EUROPEAN TELECOM OPERATORS ARE WELL PLACED TO MEET FUTURE INVESTMENT REQUIREMENTS IN DIGITAL INFRASTRUCTURE

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This study is an independent report funded by the Computer & Communications Industry Association (CCIA Europe). The opinions offered herein are purely those of the authors and do not necessarily represent the views of CCIA Europe.

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Executive Summary

This paper assesses the validity of the recurring European narrative of a suffering telecom sector. This narrative has been context for the discussions the European Commission has initiated regarding its upcoming Digital Networks Act (DNA), and the radical policy changes proposed appear to be designed in response.

Incumbent telcos' narrative

For a number of years now, incumbent operators in Europe have promoted this narrative to justify radical changes in European regulation. Europe, they say, is lagging behind in digital investment even though telecom operators, and particularly incumbents, have been investing heavily in 5G and FTTP coverage. There is still significant investment required to meet the targets set by the European Commission, and to manage the volumes of internet traffic on their networks, which they say is increasing exponentially. They express doubt as to their own ability to keep financing digital infrastructure build as investors lose confidence in telecom operators and potentially decide to invest elsewhere unless returns improve.

Europe is not lagging behind

We find that Europe is very largely on track to meet the Commission's 2030 connectivity targets. The European Commission's own publications forecast that the goal for 100% 5G mobile coverage should be met by 2030, and Very High Capacity Network (VHCN) coverage will reach 94% coverage. We also find that while the EC targets have not changed since 2023, informal language has set out more onerous goals, but the rationale for these informal targets is rarely set out.

In particular when it comes to mobile coverage, the European Commission is increasingly talking about 5G Standalone as a target, even though the public benefits are unclear and hence the need to keep up with other countries may not be justified.

Regarding VHCN, many European countries compare favourably to other geographies like the US or even Asian leaders. A few others however, including Germany and Italy, lag behind significantly. This points to specific issues in these countries rather than systemic issues with European regulation. In short, it is unfair and largely unsubstantiated to say that Europe as a whole is falling behind its peers in digital infrastructure availability.

Financial prospects for European telcos are improving significantly

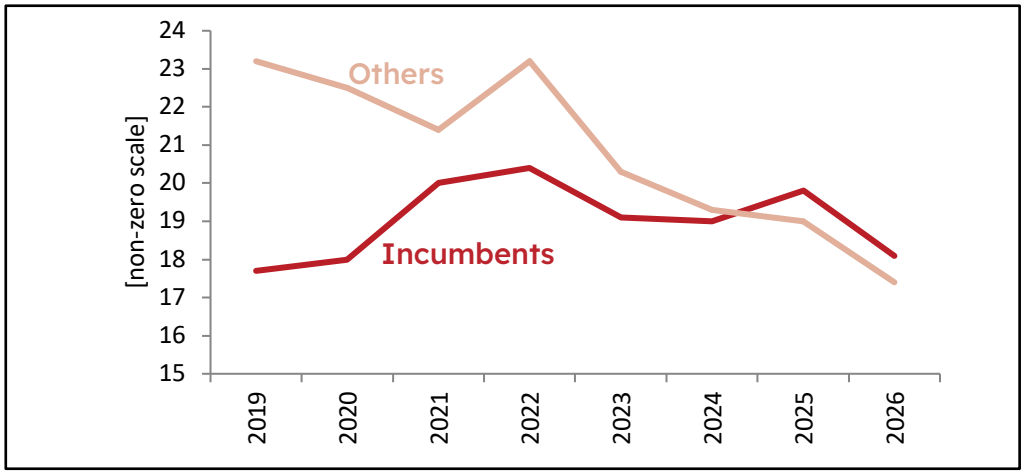
We then examine the financial prospects of Europe's telecom operators and find that they are improving significantly for the following reasons:

