aetha

Review of mobile market and implications for upcoming spectrum award

White paper

10 July 2025

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1. Executive summary

1.1 Background

Spectrum is the "lifeblood" of mobile connectivity – without it, mobile networks cannot operate. Insufficient spectrum drives additional costs for mobile operators to meet traffic demand and hampers their ability to support high-speed data applications. Furthermore, the amount mobile operators pay for the radio spectrum is critical. Mobile operators face major financial pressures due to stagnating revenues and high levels of expenditure on their networks and the investment climate is very tight. 'Unnecessarily expensive' spectrum reduces investment in digital infrastructure (including 5G/6G, edge computing, AI and quantum communications) and hampers development of the economy. The GSMA estimates that mobile technologies and services generate around 5.8% of global GDP[1]. Delays or reduction in future investment risk slowing the digital transformation of the whole economy, ultimately dampening wider economic growth and delaying the move to climate neutrality.

Dutch mobile operators face the second-highest spectrum cost in Europe – ~15% of industry revenues versus the European average of 7.9%. A large contributor to this burden was the 2012 4G spectrum auction award process – the award conditions set prior to the auction, such as setting aside spectrum for potential new market entrants, inevitably led to significant escalation in spectrum prices throughout the auction.

In the coming years, the Ministry of Economic Affairs ('the Ministry') will be undertaking a further spectrum award process which will affect the mobile market for many years to come. The award is expected to comprise a mix of re-assigning usage rights across several bands that are vital for the continuing operation of the mobile networks, and are due to expire in 2030, as well as potential new frequency bands which could be used for 5G and new technologies such as 6G.

We focus on the upcoming spectrum award because the availability and price of spectrum are under the direct control of the Ministry, in contrast to many of the other sources of financial pressure outlined above. It is therefore an area in which the Ministry can make a positive contribution towards easing (or, at least, not exacerbating) operators' financial challenges, thereby improving the ability of the operators to invest in enabling the digital economy.

In view of the importance of this upcoming spectrum award to both the continuing provision of mobile services and future investment, KPN has asked Aetha Consulting Limited ('Aetha') to develop recommendations for the upcoming award drawing upon an assessment of the Dutch mobile market, European market trends and connectivity ambitions, and international best practices. The intention is that this paper will be a helpful input at an early stage in the Ministry's planning process.

1.2 Status of the mobile market

Our assessment of the mobile market in the Netherlands considered five key areas:

- **Market structure:** There are three mobile network operators of similar scale and the ACM's 2024 market review[2] reports that around 30 MVNOs collectively have a 15-20% of the retail market. The review also reports that 82% of consumers believe there are sufficient providers in the market.

[1] GSMA, 'The Mobile Economy 2025', 15 January 2025.

[2] ACM, 'Market review telecom market 2024', 16 January 2025, www.acm.nl/nl/publicaties/marktbeschouwing-telecommarkt-2024.

- **Pricing of services:** Prices are amongst the lowest in Europe, particularly for low-usage bundles which appeal to less wealthy customers – and have fallen by 60% over the period 2009-2024[3].
- **Network quality:** Network coverage and speeds are ranked by Umlaut[4] as being the highest across several large European countries. The average download speed in the Netherlands is 81.7Mbps, ranking third highest across Europe, based on Opensignal data[5].
- **Adoption and usage:** The Netherlands is one of the most digitally developed countries in Europe with the highest level of mobile broadband take-up[6] and is consistently in the top few countries across different rankings of digital adoption and connectivity[7,8].
- **Investment levels:** The telecoms investment-to-revenue ratio is the third highest in Europe and significantly above the European average[9].

In summary, the mobile market is currently working well with customers getting high quality service for low prices with high levels of digital adoption and investment in new technologies. Our findings are in line with prior narratives on the state of the Dutch digital economy by the Ministry which note that *"The Netherlands has a safe, reliable, high-quality and accessible digital infrastructure. This has made our country an international leader for years. Our digital infrastructure is an important foundation for our digitalised society. It contributes greatly to the current and future earning capacity and broad prosperity in our country."*[10]

It is important that any measures taken by government do not risk deteriorating this situation – as major challenges lie ahead. The Ministry itself notes that *"The sustainable earning capacity of telecom companies and other investors in telecommunications networks is important for a healthy sector."* [10]

1.3 European trends and future investment requirements

Mobile operators are suffering from the combination of:

- stagnating revenues with high levels of capital expenditure as a result of intense competition
- a lack of revenue streams from new technologies such as 5G
- the need for continual investment in the network to support traffic growth
- the cost of spectrum acquisition.

To face these challenges, mobile operators in several European countries have attempted to merge to gain scale and reduce costs. However, where consolidation has been approved, this has often come with remedies which, in many cases, have led to the creation of a new entrant operator. For example, such remedies were adopted in Germany, Italy and Spain. A further example of government-created

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[3] International Telecommunication Union, ITU DataHub, https://datahub.itu.int/ *(accessed 17 March 2025)*.

[4] Umlaut, 'Mobile Network Tests', 2025, https://www.connect-testlab.com/mobile-network-tests-overview.

[5] Opensignal, 'Mobile network speeds leaped ahead in 2023, but some markets lag behind', 1 February 2024, www.opensignal.com/2024/02/01/mobile-network-speeds-leaped-ahead-in-2023-but-some-markets-lag-behind.

[6] European Commission, 'DESI dashboard for the Digital Decade (2023 onwards)', https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/desi/metadata *(accessed 28 March 2025)*.

[7] GSMA, 'GSMA Mobile Connectivity Index', https://www.mobileconnectivityindex.com/index.html *(accessed 28 March 2025)*.

[8] European Commission, 'DESI dashboard for the Digital Decade (2023 onwards)', https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/desi/metadata *(accessed 28 March 2025)*.

[9] International Telecommunication Union, ITU DataHub, https://datahub.itu.int/ *(accessed 17 March 2025)*.

[10] See Ministerie van Economische Zaken en Klimaat, 'De staat van de digitale infrastructuur: De ruggengraat van onze digitale economie', January 2024.

market entry occurred in the 2012 4G multi-band award in the Netherlands and was one of the main factors leading to the high cost of spectrum, however this did not result in a sustainable fourth operator.

Major regulatory changes are taking place across European mobile markets. The Letta report on the status of the European Single Market[11] and the Draghi report on European competitiveness[12] have both noted how EU operators suffer from a lack of scale - *"a stunning size deficit" (Letta)* - and how lower prices in Europe have benefited citizens but *"have also reduced the industry profitability, and, as a consequence, investment levels in Europe, including EU companies' innovation in new technologies" (Draghi)*. The Letta report goes on to say that *"keeping the focus only on pro-entrant regulation, would be detrimental for a technology switch towards advanced networks that require massive investments"* and that *"The scale of investments necessary in new technologies (for example edge/cloud, 6G, AI) implies that due consideration should be given to the necessity of some level of consolidation within national markets"*.

Consequently, the European focus is now on scale and consolidation rather than fostering market entry. Operators are facing significant investment in the future to achieve the European Commission's vision of a converged 'Connected Collaborative Computing Network'. Such investment challenges include completing the roll-out of high-speed standalone 5G services, making networks more secure, robust and sustainable including moving to a more open network architecture, deploying edge computing nodes, AI factories, quantum infrastructure. as well as the 6G roll out in the 2030s.

The Dutch Government's recent non-paper on a strong and competitive connectivity ecosystem[13] noted that *"The future of connectivity in the EU is of a highly strategic nature and goes well beyond fiber and 5G networks."* and called upon European governmental bodies and financial institutions to *"explore the possibility of facilitating large scale investment in cutting edge clouds and connectivity infrastructure through ambitious public-private partnerships."*

The upcoming spectrum award must support these ambitions rather than risk taking the Netherlands backwards in the digital order. In particular, taking money out of the industry through an award process which leads to high spectrum prices, would be very damaging to the operators' ability to invest. Likewise, artificially seeking to introduce a new entrant through the spectrum award process would run counter to the objective of achieving scale.

1.4 Recommendations for the upcoming spectrum award

We present our recommendations for the upcoming spectrum award process, drawing upon international best practices, to ensure the Netherlands is best placed to maximise mobile infrastructure investment and capitalise upon the wider economic growth opportunities arising from this.

[11] Enrico Letta, 'Much more than a market: Speed Security, Solidarity: Empowering the Single Market to deliver a sustainable future and prosperity for all EU citizens", April 2024.

[12] Mario Draghi, 'The future of European Competitiveness: Part B | In-depth analysis and recommendations', September 2024.

[13] Government of the Netherlands, 'NL non-paper: Towards a strong and competitive European digital connectivity ecosystem', 20 May 2025.

Spectrum to be renewed/newly awarded	The award process should be held no later than 2028, allowing sufficient time ahead of the expiry of the licences in the 800MHz, 900MHz, 1800MHz and 2600MHz bands. The upper 6GHz band should be included in this award if European harmonisation of this band for IMT has occurred, as is looking increasingly likely. At least part of the 26GHz band should be included in the award provided that demand for and the equipment ecosystem develop as expected over the next few years. Spectrum should be packaged in block sizes that are not so small as to prevent efficient use, whilst also not too large to prevent operators competing over marginal blocks – for example, in the case of sub-1GHz spectrum, a block size of 2×5MHz is typically used.
Licence conditions	Licences should ideally be infinite in duration. At the very least, a minimum 20-year licence duration should be awarded with a clear assumption of renewal. The spectrum should continue to be awarded on a service- and technology-neutral basis. Stringent coverage obligations should be imposed on license holders of low- and mid-band spectrum and licences for spectrum in each band should include a strict roll-out obligation ('use it or lose it') to ensure efficient use is made of the spectrum.
Award process	Direct licence renewal via an administrative process could be appropriate when needed to ensure service continuity and for those bands where demand does not outstrip supply. Otherwise, a simple and well-proven auction format with transparency during the bid rounds and predicable outcomes (no surprises) should be used. Formats such as the SMRA/clock hybrid, simple clock auction or the SMRA are likely to meet these requirements.
Pro-competition measures	Spectrum caps should be set across bands which are close substitutes. A cap level of 40% (as has historically been used) continues to be appropriate as it enables a minimum of three competitors to have a material holding of spectrum in each category of bands. Spectrum should not be set aside for a new entrant as this creates an artificial shortage of spectrum, limits the achievable service quality and increases costs of providing services to customers. Such a reservation is likely to increase spectrum prices in the auction which will hamper the operators' ability to invest and ultimately will get passed onto consumers. Furthermore, windfall gain opportunities may be created for speculators as has occurred in the Netherlands in the past.
Spectrum prices	Reserve prices for the spectrum should be set at the time of the auction, taking account of the market situation at that time. At present, the combination of stagnating total market revenues coupled with the need to hold ever larger amounts of spectrum to support traffic growth, is leading to a considerable reduction in spectrum prices in per MHz terms.

In summary, the Ministry should take due care to ensure that the upcoming spectrum award does not unduly risk damaging the health of the mobile market or the financial capability of operators to meet the coming investment requirements, especially if the main outcome of any radical interventions may simply be to create windfall gains for (potentially international) speculators.

2. Introduction

This report has been prepared by Aetha Consulting Limited ('Aetha') on behalf of KPN to discuss the state of the mobile market in the Netherlands, key trends and the implications of these for the next spectrum award. The intention is that this paper will be a helpful input at an early stage in the Ministry of Economic Affairs ('the Ministry's') planning process for an award where the outcome could determine the health of the mobile telecoms market for many years to come with further impacts on the digital transformation process in the Netherlands, future economic growth and the move to climate neutrality.

Our suggestions are based on best practices observed by Aetha from supporting governments/regulators and mobile operators in over 120 spectrum award processes in over 50 countries during the past 14 years (see Annex A for further details of our experience). We have also experienced situations where decisions on spectrum awards by regulators/governments have damaged the mobile market and reference examples in this report.

2.1 Background

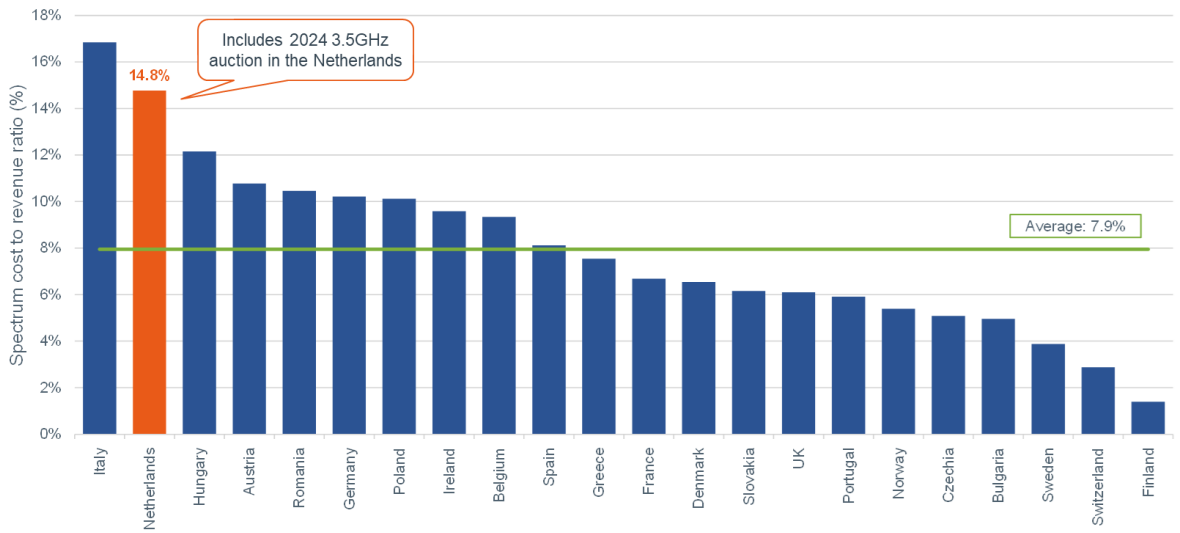
Mobile connectivity is vital for day-to-day life. As well as providing communications between individuals, it plays a vital role in the functioning of the economy through increasing business productivity and enabling digital transformation. The GSMA estimates that mobile technologies and services now generate around 5.8% of global GDP[14].

Spectrum is the "lifeblood" of mobile connectivity – without it, mobile networks cannot operate. Insufficient spectrum drives additional costs for mobile operators to meet traffic demand and hampers their ability to support high-speed data applications. Furthermore, the amount mobile operators pay for the radio spectrum is critical. Mobile operators face major financial pressures due to stagnating revenues and high levels of expenditure on their networks and the investment climate is very tight, so 'unnecessarily expensive' spectrum reduces investment in digital infrastructure – including 5G/6G, edge computing, AI and quantum communications. Delays or reduction in future investment risk slowing the digital transformation of the whole economy, ultimately dampening wider economic growth and delaying the move to a climate neutral economy.

