency: edge computing excels in handling time-sensitive data at the source, while cloud computing is more appropriate for managing large volumes of non-critical data. The edge will complement the cloud but not replace it. In fact, in some instances, the edge depends on cloud infrastructure.

Edge computing solutions, however, also come with their own set of drawbacks and challenges. They add an extra layer of complexity: tasks such as software updates, configuration management, and monitoring become more challenging in a decentralised environment. Edge computing may also require deploying and provisioning additional infrastructure (including both hardware and software components), introducing overhead and complexity to network management.

4.2. Private network use cases

While 5G edge computing may not be a one-size-fits-all solution, it stands out as a strong candidate for private network deployments. It can be a significant improvement for sectors/applications with ultra-low latency requirements (robotics/automation), sectors that demand data sovereignty (manufacturing) or use cases where there is no previous infrastructure such as Wi-Fi/fibre (construction sites). Traditionally, enterprise applications saw data-generating endpoints transmit information to a centralised enterprise application using local area networks and wide area networks. The centralised platform then processes the data, and the output is transmitted back to the endpoint. Edge computing removes the need to backhaul to the cloud, ultimately reducing delays in data transfer.

Demand for 5G edge solutions is expected to surge in the coming years as organisations seek to improve operational efficiency and deploy new emerging technologies. Early research suggested that, by 2025, 75% of data will be processed outside the traditional data centre or cloud, reflecting the growing importance of edge computing.[24] According to recent estimates, the global market for edge computing reached a value of $16.45 billion in 2023, with projections[25] indicating a compound annual growth rate (CARG) of 36.9 per cent from 2024 to 2030. Some example applications in which edge computing delivers tangible benefits include:

[24] Gartner, What Edge Computing Means for Infrastructure and Operations Leaders, 2018, https://www.gartner.com/smarterwithgartner/what-edge-computing-means-for-infrastructure-and-operations-leaders

[25] https://www.grandviewresearch.com/industry-analysis/edge-computing-market

- Extended Reality (XR): Edge computing can offload computing resources required by AR, VR and other audio-visual devices (gaming) to the edge network without latency issues. This reduction in latency is crucial for XR applications, where any delay can lead to disorientation or discomfort for users. Additionally, the high bandwidth and reliability of 5G networks enable seamless streaming of high-definition content, immersive virtual environments, and multiplayer gaming experiences without interruptions or lags ensuring maximum quality of experience.
- Manufacturing / industrial automation: One of the primary advantages of edge computing in industrial applications lies in significantly reducing latency while increasing data sovereignty. This reduces delay and allows for control and access to data without third-party involvement, supporting the mission-critical elements of the industrial environment. Data-intensive tasks such as remote monitoring, control, and robotics can be executed with remarkable precision and responsiveness, even in dynamic and complex environments. As a result, manufacturing processes become more agile, adaptable, and optimised for the demands of Industry 4.0.
- Connected Transportation: Remote control in machinery, vehicles and drones can leverage real-time data processing and low latency connectivity enabled by edge computing and 5G technology. With the ability to process data locally (it is estimated that an autonomous car can generate over 300 TB of data per year[26]), connected vehicles stand to benefit immensely. These vehicles can make real-time decisions critical for ensuring enhanced safety and security. Additionally, the synergy of edge computing and 5G facilitates swift responses to changing road conditions, contributing to improved user experiences and optimised traffic management systems.

4.3. Who is deploying edge computing in telecoms?

In line with growing interest in edge computing, the market landscape for the edge cloud is becoming increasingly diverse, involving telecom operators, cloud providers, software/hardware providers and system integrators, among others.[27] On the one hand, the fragmented market implies that none of the market players are offering end-to-end service across the value chain. Still, on the other hand, this also entails opportunities for collaboration between different stakeholders.

In that regard, cloud providers, particularly hyperscalers,[28] are strategically positioned to offer edge cloud services as they generally already possess well-established infrastructure and tools, as well as renowned user interfaces, often at a global scale.[29] As they do not maintain the connectivity part of the service, they enter partnerships with telecom operators. Examples of this include Amazon Web Services' (AWS) collaboration with Telefónica to provide edge computing and cloud native private 5G networks,[30] and with Verizon to launch the world's first MEC platform via AWS Wavelength,[31] as well as Microsoft's partnership with AT&T to launch AT&T MEC with Microsoft Azure Stack Edge.[32]

As one of the leading cloud providers in the world, AWS is also an industry leader in edge cloud services through its AWS Wavelength. First launched in 2019, Wavelength brings AWS compute and storage technologies to the edge of 5G networks, closer to the content creation or consumption points. Consequently, users can benefit from significantly lower 5G latency and higher bandwidths.[33] To make use of this infrastructure, developers can extend their virtual

[26] LexisNexis, 2020 Connected Car Forecasts: What Did They Get Right, What is to Come?, https://risk.lexisnexis.com/insights-resources/blog-post/2020-connected-car-forecasts-what-did-they-get-right-what-is-to-come
[27] GSMA Intelligence & AECC, Edge compute: Coming to a place near you, February 2024, https://aecc.org/wp-content/uploads/2024/02/070224-Edge-Place-Near-You.pdf
[28] Hyperscalers are those companies that can offer cloud computing and storage services on an extremely large scale.
[29] Ibid.
[30] Telefónica, Telefónica expands its strategic collaboration with Amazon for cloud development and the digital home, February 2022, https://www.telefonica.com/en/communication-room/press-room/telefonica-expands-its-strategic-collaboration-with-amazon-for-cloud-development-and-the-digital-home/
[31] Verizon, Verizon and AWS team up to deliver 5G edge cloud computing, December 2019, https://www.verizon.com/about/news/aws-verizon-5g-edge-cloud-computing
[32] Microsoft, AT&T MEC with Microsoft Azure, n.a., https://azuremarketplace.microsoft.com/en-us/marketplace/apps/att1.mecpluswithapez
[33] AWS, AWS Wavelength, n.a., https://aws.amazon.com/wavelength/

private cloud (VPC) to the Wavelength Zone to deliver applications to mobile devices and end users.[34] Additionally, developers can leverage the AWS' global reach owing to its familiar tools, services and application programming interfaces (APIs) together with its wide-ranging collaborations with major telecom operators such as Telefónica, Verizon, KDDI, SK Telecom, Vodafone, Bell and BT, among others, to scale up their applications quicker.[35]

The launch of AWS Wavelength has enabled the development of innovative solutions in various sectors. Identified use cases include Cellular Vehicle-to-Everything (C-2VX) for connected vehicles, high-resolution video production and live streams, AR/VR applications and industrial automation and smart factories applications,[36] all of which require low latency for optimal experiences.

In 2020, Microsoft introduced its Azure Edge Zones and Azure Private Edge Zones to capitalise on 5G opportunities to move Azure tools and services to the edge of the network. Similar to AWS Wavelength Zones, Azure Edge Zones enable developers to benefit from familiar Azure APIs, tools and services to build and scale up their applications, also thanks to the direct connection to 5G networks. Meanwhile, Azure Private Edge Zones combine private enterprise networks (embedded within data centres or private campuses, for instance) and Azure Stack Edge hardware to deliver secure, ultra-low latency and high bandwidth solutions.[37]

In 2021, Azure private MEC was introduced as an evolution of Private Edge Zones to capitalise on the growing MEC market and opportunities on 5G and edge monetisation. The solution aims to address challenges in edge and private wireless networks (e.g. edge assets in remote locations that lack network connectivity) in order to provide easier access to private and low-latency 5G networks. Unlike the single platform Private Edge Zones, MEC offers a combination of edge computing, multi-access networking stacks (i.e. to allow multiple network access types) and application services at the network edge. This also allows deployment in space- and power-constrained conditions.[38] The application was recently boosted by the introduction of Azure Private 5G Core to deploy a 5G standalone core network on Azure Stack Edge. Microsoft has partnered with telecom operators worldwide, including AT&T, BT, Deutsche Telekom, Etisalat and STC, to provide this solution to their customers and with private enterprises across several sectors to develop MEC solutions for operational insights, health and safety monitoring and quality control in manufacturing, smart city applications, tracking for logistics and transport and retail and entertainment purposes.[39] In a similar fashion, Azure public MEC is an extension of Azure located in or near telecom operators' data centres in urban areas to run low latency workloads while using the operators' public 5G networks. At the moment, this solution is only available via the partnership with AT&T in Atlanta, Dallas and Detroit in the US.[40]

Besides hyperscalers, other industry players have also become involved in edge cloud services. For example, Hewlett Packard Enterprise (HPE) has been active in offering edge cloud services for 5G networks since 2019 through its HPE Edgeline Converged Edge Systems. The system enables converged operational technology and enterprise-class IT computing and storage capabilities at the network edge. The system is designed to perform in harsh environments and, thus, to process data close to the creation points, which facilitates data-intensive and low-latency telecommunication services.[41] Eventually, the system can help fulfil customers' needs for near-real-time asset performance analytics in verticals such as energy and manufacturing.[42]

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[34] AWS, What is AWS Wavelength?, n.a., https://docs.aws.amazon.com/wavelength/latest/developerguide/what-is-wavelength.html

[35] AWS, AWS Wavelength, n.a., https://aws.amazon.com/wavelength/; IEEE ICC, Evolution of Telco Edge Cloud toward Network-as-a-Service (NaaS), May 2023, https://www.etsi.org/images/files/Technologies/ETSI-MEC-Telco-Edge-Cloud-Naas.pdf .