- Capital expenditure (capex) associated with digital infrastructure investment peaked a few years ago, and while the situation may differ from country to country, overall capex (including spectrum costs) is reducing and expected to reduce further as coverage in both fixed and mobile nears completion. Some incumbent telcos like Telefónica and Orange have communicated this to their investors for a number of years now. Even with 6G likely to emerge in the next decade, the industry as a whole is pushing for software developments rather than equipment replacement as a new mode of network evolution. Additionally, spectrum costs have been going steadily down over the last decade, and there is a strong argument to be made that spectrum needs will not increase substantially in the foreseeable future.
- Operational expenditure (opex) is also going down, and expected to go down further. This is due to a combination of factors. First, the switch-off of copper networks will eliminate the need for parallel network upkeep and shift maintenance to recent state-of-the-art platforms, unlike the 100-year old copper network. Additionally, implementation of AI solutions is already generating significant savings in fault management and maintenance.

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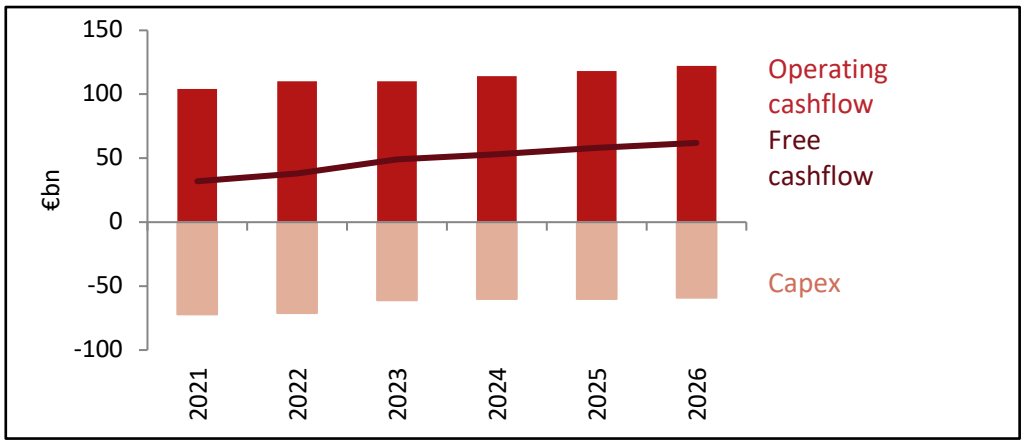
- Regarding revenue, there are also positive perspectives. While adoption of 5G and (in some markets) FTTP has been slower than anticipated, take-up is accelerating, and the dynamics of copper switch-off and mobile device renewals are reinforcing that trend. As marketing and sales focus shifts from adoption to upselling, average revenue per user (ARPU) is already rising and expected to rise further.

Capital Intensity (%), Western European telcos[1]



In combination, these factors will allow European telcos to substantially increase free cash flow over the next few years.

European telcos cashflow[2]



Traffic on telcos' networks is not growing exponentially and the cost to manage the actual growth is very limited

Could this positive outlook be undermined by telcos' need to invest heavily to handle an exponential increase in incoming traffic?

We find this not to be the case. The first and primary reason is that the rate of growth of traffic is slowing down:

- In mobile networks, traffic growth has been steadily slowing down since 2013 and was only 15% in 2024. The development of 5G has not impacted this downward trend, and the expectation is that mobile traffic will plateau within a few years. This trend is seen globally, not just in Europe.