As shown in Figure 2-1, Dutch mobile operators face the second-highest spectrum cost in Europe – ~15% of industry revenues versus the European average of 7.9%. A large contributor to this burden was the 2012 4G spectrum auction award process – the award conditions set prior to the auction, such as setting aside spectrum for potential new market entrants, inevitably led to significant escalation in spectrum prices throughout the auction.

[14] GSMA, 'The Mobile Economy 2025', 15 January 2025.

Figure 2-1: Annualised spectrum costs (auction payments and annual fees) as a proportion of mobile revenues[15]



In the coming years, the Ministry will be undertaking a further spectrum award process. This is expected to comprise a mix of re-assigning usage rights across several bands that are vital for the continuing operation of the mobile networks, and are due to expire in 2030, as well as potential new frequency bands, which could be used for 5G and new technologies such as 6G. The outcome of this award will affect the mobile market for many years to come.

We focus on the upcoming spectrum award because the availability and price of spectrum are under the direct control of the Ministry, in contrast to many of the other sources of financial pressure outlined above. It is therefore an area in which the Ministry can make a positive contribution towards easing (or, at least, not exacerbating) operators' financial challenges, thereby improving the ability of the operators to invest in enabling the digital economy.

In view of the importance of this upcoming spectrum award to both the continuing provision of mobile services and future investment, KPN has asked Aetha to develop recommendations for the award, drawing upon an assessment of the Dutch mobile market, European market trends and connectivity ambitions, and international best practices. The intention is that this paper will be a helpful input at an early stage in the Ministry's planning process.

2.2 Structure of this document

The remainder of this document is structured as follows:

- Section 3 presents our assessment of the Dutch mobile market, outlining the condition of the market at this current time.
- Section 4 covers the wider European mobile market trends and the upcoming digital infrastructure investment challenges that the industry is facing, providing insight into future requirements that policymakers need to have top-of-mind.

[15] For full details of the methodology used for this analysis, please see Aetha report 'European benchmark of relative spectrum costs', July 2024, https://www.aethaconsulting.com/european-benchmark-of-relative-spectrum-costs/.

- Section 5 details our recommendations for the upcoming spectrum award, drawing upon international best practices and our review of the mobile market. We hope this will be a valuable input to the Ministry as it makes key decisions on this award process that will inevitably shape the market for the coming decade.

3. Status of the mobile market

In order to give a clear picture of the starting point, in this section we assess the Dutch mobile market based on the following dimensions compared to other European countries:

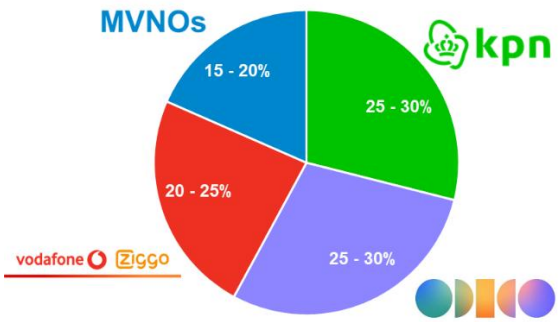
- **Market structure:** reviewing the retail and wholesale markets and assessing the level of competition
- **Pricing of services:** assessing the overall pricing levels, the pricing of lower-usage mobile plans and the trends in pricing
- **Network quality:** considering network speeds and coverage
- **Adoption and usage:** considering mobile broadband take up, connectivity, 5G adoption and mobile screen time
- **Investment levels:** reviewing the level of telco investment and the investment-to-revenue ratio.

Where available, we present data for the EU27+ group, which includes EU member states as well as the UK, Iceland, Norway, Switzerland and Lichtenstein. Due to data availability, a subset of EU27+ is shown in some cases, and other countries are included to provide further comparison in other instances.

3.1 Market structure

The Dutch mobile market has three mobile network operators (MNOs) - KPN, VodafoneZiggo and Odido - as well as many mobile virtual network operators (MVNOs) which enhance competition at the retail level. Figure 3-1 shows that KPN and Odido have similar subscriber market shares of 25-30%, while VodafoneZiggo has 20-25%, at the retail level.[16] Notably, no single operator dominates, nor is there a significantly weaker operator.

Figure 3-1: Mobile subscriber market shares, Q3 2024 [Source: ACM]



The ACM's 2024 market review[17] reports that more than 30 providers offer mobile telecoms services and that MVNOs collectively serve 15-20% of the subscribers. The market review also shows that 82% of consumers believe there are sufficient providers in the market. Compared to other OECD countries,

[16] ACM, 'Telecom Monitor for Q3 2024', 19 December 2024, www.acm.nl/en/publications/acm-telecom-monitor-q3-2024-mobile-data-consumption-breaks-record-again-fiber-optic-also-continues-grow.

[17] ACM, 'Market review telecom market 2024', 16 January 2025, www.acm.nl/nl/publicaties/marktbeschouwing-telecommarkt-2024.

the market has a higher-than-average number of MVNOs, and their total market share is above average.[18]

In the wholesale market, MVNOs negotiate agreements with MNOs to lease network capacity. The ACM indicates that while switching MNOs presents challenges, *"the MNOs are disciplined in practice by the MVNOs as a result of the threat of a switch" [translation]*[19] helping to maintain a competitive environment at the wholesale level.

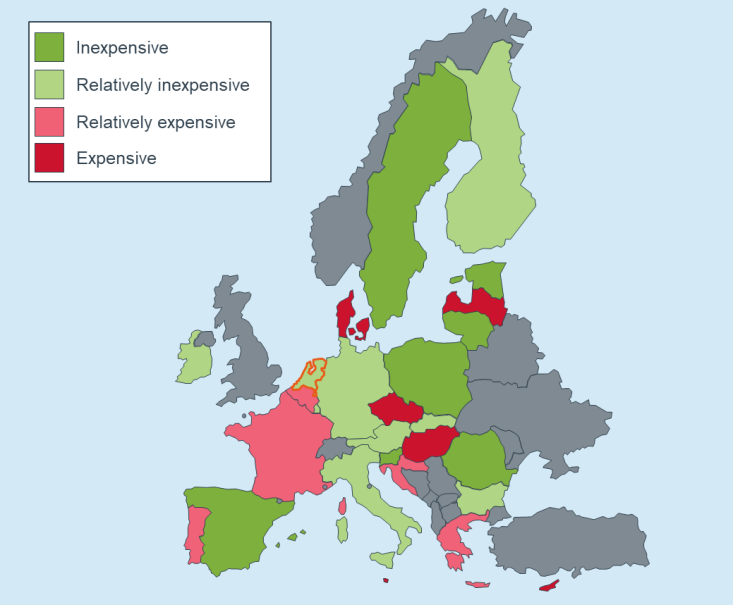
Overall, the mobile market appears to be competitive. The three MNOs have similar market shares, and at the retail level the presence of MVNOs further enhances competition, with new MVNOs continuing to enter the market. At the wholesale level there is also strong competitive pressure since MVNOs can leverage the threat of switching to negotiate competitive deals.

3.2 Pricing of services

To assess the price of mobile services, we consider the overall pricing of mobile broadband services, the pricing of low-usage bundles and overall trends in service pricing. We have focussed on low-usage bundles in this analysis because they are typically purchased by the least wealthy consumers, who feel the effects of competition and market dynamics most keenly. Therefore, this analysis addresses the most important area of the market from a citizen's perspective.

A 2021 European Commission (EC) study[20] on broadband prices classed the Netherlands as 'relatively inexpensive' for mobile broadband, as seen in Figure 3-2 below. Based on pricing for five data-only baskets and seven handset-based baskets, countries were clustered into four pricing categories: 'inexpensive', 'relatively inexpensive', 'relatively expensive' and 'expensive', using k-means clustering.

Figure 3-2: Major clusters of European countries by price level over all usage baskets (mobile broadband), 2021 [Source: EC]



[18] OECD Digital Economy Papers, 'Emerging trends in communication market competition', 24 September 2021, doi.org/10.1787/4ad9d924-en.

[19] ACM, 'KPN is allowed to take over Youfone', 21 March 2024, www.acm.nl/nl/publicaties/kpn-mag-youfone-overnemen-concentratiebesluit.

[20] European Commission, 'Mobile and Fixed Broadband Prices in Europe 2021', 28 July 2022, https://digital-strategy.ec.europa.eu/en/library/mobile-and-fixed-broadband-prices-europe-2021.

Figure 3-3 below shows the price of a 'mobile data and voice low-consumption basket' in 2024, expressed as a percentage of each country's gross national income (GNI) per capita.[21] In the Netherlands, this mobile package costs 0.26% of GNI per capita placing it in the cheapest third of EU27+ countries.

The basket, as defined by the ITU, includes at least 70 voice minutes, 20 SMSs and 500MB of data using at least 3G technology. In practice, the packages included in this analysis for 2024 likely offer more data and access to 4G/5G technology.

Figure 3-3: Mobile data and voice low-consumption basket as % of GNI per capita, 2024 [Source: ITU]

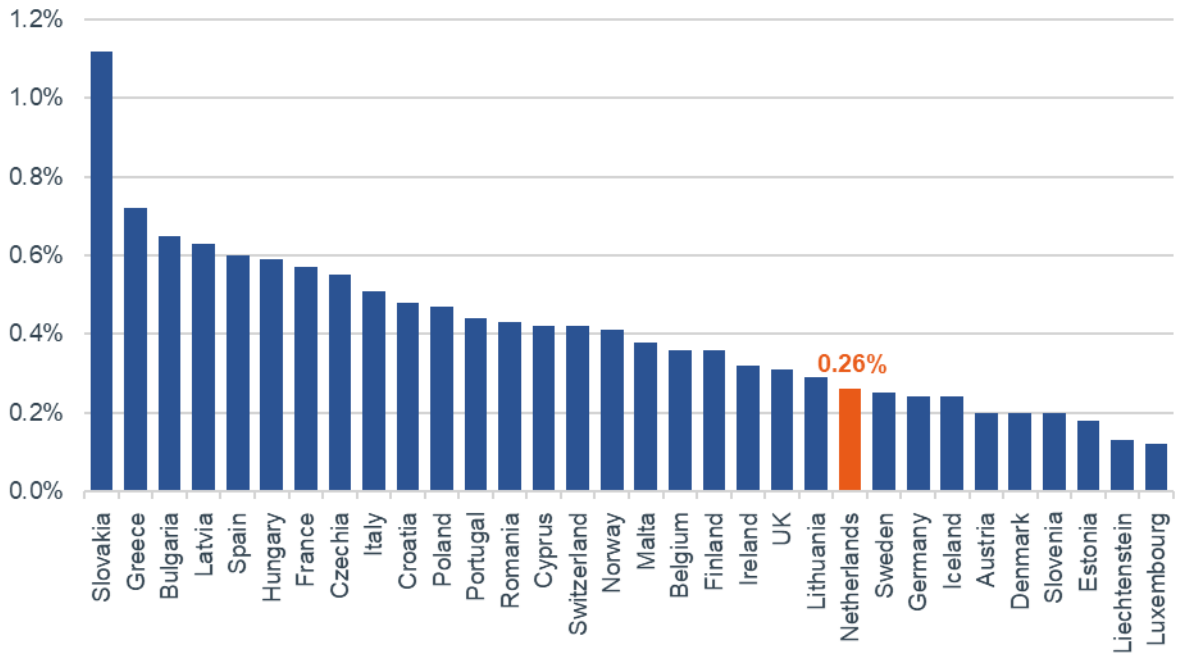


Figure 3-4 below shows that the cheapest 10GB package in the Netherlands costs EUR7 per month, which is comfortably below the European average of EUR12. The pricing information comes from the ACM's 2024 market review[22], which reports European comparisons for the cost of a 10GB data package in 2024.

[21] International Telecommunication Union, ITU DataHub, https://datahub.itu.int/ *(accessed 17 March 2025)*.

[22] ACM, 'Market review telecom market 2024', 16 January 2025, www.acm.nl/nl/publicaties/marktbeschouwing-telecommarkt-2024.

Figure 3-4: Cheapest subscriptions for 10GB packages, 2024 [Source: ACM]

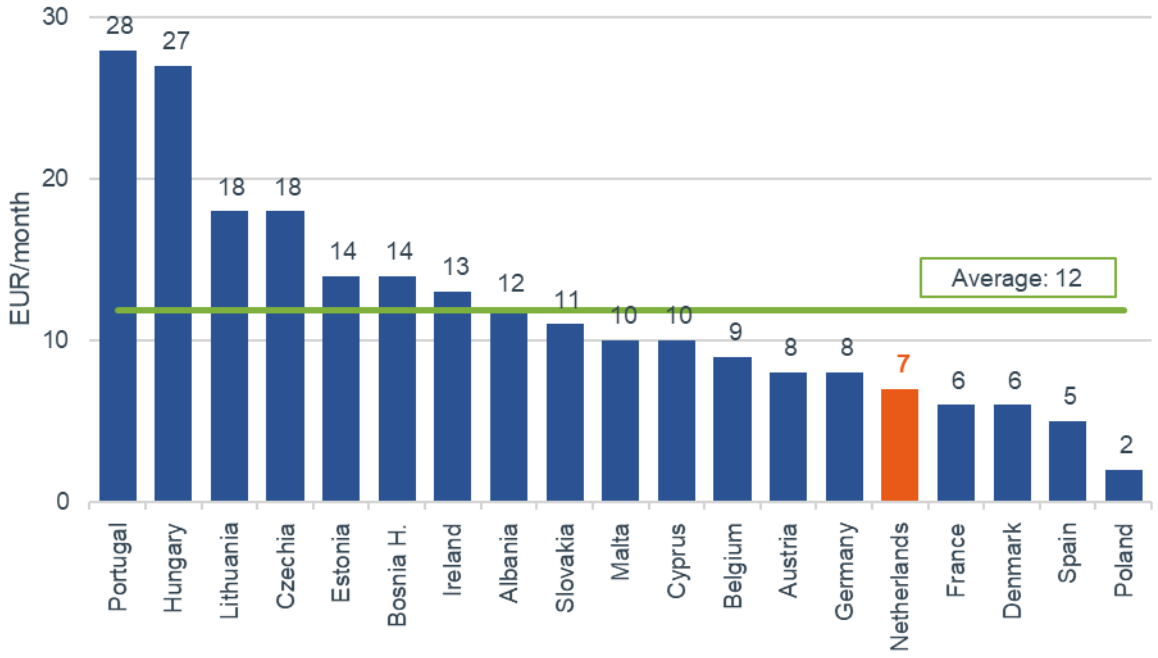


Figure 3-5 below shows current prices for the cheapest mobile packages from Dutch mobile service providers containing at least 2GB, 5GB and 10GB of data per month. Two of the providers offer 10GB packages for less than EUR7 per month and four offer 10GB for less than EUR10. The cheapest package in the table is 2GB from Lyca for EUR4.50 per month.