[36] AWS, Use cases for AWS Wavelength, n.a., https://docs.aws.amazon.com/wavelength/latest/developerguide/wavelength-use-cases.html

[37] Microsoft Azure, Microsoft partners with the industry to unlock new 5G scenarios with Azure Edge Zones, March 2020, https://azure.microsoft.com/en-us/blog/microsoft-partners-with-the-industry-to-unlock-new-5g-scenarios-with-azure-edge-zones/

[38] Microsoft Azure, Unlocking the enterprise opportunity with 5G, edge compute, and cloud, June 2021, https://azure.microsoft.com/en-us/blog/unlocking-the-enterprise-opportunity-with-5g-edge-compute-and-cloud/

[39] Microsoft Azure, Azure private MEC delivers modern connected applications for industries, February 2023, https://azure.microsoft.com/en-us/blog/azure-private-mec-delivers-modern-connected-applications-for-industries/

[40] Microsoft, What is Azure public MEC?, March 2023, https://learn.microsoft.com/en-us/azure/public-multi-access-edge-compute-mec/overview

[41] HPE, HPE Edgeline, n.a., https://www.hpe.com/us/en/servers/edgeline-systems.html; HPE, Hewlett Packard Enterprise launches platform to unleash real-time processing at the telecommunications edge , February 2019, https://www.hpe.com/us/en/newsroom/press-release/2019/02/hewlett-packard-enterprise-launches-platform-to-unleash-real-time-processing-at-the-telecommunications-edge.html .

[42] IDC, Driving Asset Performance with Digitization at the Edge, July 2021, https://www.edgecloudstore.com/datasheets/Solutions/Driving-Asset-Performance-with-Digitization-at-the-Edge-a00097795enw.pdf

Apart from the Edgeline, HPE GreenLake Edge-to-Cloud platform expands on HPE's hybrid cloud offerings to enable data processing either on-premises (i.e. at the network edge) or on cloud environments. Consequently, it enhances data connection between the edge and the cloud and reduces the complexity of data migration.[43]

4.4. The 5G Observatory view on edge computing in telecoms

How widespread will edge computing be?

Measuring the potential impact of edge computing is complex and affected by which definition you choose to adopt (i.e. where exactly is the edge?). The European Edge Observatory defines edge nodes as computer nodes that provide latencies below 20 milliseconds.[44] This is a relatively broad definition, which also includes some in-country centralised data centres that happen to be close to the data generators.

Category		Type	Deployment	Performance Features	
				Power Capacity	Latency
Cloud		In-country data centres		Between 5MW and 10MW	Up to 20ms
Edge	Metro-edge	In-country data centres (edge)		Up to 5MW	Between 10 and 20ms
	Medium-edge	Near Edge		Up to 1MW	<10ms
		Far Edge		Up to 200kW	<5ms
		On-premise (small scale)		Up to 30kW	<3ms
	Micro-edge	On-premise (micro scale)		≤1kW	~1ms
	Device edge	On device		N/A (widely depending on the specific objective or function)	<1ms

Figure 2: Edge computing categories

Source: EU Edge Observatory

If we adopt a definition similar to the one by the European Edge Observatory, it is undoubtedly true that edge computing will see growth over the next few years. This is because we expect to see significant growth in the construction of new regional data centres across the globe. This trend is partly driven by the impact of artificial intelligence (AI), which is prompting cloud companies to invest in data centres. Demand for space in data centres is so high that some have suggested demand will soon outpace supply.[45]

Yet if we use a narrower definition of edge computing as a technology that brings computing resources significantly closer to the end-user geographically (i.e. on premises or on nearby base stations), the market is much smaller. This reality is reflected by the European Edge Observatory, which notes in its Edge Deployment Data Report that only 5%

[43] HPE, HPE GreenLake, n.a., https://www.hpe.com/us/en/greenlake.html
[44] See "Edge Observatory Definition and Taxonomy": https://digital-strategy.ec.europa.eu/en/policies/edge-observatory
[45] CBRE, Europe Data Centres, 2023, https://mktgdocs.cbre.com/2299/52f6d4f5-fb27-4687-aea8-3a8fd0614466-2112251552.pdf

of infrastructure expenditure is currently allocated to edge computing, with traditional data centres still commanding the vast majority of spending.[46]

Research and consulting firm Gartner has recently downgraded its predictions for edge computing. In 2018, the firm forecast that by 2025, around 75% of enterprise data will be created and processed on the edge.[47] This year, it predicted this figure would be 50% by 2027.[48] Gartner defines edge computing as solutions that facilitate data processing "at or near" the source of data generation and outside of "traditional" data centres.

Assessing the impact on telecommunications

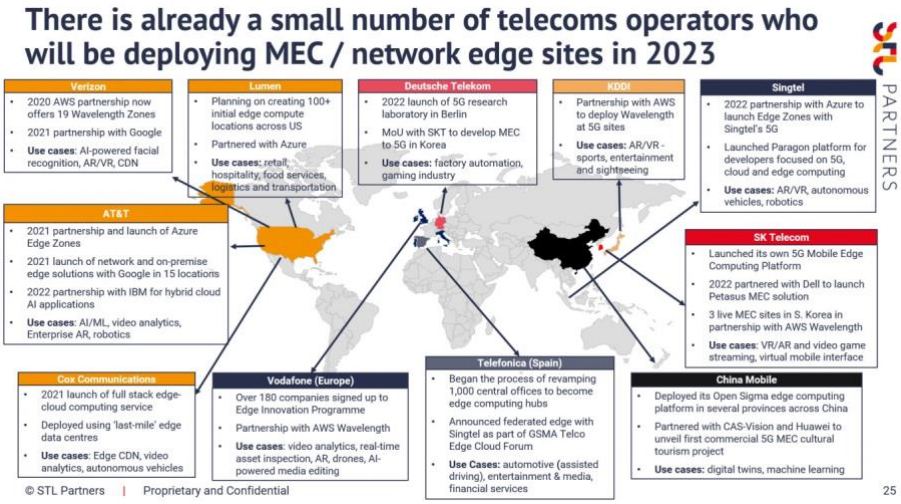
Regardless of definition, the market for edge computing is undoubtably growing, albeit at a slower pace than initially predicted by some. However, its impact on the telecommunication industry is more uncertain. It is an area where experts' opinions differ; there are some optimists, but notably, Ericsson is not among them.

There is consensus that mobile network operators (MNOs) will generally benefit from the rollout of edge computing, particularly for applications that require ultra-low latency. This is because these applications require a shorter, faster pipe to transfer data from the end-user to where data is processed to reduce latency and maintain good user experience. This will be improved as data centre operators and cloud providers move closer to the edge.

However, experts disagree on the role that MNOs will play in the deployment of edge computing. STL Partners was optimistic, noting that it had already seen a number of small-scale deployments of edge computing by telecom companies globally.[49] Yet, the company notes that adoption in Europe has been slow, with operators in the US and China taking the lead.

> *"In Europe, adoption has been slower. Vodafone is seen as one of the leaders with six edge locations across three countries in Europe (all deployed in collaboration with AWS)."*
> STL Partners

Figure 3: Telecom operators deploying MEC / network edge sites



[46] See 3.1.1. Infrastructure spending per environment in 2022: https://ec.europa.eu/newsroom/dae/redirection/document/100264
[47] Gartner, What Edge Computing Means for Infrastructure and Operations Leaders, 2018, https://www.gartner.com/smarterwithgartner/what-edge-computing-means-for-infrastructure-and-operations-leaders
[48] Source: Correspondence with Gartner analysts
[49] STL Partners defines edge computing as a computing infrastructure that is positioned on the spectrum between and including the end-device and the hyper-scalers cloud network. See: https://stlpartners.com/articles/edge-computing/what-is-edge-computing/

Source: STL Partners

Ericsson, on the other hand, said that it does not expect any significant mobile operator deployment of edge computing in the short to mid-term.[50] This is because the vendor does not expect the emergence of use cases that would require the capabilities offered by edge computing within mobile networks for both enterprise and consumer applications. Additionally, it notes that most enterprise and consumer use cases require access to multiple communications service providers (CSPs). This will push edge deployment outside of a single CSP network.

> *"There is limited edge computing deployment so far in mobile operators, and it is still in market fit exploration. There have been some initial evaluation offerings with very limited business success. The biggest limitation so far is the availability of use cases that would require such capability, it is a heavy investment and with significant limitations when it comes to use case realisation."*
> Ericsson

Former Director of Technology Resources at Ofcom in the UK Professor William Webb agreed with this assessment. He said that as an industry, mobile operators would likely play a limited role compared to hyperscalers, who have a wider customer base to support the expensive deployment of edge servers. Webb also noted that bringing computing closer to the edge has little benefit, but even if it did, many services, such as multi-player videogames, cannot be delivered from a local server, and these use cases require centralised servers to collate and distribute the movements of each player.

> *"A large number – such as hundreds or thousands of edge servers would be expensive to deploy and maintain compared to a smaller, more centralised resource. Telcos running servers would likely not have as wide a customer base as hyperscalers, and hence face higher costs as a result. With no clear use cases for edge computing, and higher costs than the existing approach, there does not appear to be a sensible business case at present."*
> William Webb

Conclusion

In summary, we expect the majority of the growth in edge computing to be driven by major cloud companies like Amazon, Microsoft, Alphabet and others. These firms have already deployed hundreds of edge computing locations globally, and they are likely to expand their portfolio of edge sites. Google Cloud, for instance, already operates 35 network edge locations in various cities around Europe.[51] MNOs will benefit from this growth, and in some instances, they will partner with cloud companies to offer the best possible experience to enterprise customers. In limited instances, MNOs might even build their own edge computing infrastructure as part of major private network projects.

However, because of the high cost and lack of use cases that require ultra-low latency, we expect edge computing to have a small impact on MNOs, with operators themselves unlikely to build out their own computing infrastructure. Edge computing in itself will not be a driver for private 5G deployments and will instead be seen as a useful addition in some limited private enterprise offerings.