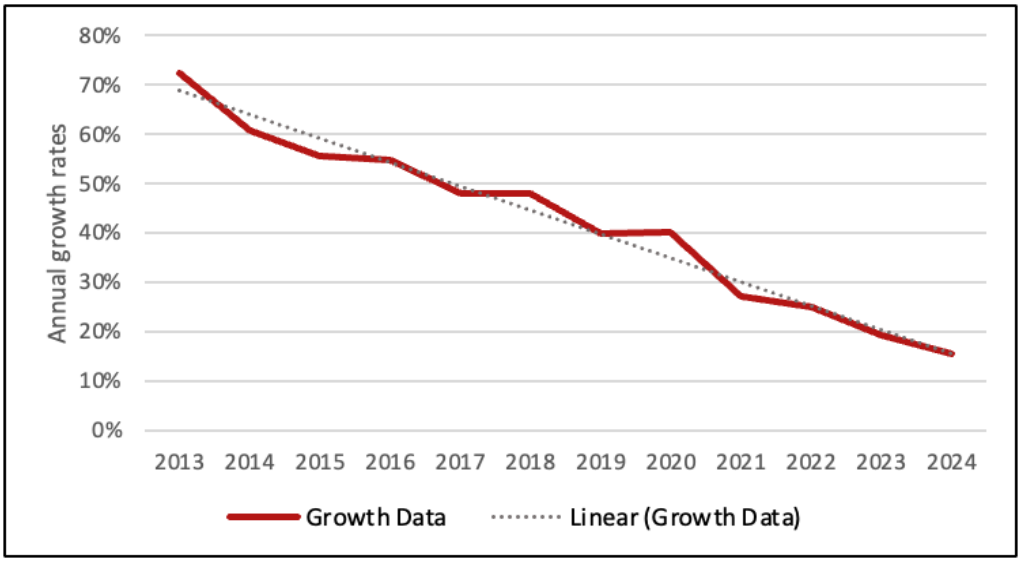
[1] Fitch, Western European Telecom Trends Diverge with Incumbents Faring Better, 9 January 2025

[2] S&P, Telecoms - Stronger signals for the sector, 14 January 2025

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- In fixed networks, traffic growth has been following similar downward trends although the expected plateau may be a little later than for mobile. For instance, there is an ongoing shift in viewing from broadcast to streaming that will sustain a bit of growth for a few more years.
- Augmented and virtual reality are not expected to significantly impact these trends as adoption has been slow and use cases show limited impact on data usage. Further, VR in particular is an indoor application very likely to be carried on wifi and fixed networks, not (more expensive) cellular networks. AI may generate increases in traffic between datacentres, but this will only affect telcos' networks marginally.

Growth rates in mobile traffic – predicted and outturn[3]



The costs of meeting the residual growth in traffic are found to be typically less than 1% of annual network capital expenditure. Not only therefore is traffic not growing exponentially, but its growth is slowing to a point where it will foreseeably plateau. The costs to handle the residual traffic growth in the next few years is tiny.

Investors are not turning their backs on telecom investment

There has been strong investment from telecom operators, but notably challengers to incumbents are investing more than incumbents in most markets. The average across Germany, France, Spain and Italy is that the national incumbent is spending less than 30% of total telecoms capex. This is significant because it means policy should not be tracking or supporting just incumbent investment.

If we compare shareholder returns across the telecom sector and beyond, we see that returns, while they vary from telco to telco, are comparable between companies inside and outside the European Union.

Similarly, when looking at credit ratings, we see that European telcos and non-European telcos are similar. With the exception of TIM and Liberty Global, all Europe's leading telcos have investment-grade credit ratings. That said, even excluding these two outliers, the EU average rating (BBB) is just slightly below the international comparators shown (BBB+).

All this suggests that investment capital is available for European telcos and this will be supported by the improving financial prospects highlighted above.

[3] The End of Telecoms History, Webb, 2024

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Policy implications

While this report does not aim to make policy recommendations, there are four areas where some conclusions can be drawn that may impact policy:

- Coverage targets were put in place at a time when some technologies, particularly Fixed Wireless Access (FWA) and Low-Earth Orbit (LEO) satellites were not mature. Today, they could help bridge the small VHCN coverage gap expected by 2030 at a fraction of the cost of FTTP;
- 5G Standalone is still a technology waiting for a market. It is no surprise therefore that operators are cautious about investing. This does not mean it won't happen, nor that this is a failure of European digital infrastructure. As of now, there is no public benefit that would warrant imposing it as a substitute target for 5G coverage;
- Excessive focus on the ability of incumbents to invest in digital infrastructure misses the fact that most investment is made by challengers in Europe. Policy needs to encourage investment from all sides of the market, and competition is often the driver for said investment;
- Telcos have invested in long-term infrastructure with business models that were more short-term oriented. There's an obvious tension there that is now easing, offering the potential of revenue generation on the back of these investments for decades to come. This long-term value must be factored into policy considerations before radical shifts to models that have helped deliver this value are made.