Figure 3-5: Pricing of low-usage packages, 2025 [Source: Service provider websites accessed 2 April 2025]

Provider	Cheapest packages (EUR/month)		
Data package size	2GB	5GB	10GB
Youfone	5.69	5.69	6.56
Lyca	4.50	5.63	6.75
Lebara	5.25	6.56	7.88
Simyo	7.00	7.50	8.00
Odido	14.00	15.00	15.00
KPN	15.00	15.00	17.50
Vodafone	14.00	20.00	20.00

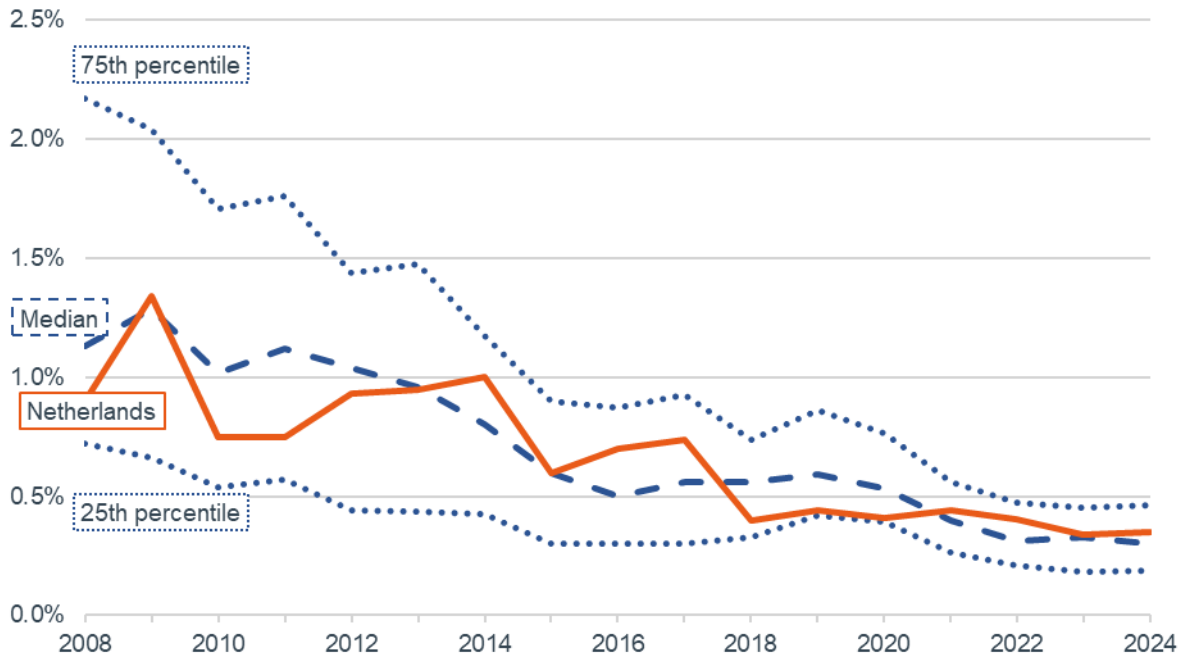
Over the past 15 years, mobile service prices have decreased significantly. The cost of a 'low-usage basket'[23] in the Netherlands fell from ~EUR43 per month in 2009 to ~EUR17 per month in 2024; a EUR26 per month price reduction (i.e. 60%), in line with the median price decrease for Europe of 57%

[23] The ITU definition of the 'low-usage basket' is: *"from 2008 to 2017, the basket is composed of 30 calls and 100 SMSs; from 2018, it is composed of 70 voice minutes and 20 SMSs"*.

over the same period.[24] Note that by 2024, the ITU 'low-usage basket' does not always represent the cheapest basket as it does not include data. Indeed, in the Netherlands the ITU 'Mobile data and voice low-consumption basket' price was ~EUR12 in 2024.

Figure 3-6 below illustrates that pricing in the Netherlands of a 'low-usage basket', as a percentage of GNI per capita, has consistently remained below the 75th percentile of the EU27+ countries and often around the median.

Figure 3-6: EU27+ mobile low usage basket pricing as % of GNI per capita [Source: ITU]



In conclusion, mobile services pricing in the Netherlands is generally lower than the European average particularly for low-usage customers. Prices are slightly below average for low-usage plans and have decreased at a similar rate to the rest of Europe over the past 15 years.

3.2.1 Network quality

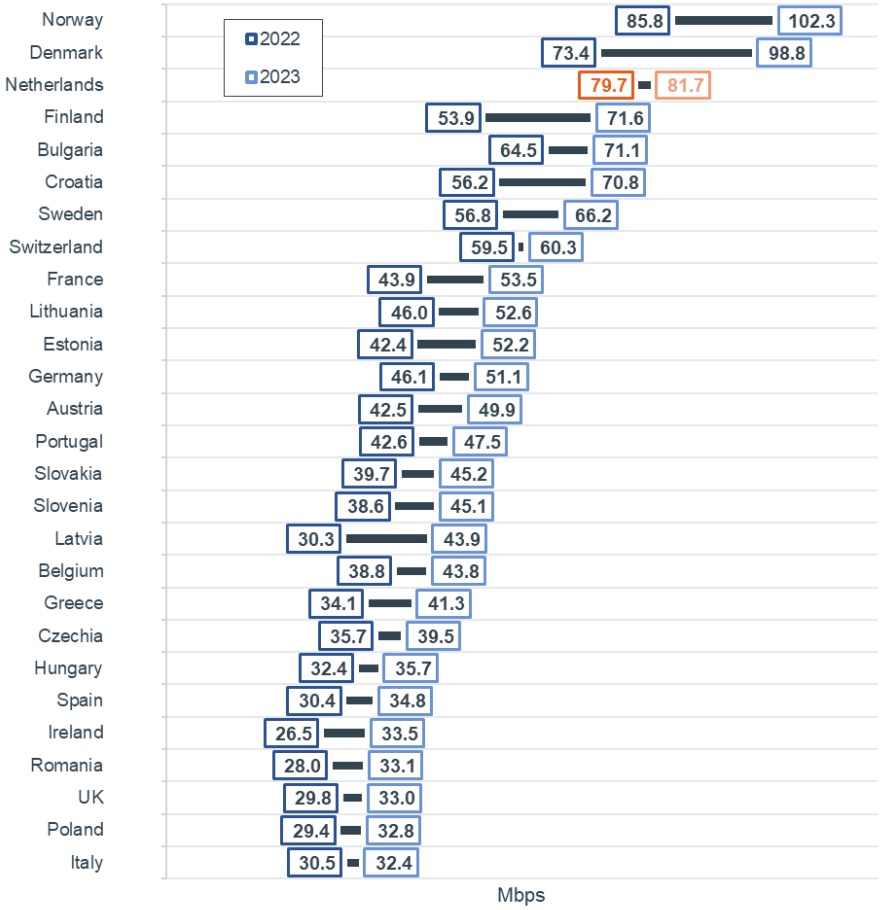
We assess network quality by considering download speeds and network coverage compared with other European countries. These are the most common metrics for network quality which are easy to compare across different countries.

The average download speed in the Netherlands was 81.7Mbps in 2023 (and was 79.7Mbps in 2022), which is the third highest across Europe, based on Opensignal data.[25] Opensignal measures download speed experience from users with 5G devices and subscriptions, but considers 2G, 3G, 4G and 5G speeds, and the availability of each generation of technology. This gives a realistic 'everyday speed experience' for a mobile user.

[24] International Telecommunication Union, ITU DataHub, https://datahub.itu.int/ *(accessed 17 March 2025)*.

[25] Opensignal, 'Mobile network speeds leaped ahead in 2023, but some markets lag behind', 1 February 2024, www.opensignal.com/2024/02/01/mobile-network-speeds-leaped-ahead-in-2023-but-some-markets-lag-behind.

Figure 3-7: Average download speed experience in 2022 and 2023 [Source: Opensignal]



Network coverage is another key component of network quality. Figure 3-8 below shows that all mobile operators have coverage quality above 99% and coverage reach of at least 97%.[26] The average coverage quality in the Netherlands is 99.5% and the average coverage reach is 98.3%.

Amongst the six countries that Umlaut has recently performed network tests for (Germany, Austria, Switzerland, UK, Spain and the Netherlands), the Netherlands has the highest coverage reach and quality. Across all six countries, the average quality is 97.7% and the average reach is 95.8%.[27]

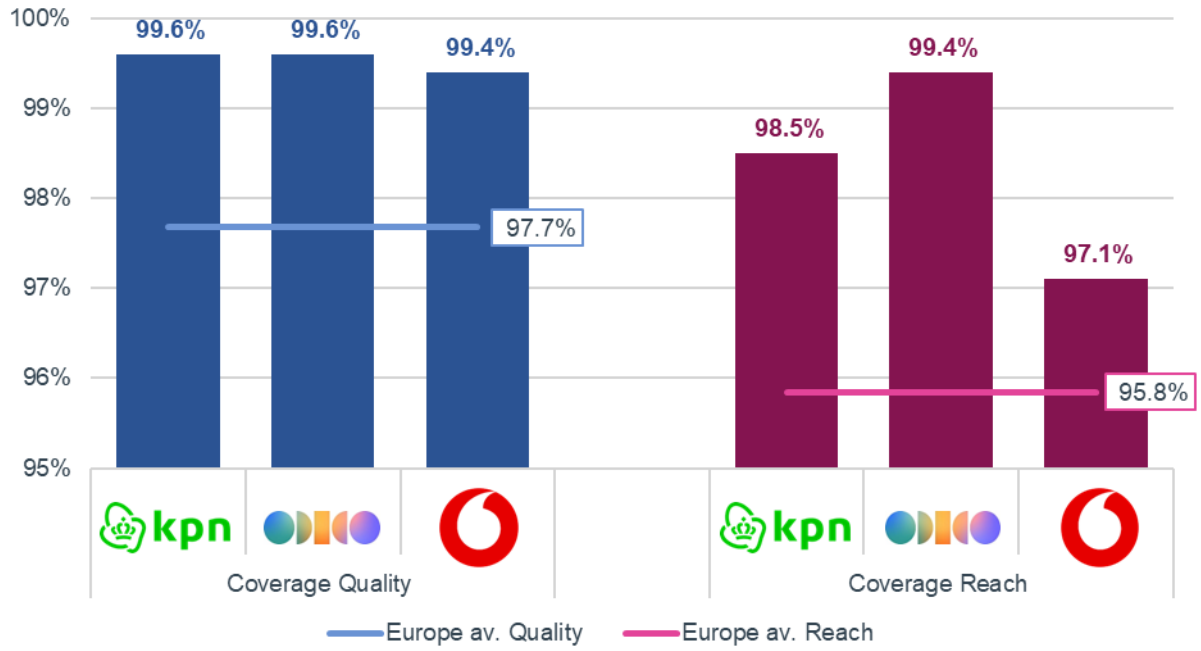
- **Coverage Reach** is measured by splitting the country into 2×2km tiles, one point is awarded for each tile that has 3G coverage, and three points are awarded if a tile has 4G or 5G coverage. The output is a percentage of the maximum possible score.[28]
- **Coverage Quality** indicates the average percentage of 4G or 5G coverage in the 2×2km tiles averaged over the area covered by all three MNOs.

[26] Umlaut, 'The 2025 Mobile Network Tests in the Netherlands, 2025, https://www.connect-testlab.com/downloads-the-netherlands.

[27] Umlaut, 'Mobile Network Tests', 2025, https://www.connect-testlab.com/mobile-network-tests-overview.

[28] Note that KPN and Vodafone have switched off their 3G networks resulting in lower scores for 'Coverage Reach' than Odido which is continuing to operate a 3G network.

Figure 3-8: Network coverage by operator, 2025 [Source: Umlaut]



Furthermore, KPN's network *"scored the highest worldwide"*[29] of the countries tested by Umlaut in its overall network test, which includes many quality KPIs.

In conclusion, all three mobile networks offer excellent coverage and download speeds making the Netherlands a European leader in network quality.

3.3 Adoption and usage

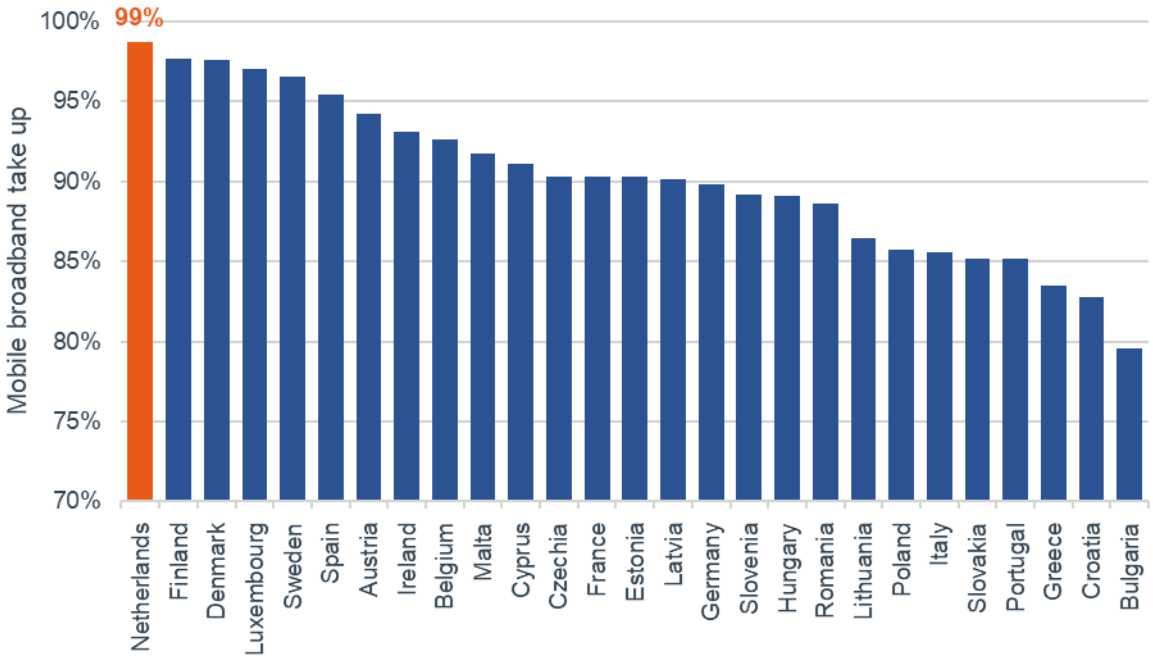
We consider a range of metrics to assess the levels of mobile adoption and usage including mobile broadband take-up, mobile connectivity, 5G adoption and mobile screen time.