Whether it is deployed by hyperscalers or MNOs, we expect edge computing that happens on site to be the least impactful. Apart from some highly secure deployments, most use cases could not justify the need to install computing resources this close to the data source due to its high cost and marginal improvement of latency (a few milliseconds at most).

[50] Ericsson's defines edge computing as computing that happens either on premise or "within or at the boundary" of an access network. See: https://www.ericsson.com/en/edge-computing
[51] Google Cloud, Network edge locations, n.d., https://cloud.google.com/vpc/docs/edge-locations

5. 5G outlook on deployment forecasting for the intermediate 2025 perspective

This chapter contains a summary of existing projections for the forecasting towards 2025 5G-related targets and, in some cases, even later.

5.1. Ericsson, Mobility Report,[52] November 2023. Scope: Global

5.1.1. Methodological framework / approach

The forecast on mobile subscription and network traffic is based on historical data from several sources, which are then corroborated with internal data from Ericsson. The forecast is scoped for a six-year time horizon, and future developments are approximated via technological advancements, market maturity, and user and macroeconomic trends.

5.1.2. Outcome summary

From 2022 to 2023, the share of 5G subscriptions in Western Europe doubled, reaching around 25% of the market (amounting to almost 140 million subscriptions).[53] Meanwhile, 4G technology remains dominant, with the subscription penetration reaching almost 70% at the end of 2023, although this represents a decline of around 10% of the market share from the end of 2022. In the next few years, 5G technology is expected to increase its stronghold in Western Europe, with a projected penetration of 85% by 2029. Concurrently, in Central and Eastern Europe,[54] 5G subscription penetration has only slightly grown from less than 1% of the total market in 2022 to 2.5% at the end of 2023. 4G technology continues to prevail with over 81% market share, which is partly explained by slower spectrum allocation processes for 5G deployments. Nonetheless, only 5G technology is expected to grow from 2025 onwards and is projected to reach half of the total market share by 2029.

5.2. GSMA, "The Mobile Economy",[55] 2024. Scope: Global

5.2.1. Methodological framework / approach

Representing the interests of mobile operators worldwide, the GSMA is considered an industry reference point for global mobile operator data, analysis, and forecasts, publishing annual industry reports and research. GSMA's annual state of mobile economy reports (global and regional versions) provide market intelligence (technology, socio-economic and financial datasets) through their in-house research team (i.e. proprietary models/forecasting methodology and datasets).

5.2.2. Outcome summary

According to the Mobile Economy report 2024, in 2023, 5G subscriptions made up 20% of the market in Europe, exhibiting an almost 10% market share increase from 2022. Although 4G still accounts for almost 70% of the market

[52] Ericsson Mobility Report November 2023

[53] Ericsson Mobility Report November 2023. According to the Ericsson Mobility Visualizer, Western Europe comprises of Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Iceland, Italy, Luxembourg, Malta, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

[54] Ericsson Mobility Report November 2023. According to the Ericsson Mobility Visualizer, Central and Eastern Europe comprises of Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Bosnia and Herzegovina, Croatia, Czechia, Estonia, Georgia, Hungary, Kosovo, Kyrgyzstan, Latvia, Lithuania, Moldova, Montenegro, North Macedonia, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.

[55] GSMA, The Mobile Economy, 2024

in 2023 in Europe, its dominance is expected to decline in the coming years as 5G is projected to attain 80% of the market by 2030. At the same time, overall mobile subscriber penetration in Europe is expected to fractionally grow from 91% in 2023 to 93% by 2030, along with a modest rise in smartphone adoption from 82% in 2023 to 91% by 2030.

Annex I: Latest developments per country

This Annex I provides an update of the latest developments per country to reflect the situation on 30 April 2024.

A1.1 Latest commercial developments

Since January 2022, commercial 5G is now available in all 27 Member States.[56] The full overview of commercial launches per operator offering 5G services across the EU27, detailing their frequency usage and, where applicable, highlighting the use of DSS technology, network configuration, i.e. 5G NSA vs 5G SA implementations, and announced coverage targets is available on the European 5G Observatory website. This information is updated regularly. Below is a summary of the main changes compared to the previous edition of the 5G Observatory report:

Belgium:

- Following the funding of 21 5G pilot projects last year, the Belgian government selected eight new projects in February 2024 to be funded this year. The projects cover various domains, including health, public safety, industry and maritime. Included in the winning tenders are Proximus, Orange Belgium and Citymesh.

Bulgaria:

- In November 2023, the Communications Regulation Commission (CRC) of Bulgaria awarded new spectrum licenses for three telecom operators, A1 Bulgaria, Yettel and Vivacom, for the use of radio frequency spectrum in the 700 MHz and 800 MHz bands.

Czechia:

- O2 Czechia reported in March 2024 the completion of its 5G network upgrade in the North Moravia region covering 618 base stations. O2 Czechia has also completed its rollout of the 5G network across the Prague Metro in November 2023, making it the first underground railway system in Europe with full 5G coverage.

Estonia:

- As of October 2023, Telia Estonia announced a 75% 5G network coverage of the Estonian population, with a plan to increase the coverage to 95% by the end of 2024. The telecom operator is currently operating over 500 base stations across the country and has recently launched commercial 5G services in the 26 GHz band.

Finland:

- DNA announced in January 2024 that its 5G services now cover an estimated 93% of the Finnish population, and the operator is now working on further expanding its geographical coverage.
- As of January 2024, Elisa's 5G network has covered more than 92% of the Finnish population. Elisa also became the first Finnish operator to launch 5G standalone subscriptions in March 2024 by utilising Ericsson's dual mode 5G Core.

France:

- In November 2023, Orange announced that its 5G+ (i.e. standalone 5G) offering will become available in 2024. Similarly, SFR reported on the activation of its 5G SA network in December 2023 during a football match in Lille, although there is no plan yet for public subscriptions. This is followed by the announcement from Bouygues Telecom in February 2024 regarding its hybrid private 5G network offering based on a 5G standalone core network developed with Ericsson.

[56] The first commercial 5G service has been launched in Lithuania in January 2022, completing EU27 deployment in 2022, Source: Telia.

- TOTEM, a subsidiary of Orange TowerCo, began its 5G deployments in underground tunnels of the future Line 15 South of the Grand Paris Express Metro Line in March 2024. The project aims to be completed by the end of 2025. When completed, the line will become the first 5G connected one across the Paris Metro system.

Germany:

- In February 2024, the German railway undertaking, Deutsche Bahn, started testing 5G services on trains as part of the Gigabit Innovation Track (GINT) research project in collaboration with O2 Telefónica, Ericsson and Vantage Towers. The project aims to trial how 5G can be integrated into network services along railway lines to provide faster internet connection.
- O2 Telefónica launched its 5G Plus service in October 2023 and became the second German operator after Vodafone to initiate 5G standalone technology across the country. The service is now available for over 90% of the German population. O2 Telefónica has also recently announced its plan in February 2024 to expand its 5G coverage on roads, motorways and railways across Germany.
- Deutsche Telekom has also reported the establishment of 5G standalone networks at the University of the Federal Armed Forces in Hamburg and at the Brandenburg University of Technology. The two projects both aim to ensure security and provide maximum 5G performance.

Hungary:

- Yettel Hungary became the first Hungarian operator to launch a 5G standalone service in November 2023. The upgrade will first be made available for Yettel's household and business subscribers and entail an increase in internet speed and performance.

Ireland:

- In January 2024, Three Ireland officially launched its 5G standalone network powered by Ericsson and became the first Irish operator to do so. Although only operating on a trial basis, the service is available for a select few customers for the next one year with the possibility to extend the trial afterwards.

Italy:

- In December 2023, the Canadian neutral host provider, Boldyn Networks, signed a 25-year #Roma5G agreement with Roma Capitale to build advanced 5G infrastructure in the city. The project includes the coverage of all metro lines and the installation of small cells, public Wi-Fi, IoT sensors and 5G CCTV cameras across Rome. The 5G infrastructure will be open to all mobile network operators. In November 2023, TIM, Iliad Italia, WindTre and Vodafone Italy signed a deal with ATAC, Rome's public transport operator, to equip all metro lines in the city with 5G in conjunction with the city's ambition to meet the 2030 Digital Decade goals.
- In October 2023, Vodafone Italy announced the construction of Italy's first private 5G mobile network in the energy sector in collaboration with the Italian energy infrastructure company, Snam. The project will connect 23 plants operated by Snam across the country.
- Similarly, WindTre announced its collaboration with PSA Italy to build a 5G private network at the Port of Genoa. The operator also recently reported that its 5G TDD coverage has increased to 72% of the Italian population as of January 2024.

Latvia:

- Tele2 Latvia announced in March 2024 its plan to increase its 5G coverage to 85% of the country by the end of the year. The operator has also announced that its 5G services are now available in all municipalities throughout the country.

Poland:

- Following the 5G auction in October 2023, Poland's Office of Electronic Communications (UKE) granted radio permits to telecoms to operate in the C-band (or 3.6 GHz band) in January 2024. T-Mobile Polska is among the successful bidders and has recently launched more than 2,000 5G base stations using the C-band. Similarly, Orange Poland has launched more than 1,200 5G base stations operating on the C-band as of March 2024.

Portugal:

- In November 2023, NOS became the first Portuguese operator to introduce a 5G standalone network, utilising Nokia's 5G Standalone Core platform. The operator also reported that its 5G coverage had reached 93% of the country.

Slovakia:

- As of March 2024, Orange Slovakia reported that its 5G network now covers 65% of the Slovakian population, with a plan to increase its coverage to 80% by the end of the year. Slovak Telekom also announced in February 2024 a 5G network coverage of 55% of the population. O2 Slovakia is still the leading operator with a 5G coverage of 70%, while another operator, 4ka, reaches around 10% of the population.