Conclusions

The gloomy narrative offered by telecom incumbents does not conform to the reality of the market, and in fact their prospects are improving. There may be exceptions due to specific market circumstances or specific player history, but these do not point to a fundamentally dysfunctional European policy environment.

In fact, the overall story is positive, as Europe has quickly developed its digital infrastructure and telcos are now poised to reap the financial returns from their significant investments.

As the European Commission develops the forthcoming Digital Networks Act, we offer the following considerations to inform its discussions and objectives. Reassessing the underlying premise of this debate through rigorous analysis is essential to ensure that the resulting legislation effectively serves Europe's best interests.

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1 Introduction

For a number of years now, large telecom operators in Europe (most often incumbents) have been calling for sweeping changes to European telecom regulation, that they argue harms their interests. In a nutshell, their reasoning goes like this:

- Europe is lagging behind in digital infrastructure investment
- Telecom operators, and particularly incumbents, have been investing strongly in 5G and FTTP coverage in the last 10 years
- There is still significant investment required to meet the EC coverage targets and increasing traffic volumes
- Investors are losing confidence in telecom operators and will increasingly deploy their capital elsewhere unless the returns on investment increase

As a consequence of all of the above, they argue that if the regulatory regime doesn't change in a way that makes life easier for the incumbents, the European Commission's Digital Decade targets will not be met and Europe will fall even further behind in terms of digital infrastructure, with dire consequences for the European economy.

The European Commission has expressed sympathy for these views. Indeed, the rationale for changes in regulation called for by these operators and the change recommendations themselves are present as suggestions or recommendations in the 2024 White Paper "How to master Europe's digital infrastructure needs?"[4], the call for evidence related to the Digital Networks Act[5] and the associated questionnaire managed by EY and WIK.[6]

The purpose of this report is not to examine the recommendations for change in regulation, but rather to assess the validity of the rationale. There are discordant notes to several of the claims listed above, not only from independent sources in the industry (financial analysts, industry experts), but also when comparing the tone of the incumbent CEOs and their representatives when talking to governments and regulators, and when talking to their own investors.

When considering changes in policy, especially as wide-ranging as those the European Commission is assessing in its recent DNA call for evidence, it is key that the basis for change be sound and unequivocal. We hope that this data-driven paper presents as clear an assessment of the above arguments as is possible to make with the public data and evidence at hand.

The structure of our paper is as follows:

- Chapter 2 looks at whether Europe is lagging behind on telecoms investment, compared to other countries.
- Chapter 3 turns to future investment requirements for telecom operators.
- Chapter 4 looks at whether growth in data usage will lead to additional investment requirements.
- Chapter 5 considers whether operators can raise the funding needed for any future investment.
- Chapter 6 looks at policy considerations.
- Chapter 7 provides conclusions.

[4] https://digital-strategy.ec.europa.eu/en/library/white-paper-how-master-europes-digital-infrastructure-needs

[5] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14709-Digital-Networks-Act_en

[6] Questionnaire for the survey on the EECC and the Digital Single Market, June 2025

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2 Is Europe lagging behind in digital infrastructure?