Figure 3-9 below shows that 99% of the population accesses the internet on a mobile device – the highest percentage in Europe.[30]

[29] KPN, 'KPN mobile network tested as best for fourth time in a row by umlaut', 4 March 2025, https://www.overons.kpn/nieuws/en/kpn-mobile-network-tested-as-best-for-fourth-time-in-a-row-by-umlaut/.

[30] European Commission, 'DESI dashboard for the Digital Decade (2023 onwards)', https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/desi/metadata *(accessed 28 March 2025)*.

Figure 3-9: Mobile broadband take up, 2023 [Source: EC]



The GSMA 'connectivity index'[31] evaluates countries based on four 'Enablers':

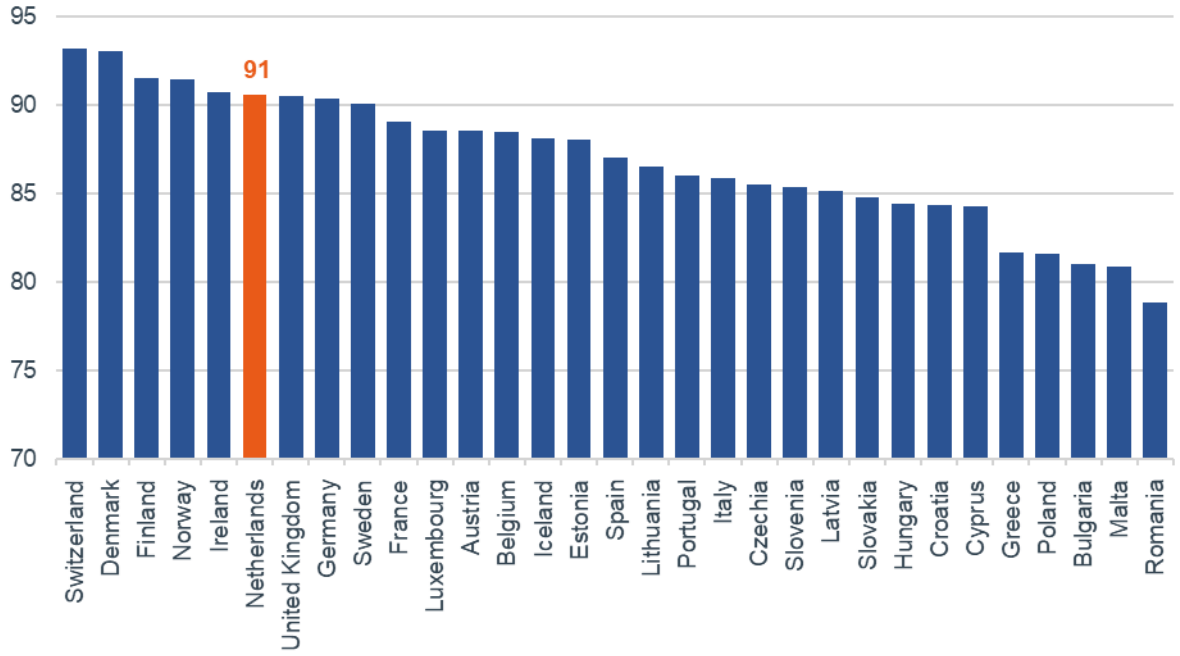
1. 'Infrastructure': network coverage, performance and spectrum available
2. 'Affordability': data and handset costs to consumers
3. 'Consumer Readiness': mobile ownership, technical skills and gender equality
4. 'Content & Services': local relevance[32] and online security.

Figure 3-10 below shows the Netherlands scores 91/100, ranking sixth in Europe, demonstrating excellent connectivity.

[31] GSMA, 'GSMA Mobile Connectivity Index', https://www.mobileconnectivityindex.com/index.html *(accessed 28 March 2025).*

[32] Includes factors such as number of top level domains per person, mobile social media penetration and language accessibility of top ranked apps.

Figure 3-10: Mobile connectivity index (out of 100), 2023 [Source: GSMA]



5G adoption is also strong in the Netherlands. Figure 3-11 below shows a 5G SIM penetration of 104%, ranking the Netherlands third in Europe.[33]

Additionally, the Netherlands scores 50/100 in the GSMA 5G connectivity index[34] placing it in the upper third of European countries, as shown in Figure 3-12 below.

The GSMA 5G connectivity index is made up of two factors:

1. '5G infrastructure': spectrum available, network infrastructure, and consumer experience
2. '5G service': affordability, adoption and market development.

[33] European Commission, 'DESI dashboard for the Digital Decade (2023 onwards)', https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/desi/metadata *(accessed 28 March 2025)*.

[34] GSMA, 'The Mobile Economy Europe 2025', 2025, https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-economy/europe/.

Figure 3-11: 5G SIM penetration, 2023 [Source: EC]

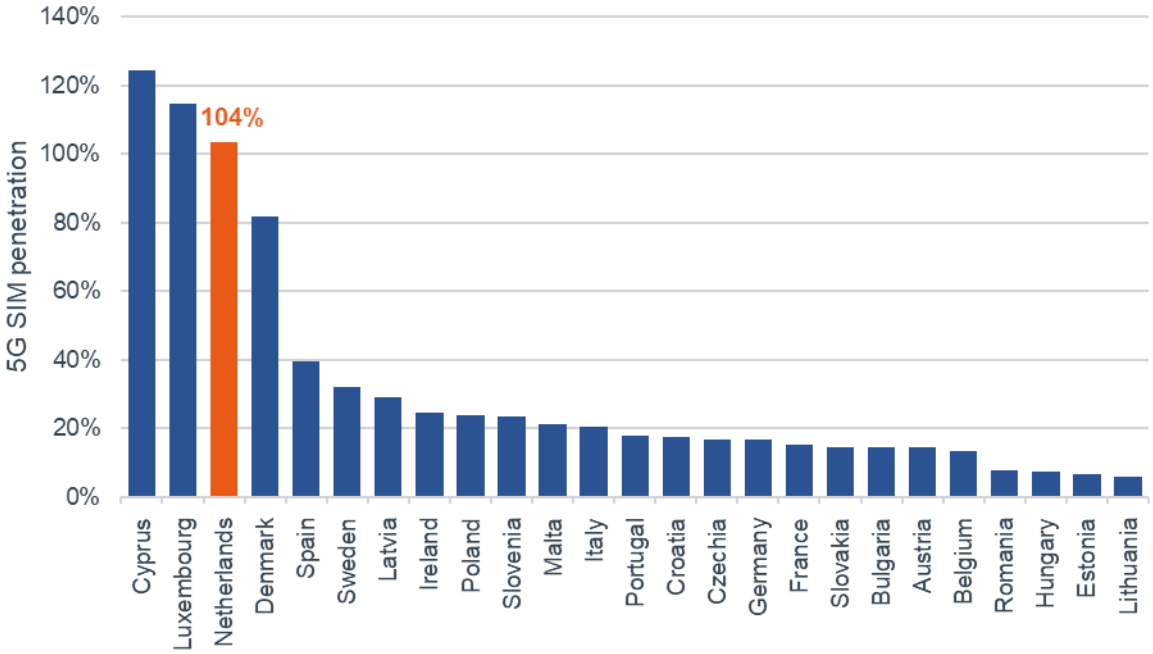


Figure 3-12: 5G connectivity index (out of 100), Q3 2024 [Source: GSMA]

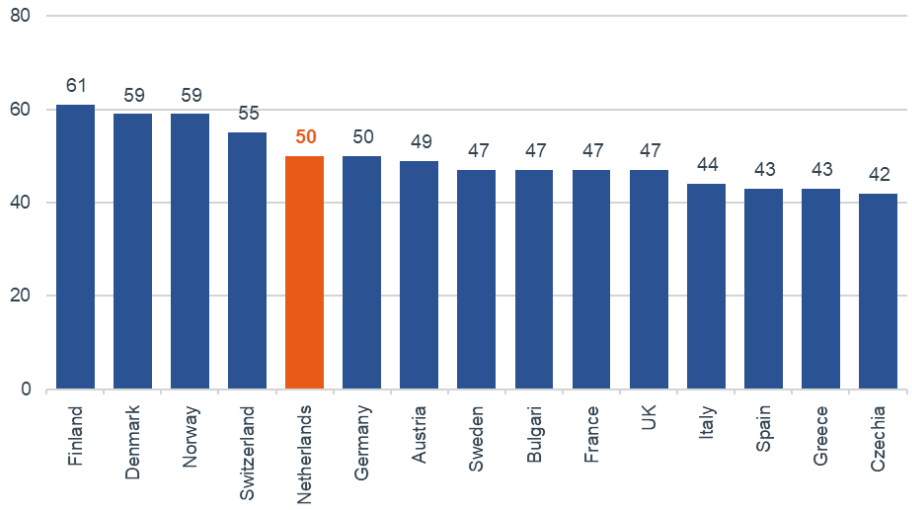
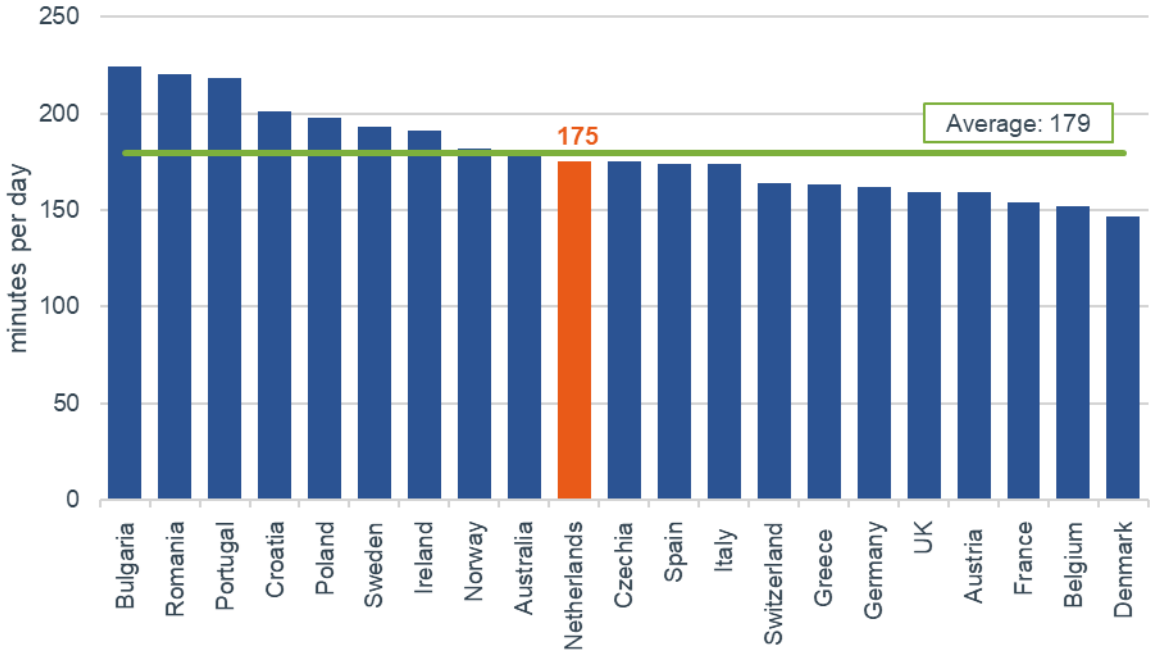


Figure 3-13 below shows that Dutch consumers spend an average of 175 minutes per day (~3 hours) using the internet on a mobile device, which aligns with the European average of 179 minutes.[35] Many factors affect screen time including economic development, wealth of an individual, and national social norms.[36]

[35] Comparitech, 'Screen Time Statistics: Average Screen Time by Country', 26 March 2025, https://www.comparitech.com/tv-streaming/screen-time-statistics/.

[36] Ooma, 'Countries around the world ranked by average screen time', 15 January 2025, https://www.ooma.com/blog/countries-around-the-world-ranked-by-average-screen-time/.

Figure 3-13: Screen time using the internet via a mobile device, 2025 [Source: Comparitech]



In conclusion, the Netherlands demonstrates high levels of digital adoption, strong mobile infrastructure making and average levels of mobile screen time usage. This indicates that it is among the most digitally developed markets in Europe.

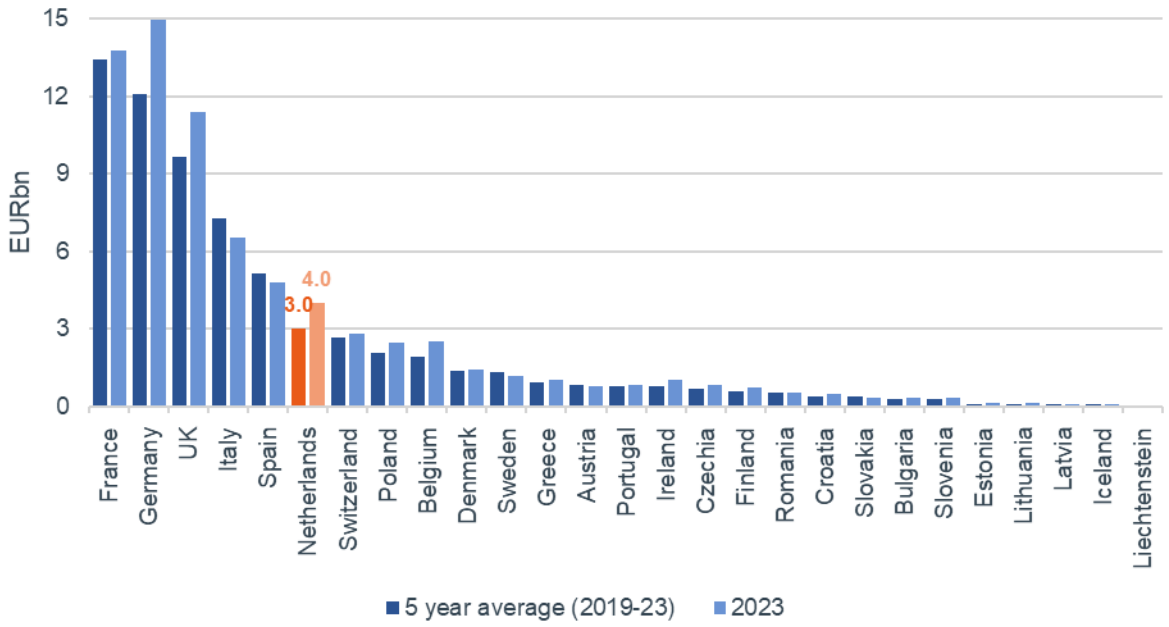
3.4 Investment levels

Figure 3-14 below shows that between 2019-2023, the Netherlands' average annual telecoms investment[37] was EUR3.0 billion, ranking sixth highest among EU27+ countries.[38] The level in 2023 alone was EUR4.0 billion.