Spain:

- Orange España announced its partnership with Ericsson in December 2023 to introduce a private 5G network for B2B customers. Previously, Orange España launched its 5G standalone network in February 2023, which is also powered by Ericsson's dual-mode 5G core. As of October 2023, Orange España's 5G SA network has been activated in 38 municipalities across the country.

A1.2 Households coverage

As already introduced in previous editions of this report, according to data collected by Omdia/Point Topic for the European Commission in 2020, the baseline for 5G coverage in the EU was 14% of households at the time when the Digital Decade announcement was first made in March 2020 (with the breakdown per Member State).

Following a change of methodology compared to previous reports, currently, all reports use data collected by Omdia/Point Topic for the European Commission for the DESI, ensuring consistency going forward. The number of households is calculated using annual NUTS 3 level population data and the average household size figures for each country, both published by Eurostat.

Table 4: 5G coverage in the EU

Country	Households coverage (mid-2023 figures)	Source
Austria	96.0%	Omdia/Point Topic
Belgium	40.4%	Omdia/Point Topic
Bulgaria	70.9%	Omdia/Point Topic
Croatia	83.4%	Omdia/Point Topic
Cyprus	100.0%	Omdia/Point Topic
Czechia	94.6%	Omdia/Point Topic
Denmark	100.0%	Omdia/Point Topic
Estonia	87.5%	Omdia/Point Topic
Finland	98.3%	Omdia/Point Topic
France	93.2%	Omdia/Point Topic
Germany	98.1%	Omdia/Point Topic
Greece	98.1%	Omdia/Point Topic
Hungary	83.7%	Omdia/Point Topic
Ireland	85.3%	Omdia/Point Topic
Italy	99.5%	Omdia/Point Topic
Latvia	53.1%	Omdia/Point Topic
Lithuania	98.9%	Omdia/Point Topic
Luxembourg	99.6%	Omdia/Point Topic
Malta	100.0%	Omdia/Point Topic
Netherlands	100.0%	Omdia/Point Topic

Country	Households coverage (mid-2023 figures)	Source
Poland	71.9%	Omdia/Point Topic
Portugal	98.1%	Omdia/Point Topic
Romania	32.8%	Omdia/Point Topic
Slovakia	79.0%	Omdia/Point Topic
Slovenia	82.1%	Omdia/Point Topic
Spain	92.3%	Omdia/Point Topic
Sweden	90.3%	Omdia/Point Topic
EU 27	89.3%	Omdia/Point Topic

A1.3 5G deployment comparison between EU and other world regions

Although the 5G Observatory primarily tracks developments in EU countries, it also follows significant international developments in the 5G sector. It is important to note that most of the figures collected on the number of 5G base stations are provided by governments, but in some cases, such as the US and Japan, they are based on market research estimates. It is possible that some market-based estimates are not entirely up-to-date or accurate. However, they allow for an indicative overview of the state of 5G deployment internationally.

Globally, South Korea is the clear leader in 5G deployment. According to the country's Communication Agency, it now has 307,000 5G base stations.[57] If the country's population is taken into account, this equals 593 5G base stations per 100,000 inhabitants. Following South Korea's lead is China, which has now deployed 3,500,000 base stations. Despite China's significant population size, this works out to 245 5G base stations per 100,000 inhabitants. The EU ranks ahead of the US, with approx. 363,000 base stations. This works out to 103 5G base stations per 100,000 inhabitants.

In terms of the assigned 5G spectrum, the 3.6 GHz band has proved to be the most used 5G band globally. All four regions in this comparison have assigned this valuable mid-band spectrum. The 28 GHz band has been assigned in South Korea, Japan, and the US. In the EU, the situation is more complex as each country assigns their own spectrum. However, all but one country have assigned at least the 3.6 GHz band for 5G deployment, while only 12 EU MSs have assigned the 26 GHz band, for which the demand has been lowest so far. See the spectrum assignment chart in Section 2.

[57] Source: Mk.co.kr citing Ministry data

A1.4 5G spectrum comparison between EU and other world regions

In this section, we compare 5G spectrum use by first introducing the "pioneer bands" identified at the EU level for the initial launch of 5G service, providing an overview of current spectrum assignment trends in the EU and contextualising these by introducing international developments.

Since the last 5G Observatory Report published in October 2023, there have been several spectrum auctions across the EU. Overall, the weighted percentage of 5G pioneer bands assigned across the EU now lies at 73%. Bulgaria's recent auction of the 700 MHz band, and Austria's auction of the 26 GHz band has increased the overall average by 2% since the publication of the last report.[58][59]

The 700 MHz band and the 3.6 GHz band remain the most widely assigned bands, as 25 out of 27 MSs have assigned 700 MHz and 26 out of 27 have assigned 3.6 GHz. The 26 GHz band has been assigned in just 12 MSs and remains the least assigned pioneer band.

Overview of pioneer bands

In 2016, with the release of the 5G Action Plan, the European Commission proposed establishing three 5G pioneer bands for the initial launch of 5G services. It proposed bands in three categories of radio spectrum: below 1 GHz, between 1 GHz and 6 GHz and in millimetre waves.

The 5G pioneer bands identified at the EU level (RSPG Opinions on a strategic roadmap towards 5G for Europe) are as follows:

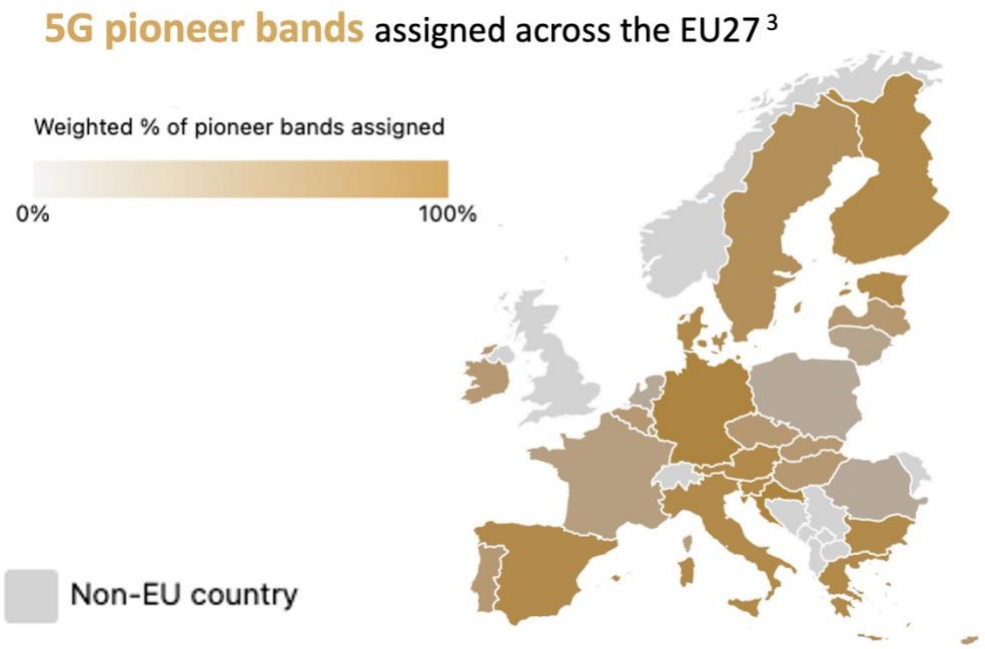
- 700 MHz (703-733 MHz and 758-788 MHz)
- 3.6 GHz (3400-3800 MHz)
- 26 GHz (at least 1000 MHz within 24250-27500 MHz)

In the years following the 5G Action Plan and the adoption of the EECC, the European Commission successfully harmonised the frequencies in these bands. The 26 GHz band was the final frequency band to be harmonised. This occurred in May 2019 with the Commission Implementing Decision (EU) 2019/784.[60] Although the technical conditions for these three bands have been harmonised at the EU level, not all Member States have assigned the pioneer bands, despite the deadlines set out in the UHF Decision (EU) 2017/899 and the EECC, stating that they should assign 700 MHz by 30 June 2020, and 3.6 GHz and 26 GHz by 31 December 2020, provided that there is market demand for the latter and there are no significant constrains to clearing the bands.

[58] https://5gobservatory.eu/austria-completes-26-ghz-and-leftover-3-6-ghz-auction/

[59] https://5gobservatory.eu/bulgaria-assigns-700-mhz-800-mhz-bands/

[60] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019D0784



EU27 trends

Source: Initial data from the annual DESI index and supplemented with new data from the PolicyTracker Spectrum Database and PolicyTracker Auction Tracker.

Pioneer bands assigned

The table below outlines how much spectrum each MS has assigned in the pioneer bands. According to the 700 MHz Decision[61] and related Commission Implementing Decision[62] and the EECC, a country must assign 60 MHz in the 700 MHz band; 400 MHz in the 3.6 GHz band and at least 1000 MHz in the 26 GHz band to achieve 100%. The percentages displayed present how much spectrum has been assigned to operators compared to these numbers.

Amongst MSs, the 3.6 GHz band has been most widely assigned. 26 out of 27 MSs have assigned at least 50% of the targeted spectrum in this band (meaning at least 200 MHz out of 400 MHz). The only remaining outlier is the Netherlands, which has not yet assigned 3.6 GHz. However, the country is expecting to hold an auction to award the band in the coming months.

The second most assigned band is the 700 MHz band, where 25 out of 27 MSs have assigned at least 50% of the targeted spectrum (meaning at least 30 MHz out of 60 MHz). This band has seen a minor increase in assignment percentage since the last report, following Bulgaria's recent spectrum auction in the 700 MHz band.

The least assigned band is the 26 GHz band. The 26 GHz band has only been majority-assigned in 12 MSs, meaning only 12 MSs have assigned at least 50% (500 MHz) of the targeted 1000 MHz. This is a minor increase since the last report following Austria's auction of the 26 GHz band.