In this section we show that:

- Europe is very largely on track to meet its 2030 connectivity targets.
- While EC targets have not changed since 2023, informal language has set out more onerous goals, but the rationale for these informal targets is rarely set out.
- In some areas, such as 5G Standalone, the benefits are unclear and hence the need to keep up with other countries is weak.
- Europe often compares well against other countries. However, there is much variation across European countries, with countries such as Germany and Italy reducing the European average.
- These variations occur because operators make different business decisions when it comes to FTTP based on national market circumstances, and are therefore likely better addressed through national policy.
- In those areas where it matters most, Europe is not falling behind its peers.

At Mobile World Congress 2024, Deutsche Telekom CEO Tim Hötges said that Europe was lagging in digital infrastructure, arguing that the US were investing significantly more in this area compared to Europe. "We will fall behind", he stated[7].

In its 2025 State of the Digital Decade package, the European Commission starts its section on challenges with this sentence: "Although there are certain advancements, the rollout of connectivity infrastructure, such as fibre and 5G stand-alone networks, is still lagging[8]."

The Commission uses this narrative of failure to justify radical changes in regulation, and yet even in its own technical publications, things do not seem so dire.

2.1 Objective assessment of Very High-Capacity Networks and 5G rollout status in Europe

Back in 2023, the European Commission set up a series of 'Digital Decade' targets, with clear goals on a variety of metrics designed to encourage the development of a more digital European economy. One of the themes of the Digital Decade is Connectivity, of which the European Commission says[9]:

> *"The availability of gigabit connectivity services and 5G mobile coverage are essential enablers of the digital transformation. Household behaviours and the uptake of new technologies such as virtual and augmented reality, AI applications, automated driving, logistics and manufacturing processes will further drive demand."*

The Digital Decade targets include two targets for connectivity:

- Availability to all European households of fixed connections able to deliver very high-speed and reliable connectivity services (measured with the Very High Capacity Network (VHCN) indicator).
- Availability in all populated areas of a 5G mobile network regardless of the spectrum band used.

[7] https://www.youtube.com/watch?v=QR28YLiKfdU

[8] 2025 State of the Digital Decade, European Commission

[9] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52023XC0929(03)

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Practically speaking, the targets established are for 100% household coverage of VHCN and 100% population coverage of 5G. The definition of VHCN is based on the connection's ability to deliver gigabit broadband service[10] and not limited to a specific technology.

In its 2025 State of the Digital Decade package[11] the European Commission says that it expects:

- the mobile 5G population coverage target of 100% should be met by 2030;
- the VHCN target is likely to be missed and instead coverage will reach 94% by 2030.

While on the fixed broadband side this can indeed be described as not meeting the target, it does not seem like a catastrophic failure especially considering all the other targets in the Digital Decade (on adoption of services, digitisation of businesses, etc.) are aspirational.

Furthermore, when establishing international comparisons, the European Commission seems to move the goalposts somewhat. For example, it says in its 2024 white paper "How to master Europe's digital infrastructure needs?"[12]:

> *"On the supply side, the 2023 Report on the state of the Digital Decade underlines in particular limited fibre coverage[13] (56% of all households, 41% of households in rural areas) and delays in the deployment of 5G standalone networks in the EU. Current trends concerning the trajectories for the digital infrastructure targets laid out in the Digital Decade Policy Programme are a cause for concern. As regards fibre coverage, progress beyond 80% by 2028 does not seem likely, putting the achievement of the 2030 target of 100% in doubt."*[14]

We can see that the targets discussed here are FTTP, not VHCN, and 5G Standalone, not 5G.

2.2 5G goals are being met

When it comes to 5G – and despite a lacklustre business model – operators in Europe are delivering as intended. The problem identified by the European Commission seems now to be 5G Standalone. However, there has not been (to our knowledge) a case made officially by the European Commission that 5G Standalone delivers a public good that would justify extending the 5G targets to 5G Standalone. The current level of deployment of 5G Standalone in Europe reflects the operators' expectations of Standalone benefits, either in additional revenue or cost savings, in light of the costs to deploy. The fact remains that Europe's deployment of 5G is on track and that Europe will deliver on its 2030 goals.

What is 5G Standalone?