[37] Note this is total telecoms investment not just mobile investment due to lack of data availability on mobile specific investment.

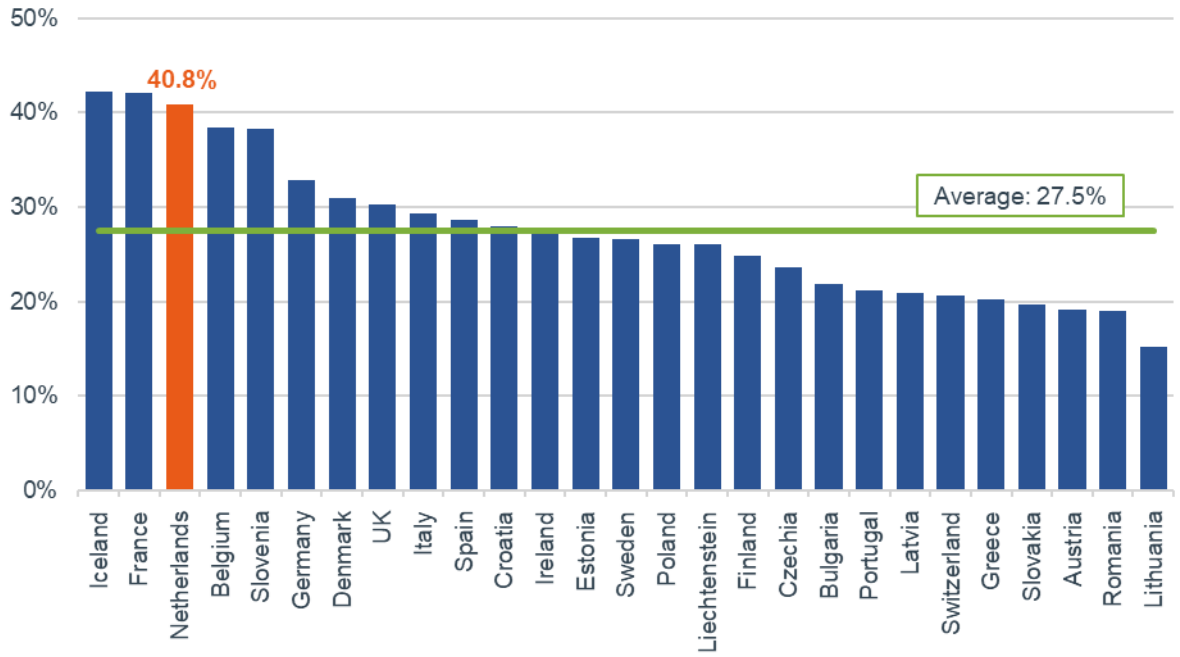
[38] International Telecommunication Union, ITU DataHub, https://datahub.itu.int/ *(accessed 17 March 2025)*.

Figure 3-14: Annual telecoms investment in EUR27+ countries [Source: ITU]



To account for different market sizes, we compare investment-to-revenue ratios. Figure 3-15 below shows the Netherlands' ratio of 40.8% in 2023 is significantly higher than the EU27+ average of 27.5%, highlighting strong investment in network infrastructure.[39]

Figure 3-15: Telecoms investment to revenue ratio, 2023 [Source: ITU]



Overall, the Dutch telecoms sector has strong levels of investment compared with other European counties, particularly when comparing investment-to-revenue ratios.

[39] International Telecommunication Union, ITU DataHub, https://datahub.itu.int/ *(accessed 17 March 2025).*

3.5 Summary

The mobile market in the Netherlands is currently working well. The three network operators compete with each other, as well as a host of MVNOs, with all MNOs being of similar scale. Prices are amongst the lowest in Europe – and have fallen by 60% over the period 2009-2024. The Netherlands is one of the most digitally developed countries in Europe with the highest level of mobile broadband take-up, network coverage and network speeds. It is also consistently highly placed in various rankings of digital adoption and connectivity. Investment levels are strong – the telecoms investment-to-revenue ratio is the third highest in Europe and significantly above the European average.

It is important to ensure that the market continues to function well. The current dynamics are successfully maintaining a competitive market with high quality and low prices for consumers. Government should take appropriate care to ensure they do not take any measures which may detrimentally impact this.

4. European trends and future investment requirements

In this section, we discuss the wider European mobile market trends and the upcoming digital infrastructure investment challenges that the industry is facing. These need to be given detailed consideration when developing policy on the upcoming spectrum award as decisions on the award will determine the extent to which mobile operators are able to overcome these challenges.

4.1 Recent European mobile market trends

Most European telecoms operators have been struggling with low levels of profitability and investment returns are estimated by market analysts to have fallen below cost of capital in many European countries[40]. Mobile operators, in particular, are suffering from the combination of stagnating revenues with high levels of capital expenditure as a result of:

- **Intense competition in many markets**. This has led to relatively low levels of revenue and average revenue per user (ARPU) compared to other countries. For example, the European ARPU in 2023 has been estimated at EUR14.8 per month compared to EUR41.7 in the USA[41]. European ARPUs fell (in real-terms) by 5.9% between 2022 and 2023, whilst ARPUs in China increased by 2.2% (again in real-terms) over the same period[41].

- **Lack of new revenue streams**. It was hoped 5G would yield new streams of revenues for mobile operators, particularly from the business sector. However, these have failed to materialise, at least to-date. Whilst Fixed Wireless Access (FWA) has provided a source of new revenue for operators in some countries, the widespread availability of fibre-to-the-home connections at affordable prices in many European countries, including the Netherlands, has limited FWA take-up to a niche.

- **The need for constant investment in the network**. Operators are constantly investing to improve network coverage and provide additional capacity to meet the growth in traffic levels. This has included the roll-out of new technologies such as 5G and massive MIMO antennas across existing sites. Additionally, the operators are having to operate multiple generations of radio technology concurrently (2G/3G, 4G and 5G) further increasing their costs.

- **The cost of acquiring spectrum**. New spectrum bands are needed to serve the additional traffic and deploy new technologies. As discussed in Section 2.1, the cost of spectrum in the Netherlands is particularly high by European standards.

As we discuss in Section 4.2 below, the wave of investment required by the mobile operators is likely to continue into the foreseeable future for both completing the roll-out of 5G and investing in new/ innovative digital infrastructure such as edge computing and AI. As the Dutch Government notes in its recent non-paper on a strong and competitive connectivity ecosystem[42], *"Connectivity should be regarded as an integral part of a wider European ecosystem of computing, high quality data and AI, which is crucial to limit European dependencies."* The Ministry itself has previously noted that *"The*

[40] See, for example, Barclays, 'On the path to value creation, but not for all', 31 January 2024.

[41] Source: Analysys Mason data cited in Connect Europe, State of Digital Communications 2025, January 2025.

[42] Government of the Netherlands, 'NL non-paper: Towards a strong and competitive European digital connectivity ecosystem', 20 May 2025.

sustainable earning capacity of telecom companies and other investors in telecommunications networks is important for a healthy sector."[43]

To face the above challenges, mobile operators in several European countries have attempted to merge to gain scale and reduce costs. However, where consolidation has been approved, this has often come with remedies which, in many cases, have led to the creation of a new entrant operator. For example, such remedies were adopted in Germany (2014), Italy (2016) and Spain (2024).

A further example of government-created market entry occurred in the 2012 4G multi-band award in the Netherlands and was one of the main factors leading to the high cost of spectrum. The auction led to Tele2 acquiring spectrum, however this did not result in a sustainable fourth operator – Tele2 was subsequently acquired by T-Mobile, the transaction being approved by the EC who indicated that *"Tele2 NL cannot be considered an important competitive force"*[44]. The acquisition resulted in a windfall gain for Tele2's shareholders. Such windfall gains from spectrum reservations have occurred in other countries across the world – for example in Australia where unduly restrictive caps in the 3.6GHz auction in 2018 created an effective reservation for entrants in the main five urban regions. This spectrum was won by Dense Air, who then sold this spectrum to one of the existing mobile operators (TPG) without having deployed any of the spectrum.

Major regulatory changes are taking place across European mobile markets. There is widespread recognition that whilst a 'pro-entrant' approach may have led to lower prices for consumers, this has been to the detriment of investment, which is particularly concerning given the scale required to meet the investment challenges of the future (as outlined in more detail in Section 4.2 below).

The Letta report on the status of the European Single Market[45] notes how European companies suffer from *"a stunning size deficit"* in comparison with global competitors (in particular United States and China). The report notes that European pro-competition regulation has brought benefits to end users in terms of the price of services but also observes that Europe has *"a liberalisation and regulation approach that may have generated strong incentives for 'excessive entry' by small-scale territorially focused operators, and, consequently unsustainable market balance harbouring low incentives for innovation investment"*. The report goes on to say that *"keeping the focus only on pro-entrant regulation, would be detrimental for a technology switch towards advanced networks that require massive investments"*.

Similarly, the Draghi report on European competitiveness[46] highlights how EU operators suffer from a lack of scale and how lower prices in Europe have benefited citizens but *"have also reduced the industry profitability, and, as a consequence, investment levels in Europe, including EU companies' innovation in new technologies"*. The report further notes that *"Regulation and competition policy in the telecom sector have in fact, disincentivised consolidation, favouring a multiplicity of players in each market"*. The report also suggests that studies have indicated that *"industrial policies have the potential to promote further consolidation without necessarily leading to price increases for consumers"*.

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[43] See Ministerie van Economische Zaken en Klimaat, 'De staat van de digitale infrastructuur: De ruggengraat van onze digitale economie', January 2024.

[44] European Commission DG Competition, 'Commission Decision of 27.11.2018 declaring a concentration to be compatible with the internal market and the functioning of the EEA Agreement: (Case M.8792 – T-Mobile NL/Tele2 NL)', Reference C(2018) 7768 final, 27 November 2018.

[45] Enrico Letta, 'Much more than a market: Speed Security, Solidarity: Empowering the Single Market to deliver a sustainable future and prosperity for all EU citizens", April 2024.

[46] Mario Draghi, 'The future of European Competitiveness: Part B | In-depth analysis and recommendations', September 2024.

The Letta report also notes that *"The scale of investments necessary in new technologies (for example edge/cloud, 6G, AI) implies that due consideration should be given to the necessity of some level of consolidation within national markets"*.

Consequently, the European focus is now on scale and consolidation rather than on fostering market entry. Outside the EU, the UK government has recently approved the merger of Vodafone and Three, which will reduce the number of MNOs from four to three. Back in 2016, a proposed merger between O2 and Three was disallowed due to concerns over potential price increases. In contrast, remedies in the recent merger approval[47] focus on ensuring future investment by the merged entity (which in turn is expected to encourage similar investments from the other two remaining MNOs). Within the EU, the Romanian competition authority is currently reviewing proposals to divide the assets (customers, spectrum and network assets) of Telekom Romania Mobile between Vodafone and Digi Mobil which would reduce the number of competing MNOs in the market from four to three.

4.2 The need for future investment

As discussed above, despite stagnating market revenues, Europe's mobile operators are facing significant investment challenges:

- **Continuing the roll-out of 5G**. The EC's Digital Decade targets include an ambition for all populated areas to be covered by 5G, by 2030[48]. The DESI 2024 indicators[49] show the Netherlands in joint first position with 100% of households already covered by 5G. Nonetheless, further roll-out of the 3.5GHz band will be required in the coming years to provide full-speed 5G services together with the roll-out of 5G standalone across the network footprints. Whilst satellite direct-to-device (D2D) technology is a major breakthrough in extending coverage to areas currently unserved by mobile networks[50], the services supported, data speeds and capacity available are not comparable to those of terrestrial networks. Therefore, where it is economically viable to provide mobile services terrestrially, mobile operators should continue to do so. In the event that satellite technology closes the gap with terrestrial services, this will provide an additional source of competition in the market.

- **Investing in more secure and robust networks**. In view of the importance of telecoms networks to day-to-day life and society as a whole, governments are requiring operators to increase their investments in security including stronger protection against cyber-attacks[51], diversification of supply chains[52] as well as improving robustness in the event of natural disasters. Specific requirements have also been set out by the Dutch Government in the 2019 Decree on the Security and Integrity of Telecommunications Networks[53]. Networks are also moving towards a more open and distributed architecture (including e.g. Open RAN, Virtualised RAN and Cloud RAN) which requires further investment in time/resources as well as new equipment and services. Smaller operators lacking scale may struggle to amass the necessary funds to invest in cybersecurity and

[47] UK Competition & Markets Authority, 'Anticipated joint venture between Vodafone Group plc and CK Hutchison Holdings Limited concerning Vodafone Limited and Hutchison 3G UK Limited: Final Report', Reference ME/7064/23, 5 December 2024.

[48] European Commission, '2030 Digital Compass: The European Way for the Digital Decade', March 2021.

[49] See European Commission. 'Shaping Europe's digital future: DESI indicators', available at https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/desi/charts/desi-indicators.

[50] This will be of greater relevance in EU member states with large areas that are uncovered by mobile networks.

[51] See, for example, European Union, 'Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 on measures for a high common level of cybersecurity across the Union', 27 December 2022.

[52] See, NIS Cooperation Group, 'Cybersecurity of 5G networks: EU Toolbox of risk mitigating measures', January 2020.

[53] See 'Besluit veiligheid en integriteit telecommunicatie', 5 December 2019.

robustness, which could result in a point of weakness/vulnerability not only for those operators but for the entire industry.

- **Creating a converged Connected Collaborative Computing Network**. The EC's White Paper 'How to master Europe's digital infrastructure needs?'[54] notes the importance of creating a fully converged network infrastructure as part of an ecosystem spanning semiconductors, computational capacity in both edge and cloud environments, radio technologies and other connectivity technologies, data management and applications. Specifically, this will require mobile operator investment in a range of technologies including:
  - **Deployment of edge computing nodes**. The Digital Decade targets are for 10 000 secure edge nodes to be deployed across Europe by 2030. As of 2024, only 320 live operator edge nodes had been deployed[55].
  - **Artificial intelligence factories**. In addition to making use of AI for their own customers and network operations, telecoms operators are being encouraged by EU policymakers to establish AI factories[56] (data centres optimised to run AI workloads) providing services to businesses. Part of this goal is driven by the need for AI and data sovereignty in Europe.
  - **Deploying quantum communications infrastructure**. The EuroQCI initiative[57] aims to deploy a secure quantum communication infrastructure across the whole EU. Further communications initiatives are likely to be required to meet Europe's Digital Decade target of being at the cutting edge of quantum by 2030.
- **Creating sustainable networks**. The EC has outlined its sustainability vision for Europe within the 'European Green Deal', which aims for Europe to achieve net zero greenhouse gas emissions by 2050, making it the first climate-neutral continent.[58] The telecoms industry has a key role to play in this, both in reducing its own carbon footprint and in expanding connectivity to enable other sectors to achieve climate neutrality.
  - The forthcoming EU Code of Conduct on sustainable telecommunications networks[59] is expected to encourage operators to deploy the latest most-energy efficient technologies to ensure its energy consumption is as low as possible.
  - Telecoms networks will help enable many other industry sectors as well as the public to become fully sustainable. Having access to the internet and mobile communications has reduced the need for travel in many ways and the application of new technologies such as AI over communications networks have the potential to increase productivity further and lower the energy footprint of society as a whole.