[61] https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32017D0899
[62] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2016.118.01.0004.01.ENG

Table 5: Pioneer bands assigned in the EU

Country	% of band assigned		
	700 MHz	3.6 GHz	26 GHz
Total harmonised spectrum (100%)	60 MHz	400 MHz	1000 MHz
Austria	100.00%	97.50%	100.00%
Belgium	100.00%	97.50%	0.00%
Bulgaria	100.00%	90.00%	100.00%
Croatia	100.00%	100.00%	100.00%
Cyprus	100.00%	100.00%	0.00%
Czechia	100.00%	100.00%	0.00%
Denmark	100.00%	97.50%	100.00%
Estonia	100.00%	97.50%	100.00%
Finland	100.00%	97.50%	100.00%
France	100.00%	77.50%	0.00%
Germany	100.00%	100.00%	100.00%
Greece	100.00%	97.50%	100.00%
Hungary	83.33%	97.50%	0.00%
Ireland	100.00%	87.50%	0.00%
Italy	100.00%	80.00%	100.00%
Latvia	100.00%	87.50%	0.00%
Lithuania	66.67%	75.00%	0.00%
Luxembourg	100.00%	82.50%	0.00%
Malta	0.00%	75.00%	0.00%
Netherlands	100.00%	0.00%	0.00%
Poland	0.00%	100.00%	0.00%
Portugal	83.33%	100.00%	0.00%
Romania	50.00%	65.00%	0.00%
Slovakia	100.00%	100.00%	0.00%
Slovenia	100.00%	95.00%	100.00%
Spain	100.00%	95.00%	100.00%
Sweden	66.67%	100.00%	85.00%

Number of countries that have assigned at least 50% of the band	25	26	12

International trends in spectrum allocation

The three 5G pioneer bands harmonised by the European Commission roughly fit into the three categories of 5G frequencies often used by spectrum policy makers: low-band, mid-band, and high-band.

Although there are international discrepancies on which bands are used in each category, classifying the spectrum in this way allows for an easier international comparison of the state of 5G spectrum harmonisation and assignment. The following table provides an overview of which spectrum bands are assigned for 5G in various international markets.

Table 6: Overview of which spectrum bands are assigned for 5G in various international markets[63]

Country	Low-band (<1 GHz)	Mid-band (1 - 6 GHz)	High-band (>6 GHz)
China	700 MHz	2.6 GHz 3.6 GHz 4.9 GHz	-
South Korea	700 MHz	3.6 GHz	28 GHz
Japan	700 MHz	3.6 GHz 3.7 GHz 4 GHz 4.5 GHz	28 GHz
USA	600 MHz	2.5 GHz 3.45 - 3.55GHz 3.5 - 3.7 GHz 3.7 - 3.98 GHz	24 GHz 28 GHz 39 GHz 47 GHz
EU	700 MHz	3.6 GHz	26 GHz

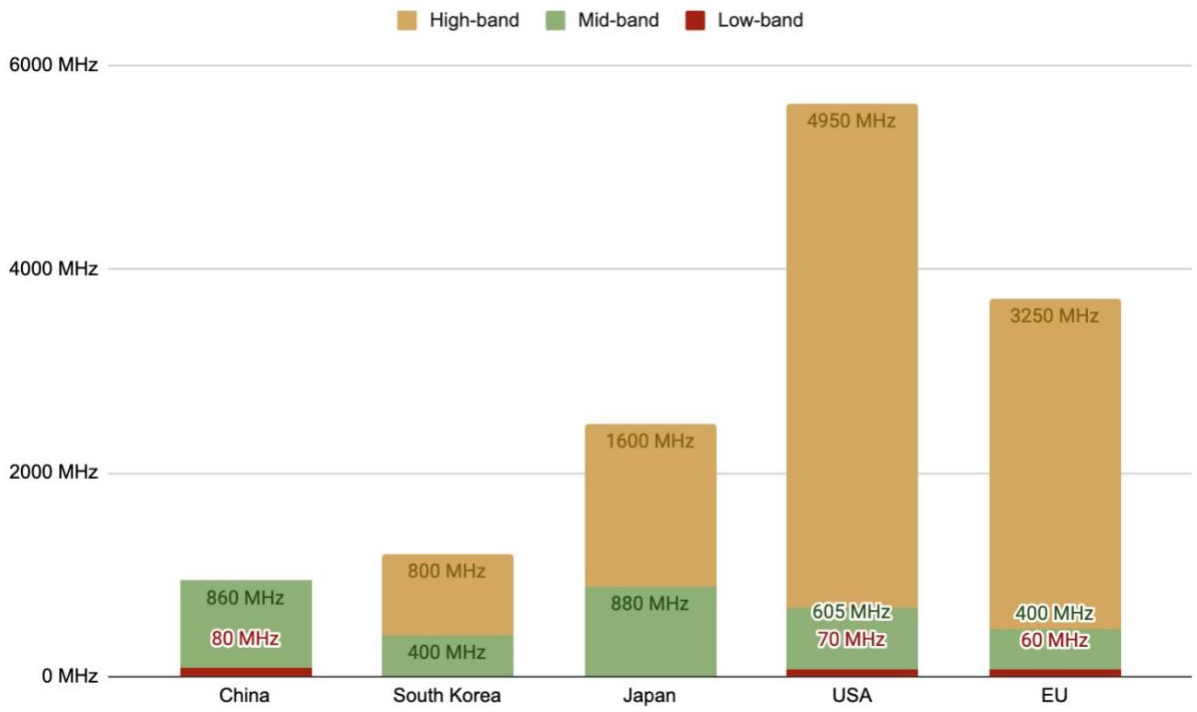
Internationally, the mid-band 5G spectrum has been established as the workhorse band for 5G. It has been assigned in most major markets, including China, South Korea, Japan, and the US. Japan is leading with mid-band 5G assignments. The country has allocated 880 MHz of spectrum in the band for 5G services. China comes in second with 860 MHz assigned.

The low-band spectrum has proven to be slightly less popular. In fact, in South Korea's initial 5G auction in 2016, the 700 MHz low-band spectrum remained entirely unsold. More recently, however, the country decided to award 20 MHz of 700 MHz spectrum to a new entrant called Stage X.

[63] Source: Data on international spectrum assignments is sourced from the Policy Tracker database.

Initially, 5G frequencies in the high bands proved to be very popular. The US led the world in making the high bands available for 5G, and Japan and South Korea quickly followed. The United States leads with 4950 MHz of spectrum assigned in the high-band. However, it appears that there is less demand for this band in Europe, with only one country (Austria) assigning the band in the past six months. In South Korea, meanwhile, the country's regulator, the Ministry of Science and ICT (MSIT), decided in early 2023 to revoke 28 GHz band licences from KT and LG Uplus, later re-assigning the band to Stage X.

Figure 4: Authorised 5G spectrum in international markets[64]



A note on methodology:

China, South Korea, Japan

The source of data for China, South Korea and Japan is the PolicyTracker spectrum database. This is a comprehensive database of spectrum assignments.

All national spectrum licences were added up to find the total amount of spectrum that was assigned to mobile operators in each country. Only bands shown on the left side of the scoreboard were included in this. All of these bands are used to provide 5G services in their respective country.

US

[64] Note: Due to the nature of spectrum assignments in the US being regional, only the three big national operators were included: T-Mobile; AT&T and Verizon. The final spectrum amount was divided by the number of licenses to give a picture of how much spectrum is assigned in an average licensing area. For the EU, the data shows how much spectrum has been harmonized at an EU-level. Some individual countries may have more spectrum assigned for 5G, while some may have less or none. Source: Data on international spectrum assignments is sourced from the Policy Tracker database.

In the United States, licences are usually awarded regionally, a common example being the use of PEAs (partial economic areas) of which there are 406.[65] This makes it difficult to know how much spectrum mobile operators hold on a national level, as they hold different amounts of each band in each licence area. Because of this, we have chosen to instead use the amount of spectrum that was initially made available to mobile operators by the country's spectrum regulator, the Federal Communications Commission (FCC), at auction. This data comes directly from the FCC, and the list of awards can be found in the table below.

In the 2.6 GHz band spectrum, licenses are held by educational institutions. These are called Educational Broadband Service (EBS) licenses. T-Mobile leases a majority of these licences and has purchased some.[66] The total number of spectrum that T-Mobile holds in these licences is unknown. However, an estimate made by the FCC suggests the operator holds 155 MHz of spectrum in this band. [67] This is the estimate used in our data.

Regarding the CBRS auction, we have only counted the priority access licences (PAL), and the other spectrum made available is on an unlicensed basis.

Not all spectrum made available at these auctions will have been sold to operators. However, the amount of unsold spectrum licenses in these auctions is small. Furthermore, the amount of spectrum was cross-checked with the PolicyTracker spectrum database. This is a comprehensive database of spectrum assignments in over 100 countries.