There are two variants of 5G - non-standalone (NSA) and standalone (SA). In NSA, 4G is used to control the handset while 5G is used to deliver data. In SA 5G is used for both control and data. Operators initially deployed NSA as this was standardised first, implementing the radio access network (RAN) or base stations in 5G. To upgrade to SA requires deploying a 5G core network in addition to the 5G RAN. Certain features of 5G can only be delivered with SA, including low latency services and network slicing.

2.3 VHCN Coverage issues are country specific, not Europe systemic, and are within reach

On the subject of fixed broadband, and in particular VHCN, it's difficult to do a like-for-like coverage comparison with other countries in the world since different countries track and publish different pieces of data differently.

The US numbers, as published by the FCC, put coverage of 1Gbps download speed broadband solutions at 60%[15]. This would suggest a significantly better coverage in Europe compared to

[10] This includes FTTP, but also various flavours of Cable TV (CATV) services. The latest technology upgrades of CATV (Docsis 3.1 and above) enable broadband download speeds of a gigabit per second or more

[11] https://digital-strategy.ec.europa.eu/en/library/state-digital-decade-2025-report

[12] https://digital-strategy.ec.europa.eu/en/library/white-paper-how-master-europes-digital-infrastructure-needs

[13] The Commission is taking here about FTTP, not VHCN

[14] Same as footnote 10

[15] https://broadbandmap.fcc.gov/area-summary/fixed

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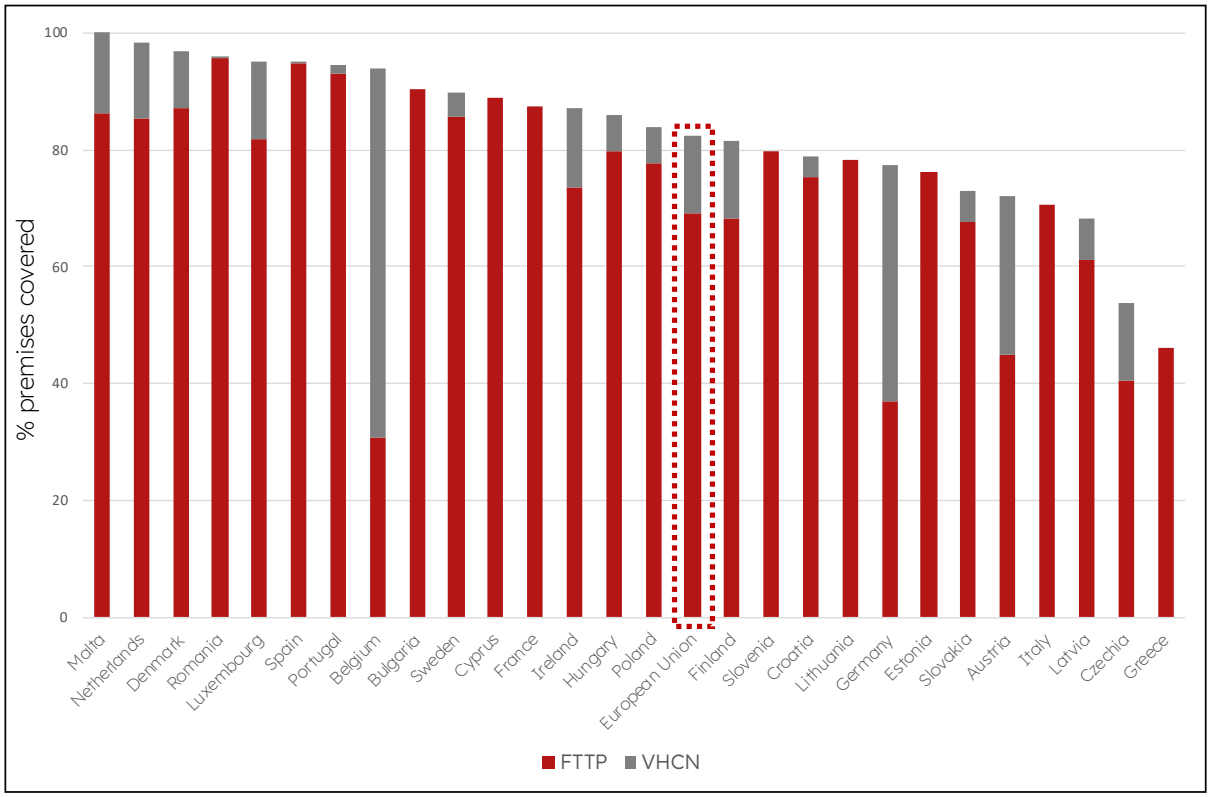
the US. However, Europe is undoubtedly behind China, Japan and South Korea[16]. So while it cannot be said that Europe leads the world in VHCN coverage, it also cannot be stated that Europe is lagging behind.