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[54] European Commission, 'White Paper: How to master Europe's digital infrastructure needs?', Reference COM(2024) 81 final, 21 February 2024.

[55] Source: Connect Europe, State of Digital Communications 2025, January 2025.

[56] See European Commission 'Communication from the Commission to the European Parliament, The Council, the European Economic and Social Committee and the Committee of the Regions on boosting startups and innovation in trustworthy artificial intelligence, Reference COM(2024) 28 final, 24 January 2024.

[57] See European Commission. 'The European Quantum Communication Infrastructure (EuroQCI) Initiative', accessed at https://digital-strategy.ec.europa.eu/en/policies/european-quantum-communication-infrastructure-euroqci

[58] European Commission, 'A European Green Deal', 7 June 2022.

[59] The EU Code of Conduct for the sustainability of telecommunications networks is expected to be published in 2025 in line with the EU action plan for digitalising the energy system – see European Commission 'Communication from the Commission to the European Parliament, The Council, the European Economic and Social Committee and the Committee of the Regions on Digitalising the energy system – EU auction plan', Reference COM(2022) 552 final, 18 October 2022.

- **Preparing for the roll-out of 6G**. Whilst the development of 6G is at a very early stage and the details and timing of roll-out are uncertain, it will inevitably require additional investments by the mobile operators. The Ministry has recognised that *"a continued strong focus on the development and roll-out of new technologies is important."*[43]

The investments required in the future go well beyond the usual 'next G' technology upgrade cycle and place a greater financial load and level of risk on the operators. As the recent Dutch Government non-paper on European digital connectivity[42] states, *"The future of connectivity in the EU is of a highly strategic nature and goes well beyond fiber and 5G networks."* and that *"a leading position on network technology is difficult to conceive in the absence of a strong European position on semiconductors, quantum technology cloud technology, AI and cybersecurity."*

Furthermore, these investments are not just vital for the health of the telecoms sector but also for the sustainability and growth of the wider economy. For example, the Draghi report notes (with concern) that *"The declining profitability of the telecom sector now may represent a risk for industrial companies in Europe, in a phase when state of the art infrastructure is required to digitise manufacturing, supply and distribution chains."* and also that *"The telecommunication equipment and software sector are also key for the EU's cyber-resilience, security of strategic infrastructures, and protection of citizens' and business data."*

This need for investment is endorsed in the recent Dutch Government non-paper[42] which calls upon European governmental bodies and financial institutions to *"explore the possibility of facilitating large scale investment in cutting edge clouds and connectivity infrastructure through ambitious public-private partnerships"*, in recognition of the roles of both industry and the state.

4.3 Summary

Major changes are taking place across Europe in respect to the approach to regulating mobile markets. Historically the focus has been on fostering competition, including remedies to create new entrants in cases where mergers between existing mobile operators were approved. New entrants were also created through reservations of spectrum during spectrum auctions. However, there is now broad recognition (as expressed in the Letta and Draghi reports) that this approach has had a negative impact on industry investment and that scale is going to be critical for operators to address the upcoming major investment challenges. Such challenges include ongoing mobile technology upgrades including completing the roll-out of high-speed standalone 5G services and rolling-out 6G in the 2030s, which may require the deployment of a denser network as well as the move to a more open and distributed network architecture to make networks more robust, secure and sustainable. There is also a need for new, higher risk, investment in areas such as edge computing nodes, AI factories, deploying quantum infrastructure etc. These new investments will enable national operators to play a more central role in the new digital economy, which is vital for both national sovereignty/security as well as economic growth. To provide the scale needed to meet these challenges, there is a recognition that consolidation is required.

The telecoms market in the Netherlands is working well. The Ministry itself has noted that *"The Netherlands has a safe, reliable, high-quality and accessible digital infrastructure. This has made our country an international leader for years. Our digital infrastructure is an important foundation for our digitalised society. It contributes greatly to the current and future earning capacity and broad prosperity in our country."*[43]

The upcoming spectrum award must both maintain this situation and support the wider sectoral ambitions, rather than risk taking the Netherlands backwards in the digital order. As discussed earlier, we focus on the spectrum award as this is an area which is under the direct control of the Ministry, unlike other aspects of the market such as the stagnating industry revenues. More specifically, in the

event the Ministry were to take money out of the industry through an award process which leads to high spectrum prices, this would be very damaging to the operators' ability to invest. Likewise, artificially seeking to introduce a new entrant through the spectrum award process would run counter to the objective of achieving scale and, based on past experience in the Netherlands and other countries, would probably result in consolidation in the medium-term with only speculators benefitting by acquiring spectrum at a price below the fair market value.

Any negative impacts would not just be felt by the telecoms industry – since mobile connectivity is a key part of day-to-day life and underlies the whole digital transformation process. Delays to and reductions in investment in mobile infrastructure will have a damaging multiplier effect across the whole economy. A study undertaken by Ecorys[60] on behalf of the Ministry identified that the economic contribution of digital infrastructure to the Dutch economy directly generated EUR15.8 billion of value in 2021 and also there were a further EUR8.4 billion of indirect benefits to other companies that are indirectly active in the sector (e.g. suppliers of network equipment). Furthermore, the Ministry has also noted[43] that digital infrastructure creates value in other sectors as well as society as a whole – the broader prosperity benefits from digital infrastructure, including a more inclusive society. A study by Dialogic for the Ministry has concluded that the availability of high-quality digital infrastructure is a decisive factor for organisations when making decisions on where to base themselves[61]. The damage from delays to or reductions in deployments of mobile infrastructure will therefore have many spillover impacts on the wider economy.

[60] Ecorys, 'Economisch belang digitale infrastructuur', 25 September 2023.

[61] Dialogic, 'Het belang van digitale infrastructuur voor de Nederlandse digitale knooppuntrol', 15 December 2023.

5. Implications for the upcoming spectrum award

In this section, we present our recommendations for the upcoming spectrum award, drawing upon international best practices and the need to ensure the mobile market continues to perform well for the citizens of the Netherlands and enable the operators to provide the digital infrastructure needed by the country.

5.1 Background – expiring spectrum bands

The upcoming award is expected to include (at a minimum) the following frequency bands, whose licences are due to expire in 2030:

- **800MHz** – 2×30MHz of paired spectrum currently used to provide a 'coverage layer' for 4G across the country. Signals from low-frequency spectrum (e.g. below 1GHz) travel further and deeper indoors than higher frequency spectrum. They are therefore a complement to higher frequencies to ensure mobile signals are received by as many end users as possible. It is expected this spectrum will continue to be used for 4G coverage in the short-term as well as being usable for 5G and/or 6G in future.
- **900MHz** – 2×35MHz of paired spectrum currently used to provide 2G and 4G services – again benefiting from the coverage provided by low-frequency spectrum. Over time the 2G networks are expected to be shut down and this band is expected be used for 4G, 5G and potentially 6G in future.
- **1800MHz** – 2×70MHz of paired spectrum is currently being used to provide 4G services – providing additional capacity for both technologies. Again, over time, this spectrum could be used for 5G and potentially 6G in future.
- **2600MHz** – this band is currently configured as 2×65MHz of usable paired spectrum and 40MHz of usable unpaired spectrum. The spectrum is used by all the operators to provide 4G capacity on sites where additional capacity is required. In future, the band is expected to be used to provide additional capacity for 5G and 6G.

Several additional frequency bands could also be considered for inclusion as part of the award process, including the 26GHz and upper 6GHz bands. We discuss these further in the following section.

5.2 Spectrum to be renewed/newly awarded

5.2.1 Timing of award

As the existing spectrum licences are due to expire in 2030, we recommend an award process is held no later than 2028. This would provide certainty to the industry and avoid a situation where operators are not able to make investments in a band due to uncertainty about access post 2030.

A short period between the award and licence expiry would not allow sufficient time to plan and implement the necessary network reconfigurations, particularly if the operators are unable to secure a minimum amount of spectrum in each band. The expiring spectrum licences are in bands that are key to ongoing service provision including for providing wide-area coverage of 4G and 5G networks. Any changes in spectrum holdings resulting from the award process would require reconfiguration of the network and any significant changes could have impacts on end customers. For example, in the event of any operator facing a material reduction in spectrum holdings, this could, in the short-term, result in

service disruption whilst the network is reconfigured and, following this, could also result in a material lessening in service quality.

5.2.2 Possible additional spectrum bands

In addition to the existing spectrum bands approaching the end of their licence term, new spectrum bands should be included if there is a clear upcoming need for this spectrum and the international harmonization of the spectrum is at a suitable state of development so that an equipment ecosystem (network and user devices) can develop.

We note that the upper 6GHz band (6425-7125MHz) is increasingly being considered for high-power mobile use and could become the main pioneer band for 6G. ECC Group PT1 is currently studying such mobile use of the spectrum, and the Radio Spectrum Policy Group (RSPG) has recently issued a draft opinion on the future long-term use of this band[62]. This opinion proposes that a significant part of the band be allocated for priority use for mobile. Furthermore, CEPT has been mandated by the EC to report by July 2027 on the technical conditions enabling the band to be used by both mobile and Wi-Fi. Regulators in Australia[63] and the UK[64] have recently announced their intention to use part/all of the band for mobile. China has already allocated the band for public mobile networks. Subject to the outcome of the various European technical investigations and policy developments and subsequent timing for the commercialisation of equipment (which was initially seeded by China's allocation of the entire 6GHz band to mobile), it is therefore appropriate to consider including spectrum in the upper 6GHz band as part of the upcoming award.

The 26GHz band (24.25-27.5GHz) was one of three European pioneer 5G bands[65]. However, less than 50%[66] of EU countries have assigned at least 1GHz of spectrum in this band. This is primarily because it is not cost efficient to deploy this band for the amount of network capacity required at this time and there is limited network equipment and device support. Nonetheless, it is expected that, despite its limited propagation, the 26GHz band will be needed for additional mobile capacity in key traffic hotspots (urban centres, transport interchanges, sports stadia). If this need arises as expected and the equipment ecosystem has further developed, this band could be considered for inclusion in the upcoming award.

The 600MHz band (614-698MHz) is currently allocated for use for digital terrestrial television (DTT) transmissions across Europe and unfortunately individual member states cannot make separate decisions over its use since television makes use of high-power transmitters which transmit signals for long distances across national borders. Consequently, the spectrum cannot be made available for mobile services until a harmonised European decision to do so has been implemented, since mobile usage in the Netherlands and continued usage of the spectrum for TV in neighbouring countries could result in harmful interference between the two services. In accordance with the Article 4 of the UHF

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[62] European Commission Radio Spectrum Policy Group, 'Draft Opinion on Long-term vision for the upper 6 GHz band', Reference RSPG25-018, 17 June 2025.

[63] ACMA, 'Future use of the upper 6 GHz band: Outcomes paper', December 2024.

[64] Ofcom, 'Expanding access to the 6 GHz band for mobile and Wi-Fi services: Proposals for AFC in Lower 6 GHz and mobile / Wi-Fi sharing in Upper 6 GHz: Consultation', 13 February 2025.

[65] European Commission Radio Spectrum Policy Group. 'Strategic roadmap towards 5G for Europe: Opinion on spectrum related aspects for next-generation wireless systems (5G)', Reference RSPG16-032 FINAL, 9 November 2016.

[66] See European 5G Observatory, 'Percentage of pioneer bands assigned', available at https://5gobservatory.eu/observatory-overview/interactive-5g-scoreboard/#pioneer-chart.

Decision[67] and the recent RSPG opinion on the use of the UHF band[68], it is not anticipated that harmonised European mobile use of the band will occur before 2030 at the earliest, and therefore it is unlikely that this band could be included in the upcoming award process.

5.3 Licence conditions

5.3.1 Licence duration

Spectrum licences need to be awarded for a sufficiently long period to enable the users to recover fully the investments required to deploy and utilise the spectrum. Now that the mobile market has matured with companies having invested in deploying nationwide network grids that are based on the historic spectrum available, and since all three operators in the Netherlands broadly hold an equal amount of spectrum, there is no major benefit from a significant reconfiguration of spectrum holdings between the operators every few years.

If the spectrum were to be licensed on an indefinite basis, this would avoid any 'dead period' in the last few years of a spectrum licence where there is a disincentive to invest (e.g. deploying the latest technologies) since it is not certain whether the user will retain access to the spectrum following the expiry of the licence.

As discussed above, there are no major benefits from awarding licences of fixed duration in contrast with the economic losses from the 'dead period' at the end of the fixed licence. We therefore recommend that the Ministry start to award licences with indefinite duration.

If this is not possible, the longest possible licence duration should be considered. We note that in 2022 the Spanish Government revised the General Telecommunications Law allowing for a maximum licence term of 40 years (previously 20 years).

The OECD's 'best practices in spectrum management' includes the importance of long-term licences[69]:

"Transparency and predictability regarding licence duration and renewal are important for all spectrum users, but may be particularly relevant to foster investment in capital-intensive services (e.g. mobile networks). In the case of mobile networks, spectrum licences awarded for sufficiently long periods, or that at least provide licensees with sufficient certainty at the time of assignment that their licences will be renewed by a transparent renewal path (including methodologies to define renewal conditions) are important to promote network investments.

Long-term licences with a high probability of renewal, within reasonable conditions, provide higher incentives to invest in networks."

The European Electronic Communications Code (EECC) requires policymakers in EU member states to provide *"regulatory predictability"* over a period of at least 20 years.[70] At a minimum, the Ministry should follow this, together with a clear assumption of renewal at the end of the licence period.

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[67] European Union, 'Decision (EU) 2017/899 of the European Parliament and of the Council of 17 May 2017 on the use of the 470-790 MHz frequency band in the Union', 25 May 2017.

[68] European Commission Radio Spectrum Policy Group. 'RSPG Option: Strategy on the future use of the frequency band 470-694 MHz beyond 2030 in the EU)', Reference RSPG23-035 FINAL, 25 October 2023.

[69] See OECD, 'Developments in Spectrum Management for Communications Services', OECD Digital Economy Papers, No. 332, October 2022.