Low-band spectrum	**MHz**	**Source URL**
600 MHz (Incentive auction)	70	https://auctiondata.fcc.gov/public/projects/1000

Mid-band spectrum	MHz	Source URL	Comments
CBRS (PAL licences)	70	https://www.fcc.gov/auction/105/factsheet	70 MHz was awarded as priority licences. However, operators may be able to use the entire CBRS range of 100 MHz in some circumstances.
3.45 - 3.55 GHz (Auction 110)	100	https://www.fcc.gov/auction/110/factsheet	
3.7 - 4.2 GHz (Auction 107) (C-band auction)	280	https://www.fcc.gov/auction/107/factsheet	

[65] https://www.fcc.gov/oet/maps/areas
[66] https://www.lightreading.com/5g/inside-the-messy-world-of-t-mobiles-midband-5g-spectrum-licenses/d/d-id/774745
[67] https://www.fcc.gov/reports-research/reports/consolidated-communications-marketplace-reports/CMR-2020

2.6 GHz (T-Mobile's holdings of education spectrum)	155	https://www.fcc.gov/reports-research/reports/consolidated-communications-marketplace-reports/CMR-2020	FCC estimate from 2020 marketplace report (p.24)
Total	605		

High-band spectrum	MHz	Source URL
28 GHz (Auction 101)	850	https://www.fcc.gov/auction/101/factsheet
24 GHz (Auction 102)	700	https://www.fcc.gov/auction/102/factsheet
37 GHz and 39 GHz (Auction 103)	2400	https://www.fcc.gov/auction/103/factsheet
47 GHz (Auction 103)	1000	https://www.fcc.gov/auction/103/factsheet
Total	4950	

European Union

Because spectrum assignments differ across EU MSs, the number used in the scoreboard shows how much spectrum has been harmonised at the EU level. Some individual countries may have more spectrum assigned for 5G, while some may have less.

A1.5 5G verticals and trials

Overview

Whereas previous generations of mobile technologies primarily focused on human communication, including voice, data, and the internet, 5G has the ability to provide services for a range of industries where mobile telecoms have so far had little purchase. Because 5G features low latency and high speeds, it is well suited to enter the so-called "vertical" markets such as industrial and agricultural automation, the automotive industry, transport and healthcare. Early in the development of 5G/IMT-2020, the ITU identified 5G as a "key driver" for industrial and societal changes.

The 3GPP standardisation body released the first 5G specification in 2017 (Release 15). After the release of Release 15, the focus quickly turned to optimising 5G for vertical domains in Release 16, which is informally referred to as '5G Phase 2'.

In June 2020, Release 16 was published, focussing on the verticals' needs. Enhancements were made to 5G System enablers for verticals, including industrial automation, time-sensitive communication (TSC), Ultra-Reliable and Low Latency Communication (URLLC) and Non-Public Networks (NPNs). Enhancements were also made to the Cellular Internet of Things (CIoT) and support for 5G system Vehicle-to-Everything (V2X) communication.

Release 17, which was frozen in early 2022, included more features for 5G verticals, including a new IoT standard called NR-light and support for non-terrestrial networks (NTNs). Furthermore, more spectrum frequencies are now supported in the 52.6-71 GHz range. Release 18, which is expected to be frozen at the end of Q2 of 2024, includes even more specifications for 5G verticals. The system architecture includes 5G multicast broadcast services, vehicle-mounted relays, and Personal IoT Networks. R-18 identified additional applications that the new standard enables, such as enhancements to V2X, UAS applications, 5G messaging, Future Factories and capability exposure for IoT platforms.[68]

5G verticals in the EU

With the announcement of the EU Digital Decade Communication, the European Commission has put emphasis on the importance of the digital transformation of business. The communication outlined that 5G will play an important part in this transformation. It states, *"digital technologies including 5G, the Internet of Things, edge computing, Artificial Intelligence, robotics and augmented reality will be at the core of new products, new manufacturing processes and new business models based on fair sharing of data in the data economy."*

In Europe, trials of 5G verticals have been encouraged through the 5G Public Private Partnership project (5G PPP), which is funded by European Union research funding grants totalling €700m matched by €3.5bn of private investment between the period 2014-2020.

Furthermore, the 5G-PPP Vertical Engagement Task Force (VTF) has been established to coordinate and monitor activities related to working with the vertical sector. The vertical sectors considered by 5G-PPP VTF are:

- Automotive
- Manufacturing
- Media
- Energy
- E-Health
- Public safety

[68] Source: https://www.3gpp.org/specifications-technologies/releases/release-18

- Smart cities

5G vertical spectrum: Is there a need for a dedicated spectrum?

The licensing model (or model***s***) needed for 5G verticals is the subject of an ongoing debate in spectrum management circles. 5G verticals can either use spectrum already assigned to mobile operators or they can rely on dedicated spectrum licences issued by national regulatory authorities.

Some stakeholders argue in favour of a dedicated spectrum. They say that dedicated spectrum access regimes enable innovation and competition, as they provide a new spectrum access option for industries.[69] It is also argued that a dedicated spectrum is better suited for some applications which have particularly demanding quality of service (QoS) requirements, such as utilities.

There are also arguments against the dedicated spectrum. The mobile industry association, GSMA, says[70] that doing so may cause fragmentation. The organisation says that this could make it harder for operators to achieve contiguous blocs – which will then result in reduced speeds and QoS.

Despite this ongoing debate, an increasing number of countries are adopting a local licensing model that uses dedicated spectrum for 5G verticals. Germany was the first country to decide to reserve the 3700-3800 MHz band for verticals. This may be because of the potential benefits for industrial companies, which account for about 20% of the country's GDP.[71]

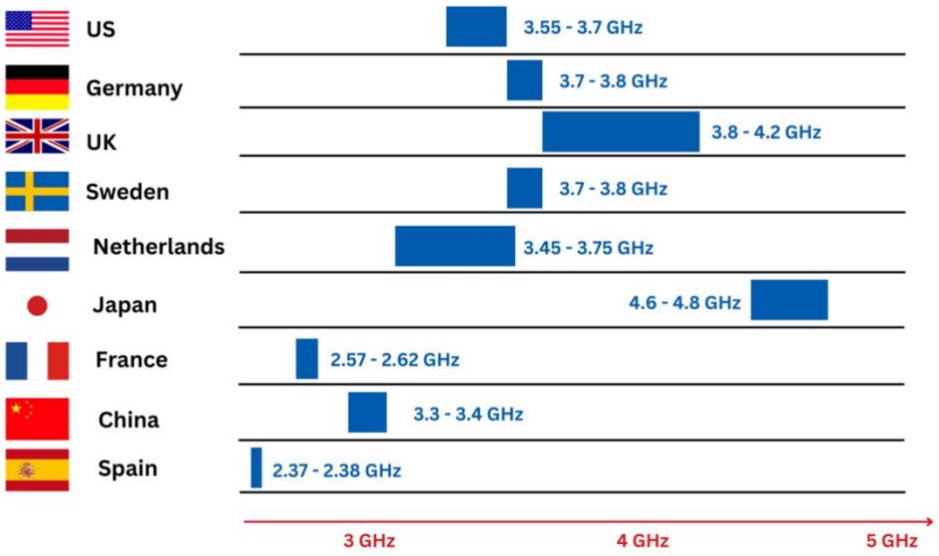
In total, 10 EU countries have proposed or implemented a local licensing model. These countries are as follows:

- Austria
- Belgium
- Croatia
- Denmark
- Finland
- France
- Germany
- Netherlands
- Poland
- Portugal
- Sweden
- Slovenia

Although many European countries have adopted the approach of dedicating spectrum for verticals, the exact portions of spectrum used for these licences vary across Europe. This can cause issues when it comes to harmonisation efforts or standardising equipment. However, the 3.8-4.2 GHz band is emerging as a potential solution for this problem. The band has the potential to become the de facto vertical band for Europe.

[69] https://www.rcrwireless.com/20221118/5g/americas-inventive-spirit-at-its-finest-cbrs-model-must-be-extended-says-cbrs-industry
[70] https://www.gsma.com/spectrum/resources/mobile-networks-for-verticals/
[71] https://www.statista.com/statistics/295519/germany-share-of-economic-sectors-in-gross-domestic-product/

Figure 5: Variation of spectrum frequencies for 5G verticals in different countries



Source: Variation of original graphic from ARCEP[72]

The UK was the first European country to release[73] the band in 2019 exclusively for local private and shared networks. France has also followed in the UK's footsteps by opening up the 3.8-4.0 GHz band for 5G verticals licences.[74] Norway has also begun offering free trial licences in the 3.8-4.2 GHz range.[75] Meanwhile, the Belgian regulator BIPT has also opened up the band. In January 2024, BIPT announced that it would begin accepting local licence applications in the band.[76]

The European Radio Spectrum Policy Group (RSPG) has previously published a consultation recommending Member States to explore the use of the 3.8 – 4.2 GHz band for 5G verticals.[77] In 2021, the European Union's Radio Spectrum Committee (RSC) mandated CEPT to develop harmonised technical conditions for the shared use of 3.8-4.2 GHz. However, the work on these efforts is still ongoing within the technical body. The final CEPT response to its mandate is expected to be published at the end of 2024.

In Asia, the notion of 5G private networks has some traction. In Japan,[78] a significant number of major companies have already acquired a spectrum licence.[79] The country's communications ministry started to issue licences for the deployment of local 5G networks in 3.7 GHz, 26 GHz and 28 GHz frequency bands as early as December 2019. In South Korea, the Ministry has made 100 MHz in the 4.7 GHz band and 600 MHz in the 28 GHz band available for campus networks at a fee of up to USD 88 per block.[80]

In China, The Ministry of Industry and Information Technology (MIIT) granted its first 5G private network licence in December 2022 to a domestic aeroplane manufacturer. The company will receive spectrum in the 5925-6125MHz

[72] https://www.lesnumeriques.com/pro/5g-industrielle-la-france-est-encore-loin-du-compte-n177861.html
[73] https://www.policytracker.com/ofcom-makes-3-8-4-2-ghz-available-for-private-networks/
[74] https://www.policytracker.com/france-seeks-to-expand-industrial-5g/
[75] https://www.policytracker.com/norway-offers-free-3-8-4-2-ghz-private-network-test-licences-to-businesses/
https://www.bipt.be/operators/publication/decision-of-19-december-2023-concerning-local-private-networks-in-the-3800-4200-mhz-band-and-the-assignment-of-e.212-mobile-network-codes
[77] https://www.policytracker.com/3-8-4-2-ghz-gains-momentum-after-rspg-backing/
[78] https://www.policytracker.com/japan-awards-its-first-commercial-licences-for-local-5g/
[79] https://www.policytracker.com/japan-awards-its-first-commercial-licences-for-local-5g/
[80] https://www.policytracker.com/south-korea-to-allocate-local-5g-spectrum-for-the-first-time/

and 24.750-25.15 GHz bands. The Chinese government is trying to promote industrial 5G networks, which it says is key to "boosting manufacturing prowess".[81]

In the US, the FCC is hoping that its three-tier CBRS (Citizens Broadband Radio Service) approach will allow enterprises to deploy private 4G and 5G networks and verticals. The CBRS regime has seen steady growth over the years as more companies begin using the band. A report by the National Telecommunications and Information Administration (NTIA) suggests the band is being widely adopted. It found that between April 2021 and January 2024, the number of CBRS devices grew by 121%.[82]

Nevertheless, internationally, the majority of the countries have not yet reserved frequencies for enterprises. In these markets, verticals will have to rely either on unlicensed spectrum, services provided by MNOs or secondary access to mobile spectrum. Unlicensed spectrum may prove to be successful for certain private network scenarios, but mission-critical applications are wary of unlicensed spectrum, which could have severe interference issues from other users.