In fact, if we go below the EU averages reported by DESI[17], we note that countries such as Spain, France, Portugal, Denmark and Sweden are very close to the Asian benchmark countries in terms of coverage, and conversely countries such as Italy, Germany and Greece lag significantly.

This demonstrates that there is no systemic shortfall against the Digital Decade targets to warrant a radical change in policy. Rather, the issues are specific to certain countries.

If the issues are not systemic, then it is worth looking at coverage on a country-by-country basis to try and understand what may be happening. Considering their weight, these two countries drag down the European averages and likely contribute substantially to the 'failure narrative' present in the European Commission's communications. In other words, when it comes to fixed broadband, there isn't a European failure, there are (primarily) German and Italian failures.

Figure 2.1: VHCN and FTTP fixed broadband coverage in EU countries, 2024[18]



There are common and specific challenges in these two countries. In both, copper loops in legacy broadband were short and high quality which meant that copper enhancement technologies like VDSL were very effective at delivering 100Mbps service at a very low investment cost. This reduced the incumbents' appetite for FTTP deployment. Furthermore,

- in Germany, the CATV platform, which has a substantial footprint, has not been expanding its reach for over a decade. It has been upgrading its existing outside plant to gigabit capabilities. FTTP deployment initially came from alternative operators deploying FTTP to compete directly with the incumbent's VDSL solutions. Only in the last few years did Deutsche Telekom start to deploy FTTP in earnest. That deployment is

[16] South Korea and China respectively have 96,6% and 93,6% FTTP penetration (the ratio of FTTP subscriptions to households) according to the FTTP Council / Idate 2024 Global Ranking, so while this is not coverage per se, it can only be lower than coverage. Japanese FTTP coverage was 99.1% in 2020 according to the MIC Ministry of Internal Affairs and Communications.

[17] DESI, 2025 - https://digital-strategy.ec.europa.eu/en/policies/desi

[18] Ibid.

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focused primarily on areas already covered by CATV, hence not expanding the coverage numbers much. Publicly financed schemes for rural FTTP are now emerging, but are very recent and have not had a measurable impact yet;

- in Italy, there was no legacy CATV, and with the exception of local initiatives such as Milan's Metroweb, there was limited FTTP deployment until a consortium that would become Open Fiber won a number of public-private partnership tenders to deploy FTTP in white areas, then built on that momentum to also deploy in denser (grey and black) areas. This spurred incumbent Telecom Italia on to deploy some FTTP as well, but often competing with Open Fiber rather than reaching out to areas not currently covered. FTTP coverage in Italy is now progressing fast, close to double digits annually in the last few years, which suggests that the Italian problem may be in the process of solving itself.

In both instances, the slow deployment of FTTP by the incumbent operator was not the result of a lack of investment capability, but rather a choice to focus on the revenues generated by the existing VDSL plant. Furthermore, current investment in FTTP is often not focused solely on extending coverage but rather on competing with either other FTTP operators or CATV operators.