[70] See Article 49(2) of European Union, 'Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code', 17 December 2018.

5.3.2 Usage of the spectrum

We support continuation of the approach of awarding spectrum on a service and technology neutral basis. This will allow spectrum users to determine the most effective use of the spectrum and provides flexibility over time e.g. reallocation for 6G in the future. Such flexibility helps maximise the long-term economic benefits of the spectrum.

Stringent coverage obligations should be imposed on license holders of low- and mid-band spectrum and licences for spectrum in each band should include a strict roll-out obligation ('use it or lose it') to ensure efficient use is made of the spectrum.

5.4 Award process

5.4.1 Type of award

Regulators have historically relied on a variety of different award formats to make spectrum available:

- **Auctions**: Spectrum auctions are the most commonly used mechanism to award spectrum and typically award spectrum to the bidders that are prepared to pay most for the spectrum. Auctions have been used for over 80 awards in Europe over the last 10 years.
- **Administrative assignments/renewals**: Occasionally, licences have simply been extended for the existing licence holders, often as a result of there being no demand from other parties. Sometimes the renewal has been granted on the basis of the mobile industry agreeing to extend mobile network coverage in return for a lower price for the renewed spectrum.
- **Partial renewal**: Partial renewal is a hybrid administrative/auction process, within which existing licensees are guaranteed renewal for part of their spectrum, to provide them with a minimum quantity to ensure service continuity, whilst allowing competition for remaining spectrum.
- **Beauty contests**: Spectrum has historically been awarded through beauty contests, where applicants have to signal their plans with respect to meeting a number of qualitative scoring criteria set by the regulator (in line with its priorities). However, beauty contests have sometimes been challenged resulting in lengthy litigation processes.

Direct licence renewal via an administrative process could be appropriate when needed to ensure service continuity[71] and in cases where demand does not exceed supply. Otherwise, a competitive award process such as an auction is typically appropriate. Adopting such an approach has multiple benefits, including increased transparency in the award process with allocation decisions being made based on objective criteria.

5.4.2 Auction format

In the event that an auction is the most appropriate method for renewing the spectrum or/and assigning new spectrum bands, key decisions need to be made regarding the design of the auction.

[71] Article 50(2) of European Union, 'Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code', 17 December 2018, sets out that *"In taking a decision pursuant to paragraph 1 of this Article, competent authorities shall consider, inter alia: ….. (f) the need to avoid severe service disruption"*.

The choice of auction format and associated rules can have a major impact on the outcome of the auction. Whilst the choice of format is situation dependent (there is no 'one size fits all' format), we recommend a format that:

- Offers simplicity: Complexity should only be added where there is a strong benefit.
- Is transparent (no surprises): The final auction outcome should emerge as the auction evolves, through a price discovery mechanism, allowing the bidders to take corrective action as the auction proceeds, rather than being surprised by the final outcome.
- Is 'tried and tested': Given the importance of spectrum to the functioning of the mobile market and the many investment challenges that lie ahead, this is not a time to experiment. As we detail below, an unexpected auction outcome could materially impact on the operation and competitiveness of the mobile market – with implications for the wider economy – for many years to come.

If these principles are adhered to, auctions can have many benefits, allowing an efficient allocation of spectrum to be achieved within a robust and transparent process.

The following auction formats have been used in recent spectrum auctions in the Netherlands:

- 2012 multiband auction – Combinatorial Clock Auction (CCA)
- 2020 multiband auction – SMRA/clock hybrid auction
- 2024 C-Band auction – Simple clock auction.

The 2012 auction resulted in very high prices. This was primarily due to a reservation of spectrum for entrant bidders; however, the choice of auction format – a CCA – may also have played a role. The CCA is extraordinarily complex to understand, it requires bidders to place bids on a wide range of packages and it can produce unexpected outcomes (both in terms of which package a bidder wins and the price paid). We, therefore, recommend that the CCA and other similar formats (e.g. Combinatorial Multi-Round Ascending auction) are not chosen for the upcoming auction.

Whilst simple to understand, sealed bid auction formats (particularly when used with a first-price rule) can have unpredictable and very damaging outcomes. For example, in 2013, the Norwegian regulator used such a format for a critical multi-band auction. One of the existing three mobile operators, Tele2, failed to win any spectrum, resulting in it exiting the market a few months later via a merger with TeliaSonera, fundamentally changing the entire market structure and level of competitiveness for many years to come. Therefore, we strongly advice against deploying a sealed bid auction format in any form.

Instead, we recommend that one of the simpler multi-round auction formats with transparency during the bid rounds is chosen, such as the SMRA/clock hybrid and simple clock auction or the Simultaneous Multi-Round Ascending (SMRA) format. These formats are simpler to understand, unlikely to surprise bidders with unexpected outcomes and allow bidders to adapt their bidding strategies as the auction evolves. They have also been 'tried and tested' in numerous spectrum auctions in recent years. The appropriate choice between these formats will depend on specific the circumstances of the award (e.g. spectrum available, nature of the likely demand).

5.5 Spectrum packaging

Spectrum should be packaged in a way that enables operators to make efficient use of the spectrum. More specifically:

- Block sizes should not be so small as to prevent efficient use. For example, 3G and 4G technology benefited from a minimum carrier size of 2×5MHz whilst 5G technology in higher frequency unpaired bands benefits from many tens of MHz of contiguous spectrum.

- However block sizes should also not be too large to prevent operators from being able to compete over marginal blocks. For example, if sub-1GHz spectrum were packaged in 2×10MHz or 2×20MHz blocks, limits in the amount of spectrum available in each band (2×30MHz in the 700MHz and 800MHz bands and 2×35MHz in the 900MHz band) would mean that it would not be possible for multiple operators to compete over the spectrum with each obtaining a reasonable share. The same would be the case if high-frequency spectrum were packaged in large blocks e.g. 50MHz or 100MHz blocks in the 3500MHz band.

The choice of block size is a trade-off between these two considerations. As an example, for sub-1GHz spectrum, a block size of 2×5MHz is often appropriate, since this allows operators to acquire the level of spectrum they require. For higher-frequency bands comprising more spectrum, such as the upper 6GHz band, 10MHz or 20MHz unpaired bocks may be most appropriate, depending on the total amount of spectrum available.

Spectrum availability and packaging can have a huge impact on the auction outcome and prices paid for spectrum. For example, in the auction of 3500MHz spectrum in Italy in 2017, only 200MHz of spectrum in the band was made available in the auction and, furthermore, it was pre-packaged into two 80MHz blocks and two 20MHz blocks. The four mobile operators had to compete strongly for the 80MHz blocks of spectrum (since 20MHz is too small to offer full speed 5G services). This led to prices which were much higher than in other European countries and is one of the main contributing factors to Italian operators facing the highest spectrum cost burden in Europe (as shown in Figure 2-1).

5.6 Competition measures

In this section, we discuss the use of pro-competition measures which can be introduced as part of the rules for an award process.

5.6.1 Spectrum caps

Spectrum caps are useful for ensuring that one or more operators in a market do not acquire too much of the available spectrum, thereby damaging the ability of other operators to compete effectively in the downstream market.

Caps should be set across blocks of spectrum that are close substitutes. Now that specific technologies (e.g. 4G, 5G) are not limited to specific frequency bands, spectrum with similar propagation characteristics and equipment ecosystems can be considered to be good substitutes. For example, spectrum below 1GHz could be considered as part of a *low-frequency spectrum cap*, spectrum in the range 1GHz to 3GHz could be considered as part of a *lower mid-band spectrum cap*, spectrum in the 3 to 7GHz range could be considered in an *upper mid-band cap*, and there could also be a *high-band cap* for mmWave spectrum (e.g. the 26GHz band). If individual caps do not cover the entire frequency range, an overall spectrum cap across all spectrum bands could also be applied.

A cap of 40% has been used in previous auction processes. We believe this level remains appropriate as it strikes a good balance between allowing an operator that has greater value for a particular type of spectrum to have a higher share than its competitors, but also enables a minimum of three operators to have a material holding of spectrum in each category of bands to be able to compete.

5.6.2 Reservations and set asides

Reservations and set asides have been included in spectrum auctions to create an opportunity for market entry or provide support to smaller operators in a competitive auction process. As discussed in Section 3, we believe that the mobile market is functioning well, all three operators are of broadly similar size and artificially introducing a new market entrant could threaten the good functioning of the market,

particularly given the importance of scale in view of the current and future investment challenges. Any regulatory-imposed measures directed at changing the industry structure should be carefully considered before implementation including a detailed analysis of the wider impacts on the market and ability of the operators to meet the upcoming investment challenges.

For example, reservations could have other significant negative impacts:

- Reducing spectrum available to existing operators which could result in higher prices for consumers: By depriving the operators from access to some of the available spectrum, they will be forced to incur additional costs (for example, by having to deploy new sites) to provide the required levels of network capacity to meet traffic growth. These additional costs will flow through to higher service prices.

- High spectrum prices: Reducing the supply of spectrum in the auction would lead to scarcity, resulting in higher prices. As discussed in Section 1, the operators in the Netherlands face the second highest spectrum price burden in Europe. A large part of this was due to the set aside of spectrum for new entrants in the 2012 auction. As discussed above, restricting the supply of spectrum available in the 3500MHz auction to 200MHz was a major contributing factor to operators in Italy, facing the highest spectrum burden in Europe.

- Creation of windfall gain opportunities: There is a significant risk that organisations seek to take advantage of an artificially low price for set aside spectrum with the aim of ultimately being acquired by one of the larger operators. For example, in the 2012 auction there was a huge price differential between the non-set-aside spectrum and the set-aside spectrum in the 800MHz band, which was acquired by Tele2. In 2017 Tele2 merged with T-Mobile following only a limited roll-out of its own network. This resulted in windfall profits for Tele2's shareholders. There are many other examples of such speculative behaviour across the world – for example Dense Air acquired set-aside spectrum in the 2018 auction in Australia, which it sold just three years later to TPG. Any set aside of spectrum in the upcoming auction could therefore attract speculators (including international companies) who would seek to acquire spectrum at a price below the market value with a reasonable expectation that the spectrum, or the whole company, would be acquired by one of the three mobile operators once any spectrum sale/transfer restrictions no longer apply.

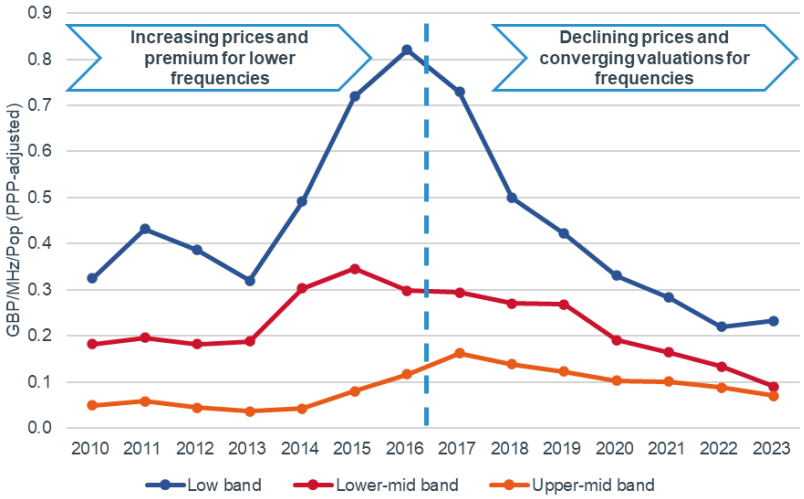
Given the risks associated with reservations, and no clear need for a new entrant in the mobile market, we recommend against making any spectrum reservations or set asides in the upcoming award process. If any such measures are contemplated by the Ministry, they should be based on a detailed assessment of the wider impacts on the industry including all existing operators' abilities to support the digital transformation of the Dutch economy.

5.7 Pricing of spectrum

It is important that spectrum prices – and, more specifically, the reserve prices set in a spectrum auction – are set close to the time of the auction and take account of the market situation at that time.

Whilst the use of international price benchmarks can be a useful input to this process, it is important to note that the benchmarking process is inherently backwards looking, and any analysis of these benchmarks should also take account of the current market value. As an illustration of this, Figure 5-1 below presents global spectrum auction prices over the last 15 years for different frequency ranges (low-band, lower mid-band and upper mid-band). There has been a significant fall in the price of spectrum (in per MHz terms) and the premium for low-frequency spectrum (again, in per MHz terms) has significantly reduced.

Figure 5-1: Global trends in spectrum auction prices



Spectrum prices are inherently falling since the amount of spectrum required to deliver the same revenue is increasing – as market revenues remain flat, traffic levels continue to increase, and the amount of spectrum required to deliver the capacity demand also increases. However, since revenues remain relatively flat, the revenue generated per MHz of spectrum and hence the price that can paid by the operators per MHz of spectrum is consequently decreasing. In a recent report on spectrum prices[72], the GSMA estimates that mobile revenue per MHz globally declined by 67% between 2014 and 2024.

In recognition of this effect, in its latest proposals for the setting of annual fees for renewed spectrum[73], the Australian regulator (ACMA) is proposing to adjust spectrum prices in the future in line with a 'Mobile service revenue per MHz per pop' index. This index will continue to decline if the level of growth in spectrum usage is not matched by corresponding revenue growth.

As indicated above, it is therefore imperative that the Ministry sets spectrum prices (including reserve prices in any auction) that take account of the market situation at that time, rather than simply relying on past auction awards – both in the Netherlands and internationally.

Setting an unduly high reserve price or other award conditions which lead to high auction prices would have a negative impact on the economy. Any short-term gains in auction revenues for government would be more than offset by the medium-term detrimental impacts on the operation of the mobile market, the prices of mobile services and levels of network investment by mobile operators.

5.8 Summary of recommendations

Spectrum to be renewed/newly awarded

- The award process should be held no later than 2028, allowing sufficient time ahead of the expiry of the licences in the 800MHz, 900MHz, 1800MHz and 2600MHz bands.
- The upper 6GHz band should be included in this award if European harmonisation of this band for IMT has occurred, as is looking increasingly likely.

[72] GSMA, 'Global Spectrum Pricing', May 2025.

[73] ACMA, 'Expiring spectrum licences, stage 3: Preliminary views paper 4: pricing for ESLs' April 2025.

- At least part of the 26GHz band should be included in the award, provided that demand for and the equipment ecosystem develop as expected over the next few years.
- Spectrum should be packaged in block sizes that are not so small as to prevent efficient use whilst also not too large to prevent operators competing over marginal blocks – for example, in the case of sub-1GHz spectrum, a block size of 2×5MHz is typically used.