Trends related to vertical trials

The 5G Observatory has been tracking the announcements of 5G trials in Europe and Internationally since 2018. The initial purpose of this was to monitor progress toward the 5G Action Plan. However, as commercial 5G networks have now launched in all EU-27 countries and the EU Digital Decade has realigned policy priorities, the 5G Observatory has shifted its focus to vertical trials.

5G verticals are still in the growth phase. 3GPP Release 16, which specifically focused on 5G vertical needs, was finalised in early 2020. Release 17, meanwhile, which introduced more vertical features, is expected to be frozen soon. Some industry stakeholders have referenced this as a potential reason for the slow development of 5G verticals, particularly when compared to the rollout of commercial 5G. Furthermore, the COVID-19 pandemic may have also contributed to delays.

5G verticals appear to be particularly developed in ports and have been extensively tested in several countries. Notable examples include:

Germany: The Hamburg Port Authority, Deutsche Telekom and Nokia have conducted an 18-month field test at the 'smart seaport' in Hamburg, Germany. This test focussed on the integration of 5G in traffic and infrastructure control.[83]

Belgium: Proximus and the Port of Antwerp have announced a 6-month trial of a private 5G network.[84]

Belgium: The Port of Zeebrugge and Citymesh have launched a private 5G network in the Port of Zeebrugge. The first phase involved connectivity for tugboats, air pollution detectors, cameras, and quay sensors.[85]

Estonia: Tallinn, Telia, Ericsson and Intel have created a 5G test and exploration area in the Port of Tallinn. This trial enabled internet connectivity for commercial cruise ship passengers while in port.[86]

[81] https://5gobservatory.eu/china-grants-first-5g-private-network-licence/
[82] https://www.fierce-network.com/wireless/new-report-shows-cbrs-working-says-ntia
[83] https://www.telekom.com/en/media/media-information/archive/port-of-hamburg-is-ready-for-5g-574536
[84] https://www.proximus.com/news/2020/20200205-Proximus-and-Port-of-Antwerp-are-preparing-for-the-port-s-digital-transformation-by-developing-a-private-5G-network-.html
[85] https://citymesh.com/en/news/port-of-zeebrugge-accelerates-innovation-by-investing-in-a-5g-network
[86] https://www.ericsson.com/en/cases/2017/5g-telia-tallink

Spain: Telefónica and APM Terminals have trialled 5G at the port of Barcelona. This test included connecting cranes, vehicles and people.[87]

From the verticals the 5G Observatory has been tracking, most appear to be occurring within private networks. See the private network subchapter for more on this, including country-by-country examples of private networks and their associated vertical trials.

[87] https://enterpriseiotinsights.com/20210311/channels/news/telefonica-apm-terminals-to-deploy-5g-and-c-v2x-port-of-barcelona?utm_campaign=20210311%20Enterprise%20IoT%20NewsletterThurs&utm_medium=email&utm_source=Eloqua

A1.6 5G private local networks

Deployment of 5G private local networks is growing across EU countries. These networks are not typically utilised by consumers (for mobile voice and data services) but use network elements and resources to provide dedicated secure services to private enterprises such as factories, plants, large campuses, ports and airports.

The 5G Observatory has produced a non-exhaustive list of private 5G networks, which is based on research of publicly available information. The Observatory team endeavour to obtain as much information on published private 5G network deployments as possible.

Over the past six months, the European landscape of private 5G network deployments has witnessed remarkable growth – with more than 20 new deployments identified since the last 5G Observatory report.

Over the last half-year, there has been significant growth in private 5G network installations across Europe, with 15 new deployments noted since the last report.

Most of these deployments (six) occurred in Germany, benefiting from a dedicated 5G spectrum for vertical networks. These included installations in sectors such as automotive manufacturing, machinery plants, and chemical manufacturing.

More recently, electric cars manufacturer Tesla announced in late May that the proof of concept for the private 5G network at its Berlin factory has transitioned into operational status. The network, which utilises the dedicated 3.7-3.8 GHz frequencies, will both indoor and outdoor coverage at the manufacturing plant to support applications ranging from wirelessly updating hundreds of cars to automated intralogistics within the plant's premises. Ericsson is the sole provider of 5G equipment.

Other countries with notable private 5G deployments in the last six months include Belgium, where it is being implemented at a hospital; Italy, for an energy infrastructure firm; and the Netherlands, where a conference and convention centre set up its own private 5G network. Interestingly, during the Rugby World Cup in October 2023, the Irish team deployed a private 5G network to aid game data analysis.

An overview of 5G private networks featuring a searchable table of major private network projects in the EU can be found here.

A1.7 Supply market trends (vendors): Major procurements, Open RAN, multivendor deployments

The telecoms equipment supply market is continuing to evolve with the expected emergence of Open RAN offers alongside those of traditional vendors. Several governments and regulatory bodies have expressed interest in these technologies, with the objective of further supporting a diversification of the vendor supply chain.

In recent times, major operators in European Union countries have continued to secure significant procurement deals. The 5G Observatory website offers a comprehensive table containing information about which vendors have successfully secured contracts for the development of 5G networks in MSs.

A1.8 EMF developments related to 5G policy goals

An EMF explainer is available online here.

Key highlights

The application of EMF limits remains inconsistent across MSs. In May 2024, the Italian Ministry of Business and Made in Italy raised the EMF limits in the country from the previous limit of 6 volts per meter (V/m) to 15 V/m[88].

The EECC recommends setting limits on exposure to electromagnetic fields (EMF) in line with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, which are about 50 times less than the level where there has been substantiated evidence of health damage. However, these limits are not binding on Member States, and there is inconsistency in how they are applied, and this can restrict the economic and social benefits of including 5G. Current EMF policies in the Member States are shown in the table below.

The Commission mandated[89] in June 2021 the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER)[90] to provide an opinion on the need for a technical revision of the annexes to the Council Recommendation 1999/519/EC[91] and Directive 2013/35/EU[92] for the frequency range 100 kHz to 300 GHz in view of the latest scientific evidence available, in particular the ICNIRP guidelines updated in 2020. This mandate further tasks SCHEER to update the SCENIHR Opinion of 2015 in light of the latest scientific evidence with regard to frequencies between 1 Hz and 100 kHz.

In its opinion published in April 2023, SCHEER advises positively on the need for a technical revision of the annexes in Council Recommendation 1999/519/EC and Directive 2013/35/EU with regard to radiofrequency electromagnetic fields (100 kHz to 300 GHz), because there is a need to recognise the recently introduced dosimetric quantities and establish limits for them.[93]

Table 7: Current EMF policies in the Member States

Countries	ICNIRP limits used?	Details
Austria	Yes	
Belgium	No	More restrictive than ICNIRP. Each region has its own limits, but those in Brussels were relaxed in August 2021
Bulgaria	No	Public exposure limit of 0.1 W/m^2 (300 MHz to 30 GHz)
Croatia	No	Power density limits are 16% of the ICNIRP guidelines
Cyprus	Yes	ICNIRP limits adopted in 2004

[88] https://5gobservatory.eu/italy-raises-electromagnetic-limits-to-promote-5g-deployment/
[89] https://health.ec.europa.eu/system/files/2021-07/scheer_q_023_0.pdf
[90] https://ec.europa.eu/health/system/files/2021-07/scheer_q_023_0.pdf
[91] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:31999H0519
[92] Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013L0035
[93] https://health.ec.europa.eu/consultations/scheer-public-consultation-preliminary-opinion-scientific-evidence-radiofrequency_en

Countries	ICNIRP limits used?	Details
Czech Republic	Yes	ICNIRP limits adopted in 2000
Denmark	Yes	
Estonia	Yes	ICNIRP limits adopted in 2002. No permit for ERP power <100W
Finland	Yes	
France	Yes	ICNIRP limits adopted in 2002
Germany	Yes	
Greece	No	60% of ICNIRP guidelines for base stations located less than 300 m from schools, hospitals... 70% of ICNIRP guidelines in other areas
Hungary	Yes	ICNIRP limits adopted in 2004
Italy	No	20 V/m as a general limit in open areas. 12 V/m inside buildings
Ireland	Yes	
Latvia	Yes	
Lithuania	Yes	
Luxembourg	No	Limit at 3 V/m per operator and per antenna system. About 0.2% of ICNIRP limit above 2 GHz
Malta	Yes	
Netherlands	Yes	
Poland	Yes	ICNIRP limits adopted in 2020
Portugal	Yes	ICNIRP limits adopted in 2004
Romania	Yes	
Slovakia	Yes	ICNIRP limits adopted in 2007
Slovenia	No	For sensitive and protected areas limits are lower
Spain	Yes	ICNIRP limits adopted in 2001
Sweden	Yes	
UK	Yes	ICNIRP limits adopted 2000

A1.9 5G corridors

Highlights (past six months):

Under the second CEF Digital calls for proposals, a further seven projects, consisting of three work projects and eight studies, were selected, covering 5G infrastructure deployments along transport corridors. More details on the projects can be found below.

The third call for proposals opened in October 2023 and was closed in February 2024. More information will be published in due time.

Following the publication of the White Paper "How to master Europe's digital infrastructure needs?" in February 2024, the development of 5G corridors funded under the CEF Digital Programme was mentioned as one way forward under Pillar I: Creating the "3C Network" – "Connected Collaborative Computing".[94] The White Paper highlights the importance of the corridors in providing a platform to test new technologies and applications in the domains of connected and autonomous driving, advanced logistics and IoT applications.

As part of the second CEF Digital calls for proposals, 42 projects were selected to receive up to €260 million of funding.[95] The projects cover a variety of topics, ranging from deployments of local 5G infrastructure to deployments of submarine cables for the security and resilience of backbone networks. As of January 2024, the European Commission has signed grant agreements with 37 of the projects selected.[96]

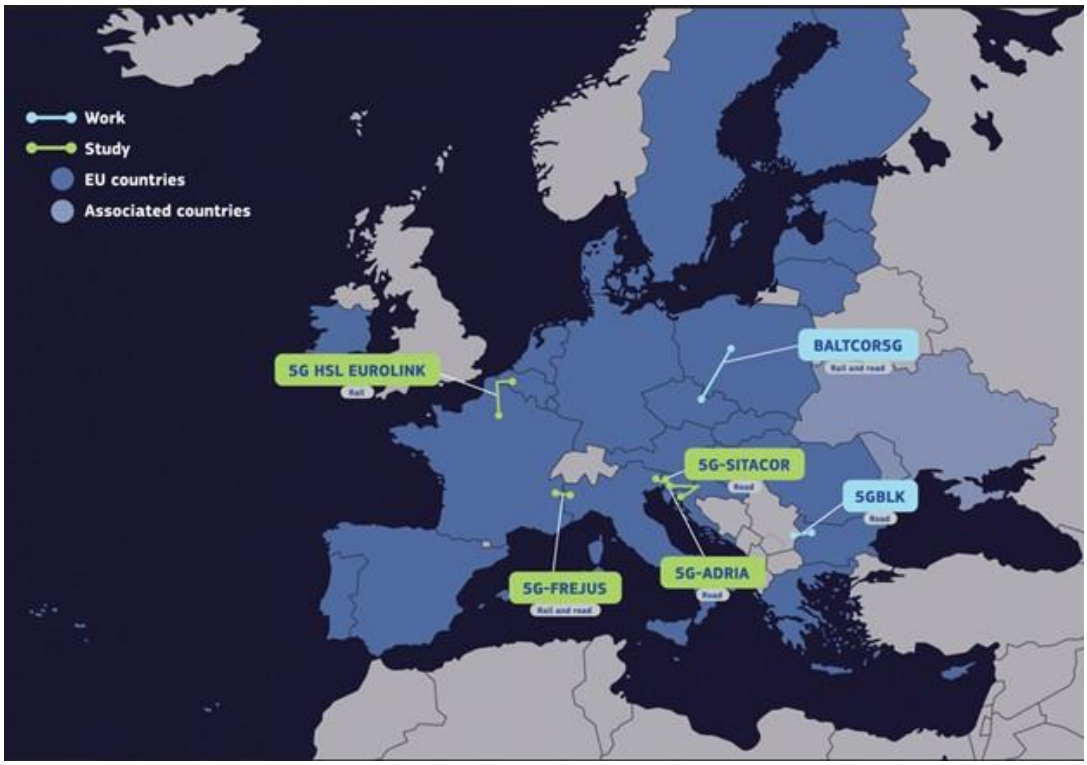
Following the second CEF Digital call and in continuation of the first call, seven 5G corridor projects were selected covering future-proof 5G infrastructure along transport corridors to enable Connected and Automated Mobility (CAM), consisting of three works and four inception studies. The projects complement 15 projects (seven works and eight inception studies) that were selected for the first call.[97]

The works encompass providing enhanced network infrastructure and deploying dark fibre to ensure uninterrupted connectivity across the Bulgarian and Serbian border, deploying 5G and C-v2x infrastructure on road corridors at the Polish-Czech border and building passive and active 5G infrastructure in the Irish Sea cross-border corridor. Meanwhile, the four inception studies will pave the way for future deployment projects along the transport corridors.[98]

The map below presents two of the works and the four inception studies selected under the second CEF Digital call.

[94] https://digital-strategy.ec.europa.eu/en/library/white-paper-how-master-europes-digital-infrastructure-needs
[95] https://hadea.ec.europa.eu/news/42-projects-selected-eu-funding-eu260-million-under-second-cef-digital-calls-2023-12-01_en
[96] https://digital-strategy.ec.europa.eu/en/news/over-eu250-million-support-secure-connectivity-across-eu-under-cef-digital-programme
[97] https://digital-strategy.ec.europa.eu/en/news/5g-corridors-call-2-selected-project-overviews
[98] Ibid.

Figure 6: 5G Corridor Projects under the second CEF Digital Call



Source: COM

The table below outlines the projects, including the amount of financing.

Table 8: 5G Corridor Projects under the CEF Digital second call

Title	Country	Grant Requested
5G High Speed Line EURO LINK Paris – Brussels 5GHSL Eurolink	FR	433.145,00 €
5G FRÉJUS - Inception study for the deployment of 5G in the Fréjus cross-border section between Italy and France	IT	499.723,00 €
5G cross-border deployment study between Slovenia and Croatia on the Mediterranean corridor	SL	735.225,00 €
Inception study for the deployment of 5G in the cross-border sections of the TEN-T Mediterranean and Baltic – Adriatic corridors between Italy and Slovenia	IT	342.742,00 €
Studies		**2.010.835,00 €**
5G BALKANS BULGARIA-SERBIA CROSS-BORDER CORRIDOR	BG	3.364.403,00 €
Baltic–Adriatic Corridor 5G and v2x network for future CAM services in cross-border section between Poland and Czech Republic	PL	2.058.524,46 €
Irish Sea 5G Corridor and v2x network for future CAM and FRMCS services in Ireland	IE	5.206.718,69 €

Title	Country	Grant Requested
Works		10.656.646,15 €
Total Call 2		**12.667.481,15 €**

Thereafter, the third CEF Digital call for proposals was closed for submission in February 2024. The call entails over €240 million of co-funding for selected tenders, of which HaDEA will co-fund €51 to €100 million contingent on the topic. The call covers the topics of 5G coverage along transport corridors, 5G and edge for Smart Communities and backbone connectivity for Digital Global Gateways.

The analysis from the previous report to introduce 5G corridors can be found here.

A1.10 5G cybersecurity toolbox implementation

Cybersecurity has been an important priority in the context of 5G development. The EU toolbox for 5G security is a set of robust and comprehensive measures for an EU-coordinated approach to secure 5G networks. The full paper providing an overview of the toolbox, as well as measures already taken by Member States can be found here.

Below are some highlights summarising the latest developments.

There have been no major developments in the implementation of the 5G Cybersecurity toolbox since the last report.

A1.11 Next generation networks contribution to reaching Green Deal targets and addressing sustainability issues

Sustainability is another key topic accompanying 5G development. The full paper providing an overview of commitments taken up by the industry (telecom operators) to reduce emissions and the role of 5G in the context of the targets set by the Green Deal can be found here.

In parallel with increasing pressure to reduce carbon emissions and rising energy prices, 5G network deployments have accelerated efforts from operators to improve their energy consumption and management, as reported in ETNO's State of Digital Communications 2024. Although 5G New Radio (NR) is more energy efficient than previous generation networks, its energy usage is expected to rise in line with the growing numbers of cell sites and antenna elements. Moreover, as 5G subscriptions still hold a relatively smaller market share, the network capacity is not yet fully utilised, resulting in unused and wasted energy. The adoption of new energy management solutions is one way to minimise this inefficiency, particularly by enabling power saving in cell site equipment, as it consumes the highest amount of energy across all network elements. Many operators have worked on intelligent power-saving features, such as a smart sleep function that allows network elements to go into standby during low-traffic periods and to supply more efficient energy sources during peak traffic. Additionally, decommissioning legacy 2G and 3G mobile networks and switching to a 4G/5G Single RAN deployment can significantly reduce energy usage. It is estimated that operators running 2G, 3G, 4G and 5G services on separate base stations can save up to 40% on energy usage by switching off 2G and 3G.

From the private sector and in conjunction with the 2024 Mobile World Congress (MWC), several industry players have shown continued efforts towards green and energy-efficient networks. For example, Intel previewed its new Xeon next-gen processors for 5G core networks, which allows for more optimised energy performance per rack and, thus, reduces energy consumption and infrastructure footprint. Meanwhile, Huawei developed its "0 Bit 0 Watt" solution to enable energy saving while still delivering premium 5G experiences. The solution entails intelligent resource and power scheduling technology to allocate network resources based on service types and scenarios.

In February 2024, Vodafone Germany announced its partnership with RWE, one of the largest energy suppliers in Germany, to power its 5G infrastructure in Germany using RWE's offshore wind farm in the North Sea starting from 2026. The Power Purchase Agreement will last for ten years and entails 250 GWh of wind energy annually to cover around 12,000 mobile base stations. Another German operator, O2 Telefónica has also reported the construction of its first energy self-sufficient 5G radio tower in Hesse, Germany, using solar cells and a highly efficient fuel cell to produce electricity on-site.

Annex II: Detailed country situation

The detailed country situation is available online via this link.