Licence conditions

- Licences should ideally be infinite in duration to prevent a 'dead period' arising at the end of the licence where investments are not viable. At the very least, the spectrum should be awarded with a minimum 20-year licence duration in line with the EECC, with a clear assumption of renewal.
- The spectrum should continue to be awarded on a service- and technology-neutral basis, enabling the market to determine the optimum use and timing for migration to new technologies.
- Stringent coverage obligations should be imposed on license holders of low- and mid-band spectrum and licences for spectrum in each band should include a strict roll-out obligation ('use it or lose it') to ensure efficient use is made of the spectrum.

Award process

- Direct licence renewal via an administrative process could be appropriate to ensure service continuity and in cases where demand does not exceed supply.
- Otherwise, a simple and well-proven auction format with transparency during the bid rounds and predicable outcomes (no surprises) should be used. Formats such as the SMRA/clock hybrid, simple clock auction or the SMRA are likely to meet these requirements.

Pro-competition measures

- Spectrum caps should be set across bands which are close substitutes for each other (e.g. low-frequency, sub-1GHz spectrum). A cap level of 40% (as has historically been used) continues to be appropriate as it enables a minimum of three competitors to have a material holding of spectrum in each category of bands.
- Spectrum should not be set aside for a new entrant as this creates an artificial shortage of spectrum, limits the achievable service quality and increases the costs of providing services to customers. Such a reservation is likely to increase spectrum prices in the auction, which will hamper the operators' ability to invest and ultimately will get passed onto consumers. Furthermore, windfall gain opportunities may be created for speculators looking to take advantage of the lower price for the set-aside spectrum with the aim of selling the spectrum/company onto one of the mobile operators later (as has occurred in the Netherlands in the past).

Spectrum prices

- Reserve prices for the spectrum should be set at the time of the auction, taking account of the market situation at that time. At the present time, the combination of stagnating total market revenues coupled with the need to hold ever larger amounts of spectrum to support traffic growth, is leading to a considerable reduction in spectrum prices in per MHz terms.

In summary, the Ministry should take due care to ensure that the upcoming spectrum award does not unduly risk damaging the health of the mobile market or the financial capability of operators to meet the coming investment requirements, especially if the main outcome of any radical interventions may simply be to create windfall gains for (potentially international) speculators.

Annex A About the authors

This annex provides details of the experience and credentials of the authors of this report.

A.1 Introduction to Aetha

We support leading technology, media and telecoms (TMT) players to make major strategic and regulatory decisions.

At Aetha, we are committed to delivering high-quality advice supported by rigorous analysis, helping our clients solve their most pressing issues. With a proven track record in both developed and emerging markets, our footprint is truly global.

Founded in 2011 by a group of highly experienced telecoms consultants – whose former employers include Analysys Mason, Deloitte Consulting, Ofcom, Oliver Wyman and PA Consulting – Aetha has grown into a recognised leader in the TMT industry.

Our senior team collectively has over 150 person-years of experience advising operators, regulators, investors and legal institutions. They are supported by a dedicated group of specialist TMT consultants.

Together, we deliver independent, evidence-based insights that continue to shape the future of the TMT industry.

A.2 Aetha's spectrum management experience

Throughout the recent unprecedented growth of wireless services, Aetha's staff have been at the forefront of spectrum policy. We have assisted regulators to award spectrum and develop regulatory frameworks.

We also support operators to understand their spectrum needs, value spectrum and bid in auctions. Aetha has supported bidders in over 120 spectrum awards worldwide in just the last 14 years (i.e. since Aetha's formation). Our technical knowledge combined with our rigorous valuation modelling approach, ensures that our clients are comprehensively prepared for auctions.

In this section, we outline some particularly relevant projects we have performed on behalf of both regulators/governments and those acquiring spectrum (predominantly mobile operators).

Projects for regulators/governments

Aetha has supported regulators in several countries with spectrum policy development and spectrum award processes. On the topic of the value of spectrum (including the setting of annual fees and reserve prices), we have advised regulators in Belgium, Malaysia, Mexico, Oman, Singapore, Slovenia, South Africa, UAE and the United Kingdom.

Projects for acquirers of spectrum

A summary of our recent spectrum award projects for acquirers of spectrum (e.g. mobile operators) is presented in the figure below. In each instance we indicate the scope of the project in terms of:

- Spectrum/regulatory strategy
- Consultation engagement
- Spectrum valuation
- Auction support.

Figure A-1: Aetha spectrum award experience in the last 13 years

Bands	Client	Country	Year	Spectrum strategy	Advocacy engagement	Spectrum Valuation	Auction support
26GHz	Confidential	Western Europe	Ongoing				✓
1500MHz, 26GHz	Confidential	Western Europe	Ongoing	✓		✓	
800MHz, 900MHz, 2100MHz, 2600MHz	Orange	Slovakia	2025	✓	✓	✓	✓
850MHz, 1500MHz, 1800MHz, 2100MHz, 2300MHz, 26GHz	True	Thailand	2025	✓	✓	✓	✓
700MHz, 800MHz	Orange	Poland	2025	✓		✓	
700MHz, 900MHz, 1500MHz, 2300MHz, 2600MHz, 3.4-3.8GHz 26GHz	Orange	Moldova	2025	✓	✓	✓	✓
600MHz, 700MHz, 3.5GHz	Mobily	Saudi Arabia	2024	✓	✓	✓	✓
3.5GHz, 26GHz	A1	Austria	2024	✓	✓	✓	✓
3500MHz	Telstra	Australia	2023	✓	✓	✓	✓
700MHz, 850MHz, 2.6GHz, 3.4-3.8GHz	WOM	Colombia	2023	✓	✓	✓	
700MHz	Tigo	Guatemala	2023		✓		✓
2.6GHz	Tigo	Guatemala	2023	✓	✓	✓	✓
800MHz, 900MHz, 1800MHz, 2100MHz, 2600MHz	A1	Croatia	2023	✓	✓	✓	✓
3.6GHz	Orange	Poland	2023	✓		✓	
3.6GHz	Orange	Slovakia	2022		✓		✓
700MHz, 800MHz, 1400MHz, 2.6GHz and 3.4-3.8GHz	Orange	Romania	2022	✓	✓	✓	✓
850MHz, 2.3GHz	Liquid	South Africa	2022				✓
700MHz, 2.1GHz, 2.3GHz and 2.6GHz	Eir	Ireland	2022	✓	✓	✓	✓
700MHz, 900MHz, 1400MHz, 1800MHz, 2.1GHz, 2.6GHz and 3.4-3.8GHz	Telenet	Belgium	2022	✓	✓	✓	✓
850MHz and 900MHz	Telstra	Australia	2022	✓	✓	✓	✓
2.6GHz and 3.4-3.8GHz	Ice	Norway	2021	✓		✓	
2.3GHz	Confidential	Indonesia	2021	✓		✓	
26GHz	Telstra	Asia-Pacific	2021	✓	✓	✓	✓

Bands	Client	Country	Year	Spectrum strategy	Advocacy engagement	Spectrum Valuation	Auction support
700MHz and 3.4-3.8GHz	BT	Western Europe	2021	✓	✓	✓	✓
3.4-3.8GHz	Shaw	Canada	2021	✓		✓	
Various	Tigo	Nicaragua	2021	✓			
3.5GHz	Tigo	El Salvador	2021	✓	✓		
700MHz, 1400MHz and 2.1GHz	KPN	Netherlands	2021		✓		
700MHz, 2.1GHz, 3.4-3.8GHz and 26GHz	WIND Hellas	Greece	2020	✓	✓	✓	✓
1500MHz, 2100MHz, 2300MHz, 3.5GHz and 26GHz	TDC	Denmark	2020	✓		✓	
700MHz, 1800MHz, 2.3GHz, 2.6GHz and 3.4-3.8GHz	dtac	Thailand	2020	✓		✓	
2.1GHz and 3.4-3.8GHz	1&1 Drillisch	Germany	2019	✓		✓	✓
2.3GHz, 2.6GHz and 3.4-3.8GHz	Mobily	Saudi Arabia	2019	✓	✓	✓	✓
700MHz, 1400MHz, 2.6GHz and 3.4-3.8GHz	SALT	Switzerland	2019	✓	✓	✓	✓
1800MHz, 3.4-3.8GHz, mmWave	T-STAR	Taiwan	2019			✓	
3.4-3.8GHz	Telstra	Australia	2019	✓	✓	✓	✓
Several	WOM	Chile	2019	✓			
AWS	Tigo	Panama	2019	✓		✓	
700MHz and 2600MHz	Tigo	Colombia	2019	✓	✓	✓	✓
700MHz	Tigo	Guatemala	2019	✓		✓	✓
600MHz	Freedom Mobile	Canada	2018	✓		✓	
900MHz, 1800MHz and 2.3GHz	Telenor	Thailand	2018	✓		✓	
800MHz, PCS and 2.6GHz	Sprint	United States	2018			✓	
700MHz, 800MHz and 1800MHz	Mobily	Saudi Arabia	2018	✓	✓	✓	✓
3.4-3.8GHz	Orange	Spain	2018				✓
700MHz	Digi	Malaysia	2018	✓		✓	
800MHz	Tigo	Ghana	2018	✓		✓	
700MHz	Tigo	Tanzania	2018	✓		✓	✓
1800MHz, 2.1GHz, 2.3GHz and 3.4-3.8GHz	Telstra	Australia	2017	✓	✓	✓	✓
1800MHz and 2.1GHz	T-Star	Taiwan	2017	✓		✓	

Bands	Client	Country	Year	Spectrum strategy	Advocacy engagement	Spectrum Valuation	Auction support
1800MHz	WIND Hellas	Greece	2017	✓	✓	✓	✓
2.3GHz and 3.4-3.6GHz	BT/EE	United Kingdom	2017	✓	✓	✓	
mmWave	Sprint	USA	2017			✓	
700MHz and 1800MHz	Mobily (Etisalat)	Saudi Arabia	2017	✓	✓	✓	✓
700MHz, 1400MHz and 2.1GHz	KPN	Netherlands	2017	✓	✓		
800MHz	Telenor	Bulgaria	2017	✓		✓	
700MHz and 2600MHz	Tigo	Paraguay	2017	✓	✓	✓	✓
AWS	Tigo	El Salvador	2017	✓	✓	✓	✓
700MHz and 1800MHz	Telenor	Sweden	2016	✓		✓	
1800MHz	TDC	Denmark	2016	✓		✓	✓
850MHz, 1800MHz, 2.1GHz, 2.3GHz, 2.6GHz	Telenor	India	2016	✓		✓	
900MHz, 1800MHz	Telenor	Norway	2016	✓		✓	
850MHz, 900MHz and 1800MHz	Telenor	Thailand	2016	✓		✓	
1800MHz	Telstra	Australia	2016	✓	✓		✓
3.4-3.8GHz	Orange	Romania	2016	✓	✓		✓
700MHz, 850MHz, PCS and AWS	Cable Bahamas	Bahamas	2016	✓		✓	✓
AWS	Tigo	Paraguay	2016	✓		✓	✓
700MHz, 800MHz and 1800MHz	Tigo	Senegal	2016	✓		✓	
800MHz, 900MHz and 1800MHz	Orange	Moldova	2015	✓	✓	✓	✓
2.6GHz	T-Star	Taiwan	2015	✓		✓	✓
1800MHz	Wind Hellas	Greece	2015	✓			
800MHz, 1800MHz and 2.6GHz	Nawras (Ooredoo)	Oman	2015	✓	✓	✓	✓
700MHz, 1800MHz, 2.1GHz and 2.6GHz	Telenor	Myanmar	2015	✓		✓	
800MHz, 900MHz, 1800MHz, 2.1GHz, 2.6GHz	Turk Telekom	Turkey	2015	✓	✓	✓	
AWS and 2.5GHz	Wind Mobile	Canada	2015	✓		✓	
850MHz and PCS	Telefónica	Mexico	2015	✓	✓		
700MHz	Avantel	Colombia	2015	✓	✓		✓

Bands	Client	Country	Year	Spectrum strategy	Advocacy engagement	Spectrum Valuation	Auction support
700MHz, 800MHz and 1800MHz	Tigo	Ghana	2015	✓	✓	✓	
900MHz and 1800MHz	Tigo	Tanzania	2015	✓		✓	
800MHz and 2.6GHz	WIND Hellas	Greece	2014	✓	✓	✓	✓
800MHz, 900MHz, 1800MHz, 2.1GHz, 2.6GHz	Telenor	Hungary	2014	✓	✓	✓	
700MHz	Telecom NZ	New Zealand	2014	✓	✓	✓	✓
AWS and PCS	Telefónica	Ecuador	2014	✓		✓	
1900MHz, 700MHz	Tigo	Honduras	2014	✓		✓	
800MHz	Tigo	Tanzania	2014	✓		✓	
800MHz and 1800MHz	Tigo	Senegal	2014	✓		✓	
800MHz, 1800MHz and 2.6GHz	Orange	Slovakia	2013	✓	✓	✓	
700MHz and 2.6GHz	Telstra	Australia	2013	✓	✓	✓	✓
800MHz, 900MHz, 1800MHz, 2.1GHz and 2.6GHz	KPN	Netherlands	2013	✓	✓	✓	✓
700MHz and AWS	Telefónica	Colombia	2013	✓		✓	✓
700MHz, PCS and AWS	Tigo	Bolivia	2013	✓		✓	
1900MHz, AWS, 2.5GHz, 700MHz	Tigo	Salvador	2013	✓		✓	
1800MHz and 2.1GHz	Tigo	Tanzania	2013	✓		✓	
700MHz, 1900MHz and AWS	Tigo	Bolivia	2013	✓		✓	
2.1GHz, 800MHz	Tigo	Chad	2013	✓		✓	
AWS	Tigo	Honduras	2013	✓		✓	
900MHz and 1800MHz	Telenor	Hungary	2012	✓	✓	✓	✓
800MHz, 900MHz and 1800MHz	Eir	Ireland	2012	✓		✓	✓
800MHz, 900MHz, 1800MHz and 2.6GHz	Orange	Romania	2012	✓	✓	✓	✓
800MHz	TDC	Denmark	2012	✓		✓	
800MHz, 900MHz, 1800MHz, 2.1GHz and 2.6GHz	Orange	Switzerland	2012	✓	✓	✓	✓
900MHz	Tigo	DRC	2012	✓		✓	
2.1GHz	Tigo	DRC	2012	✓		✓	

Bands	Client	Country	Year	Spectrum strategy	Advocacy engagement	Spectrum Valuation	Auction support
2.5GHz	BASE	Belgium	2011	✓		✓	
900MHz	Telenor	Hungary	2011	✓	✓	✓	✓
800MHz, 1800MHz and 2.5GHz	Telecom Italia	Italy	2011			✓	

Aetha Consulting Limited
24 Hills Road
Cambridge
CB2 1JP
United Kingdom
+44 1223 755575
enquiries@aethaconsulting.com
www.aethaconsulting.com