2.4 The Commission's detailed assessment is broadly positive on prospects

In Table 2.1 we have summarised the European Commission's own views on countries meeting the Digital Decade targets based on the 2025 Digital Decade Package data.

Table 2.1: EU assessment of VHCN and 5G progress per country[19]

	Projected 2030		EC Assessment		On track for 100%?	
	VHCN	5G	VHCN	5G	VHCN	5G
Austria	100%	100%	Realistic	Realistic	Yes	Yes
Belgium	100%	100%	On-track	On-track	Yes	Yes
Bulgaria	100%	100%	Good performance	Lagging	Yes	No
Croatia	100%	99%	Realistic	Realistic	Yes	Close
Cyprus	100%	100%	Advancing very well	Met	Yes	Yes
Czechia	95%	100%	Lagging	Realistic	Close	No
Denmark	#N/A	100%	#N/A	Met	Close	Yes
Estonia	100%	100%	#N/A	Likely it can reach	n/a	Yes
Finland	100%	100%	Ambitious	Achievable	No	Yes
France	100%	100%	Realistic	Realistic	Yes	Yes
Germany	100%	100%	Needs considerable acceleration	On-track	No	Yes
Greece	100%	100%	On-track	On-track	Yes	Yes
Hungary	97%	95%	Realistic	Realistic	No	No
Ireland	100%	100%	Realistic	[cautious]	Yes	No
Italy	100%	100%	[cautious]	Solid growth	No	Yes
Latvia	100%	70%	Out of reach	Met	No	No
Lithuania	98%	100%	Below trajectory	[on track]	Close	Yes
Luxembourg	100%	100%	Realistic	Realistic	Yes	Yes
Malta	100%	100%	Met	Met	Yes	Yes
Netherlands	100%	100%	On track	Met	Yes	Yes
Poland	100%	100%	[cautious]	On-track	No	Yes
Portugal	100%	100%	Achievable	Achievable	Yes	Yes
Romania	99%	62%	Will be met	[cautious]	Close	No
Slovakia	100%	99%	Challenging	Achievable	No	Close
Slovenia	100%	100%	Challenging	Within reach	No	Yes
Spain	100%	100%	On-track	On-track	Yes	Yes
Sweden	99%	100%	Realistic	On track	Close	Yes

[cautious] means the language of the Commission is not definitive but seems to err on the side of caution
Close means 98% or above

[19] 2025 Digital Decade Package

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The Digital Decade country reports are not always explicit about what the Commission expects, but on the 5G mobile side, it appears to anticipate that Czechia, Hungary, Latvia, Romania, Ireland and Bulgaria will significantly miss the EU target, with a few other countries somewhere between 98 and 100% coverage.

On the VHCN side, it anticipates that Germany is likely to miss its targets (stating that a considerable acceleration would be needed for it to happen) and has cautious language about Italy and Poland, which we read as the Commission anticipating the targets are unlikely to be met. Most of the other "likely failures" (in red in our table) are much smaller countries. What these country profiles do not allow us to assess is by how far the targets would be missed, but as the Commission anticipates a 94% average with three large countries possibly or certainly not meeting 100%, we can assume that the targets would not be missed by much. It's certainly a strong likelihood that 95% of the EU would be covered with VHCN by 2030 or very close to 2030.

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3 Financial prospects are improving

In this section we consider the future financial prospects of Europe's telcos. Some have argued that their poor financial returns necessitate regulatory change. But are their financials likely to improve even without such an intervention?

We here consider their economic prospects, taking capex (including spectrum costs), opex and revenue in turn, and conclude that there are good reasons to be optimistic that telcos will see declining opex and capex. Further, there is an expectation that revenues will grow even as these costs fall. In combination this will result in improving cashflows.

3.1 Future capex

As discussed above, in recent years Europe's telcos have been improving coverage of both FTTP and 5G, and this has required substantial investment. However, in many markets these investment cycles are approaching conclusion, and thus future capex may be appreciably lower.

3.1.1 Fixed capex

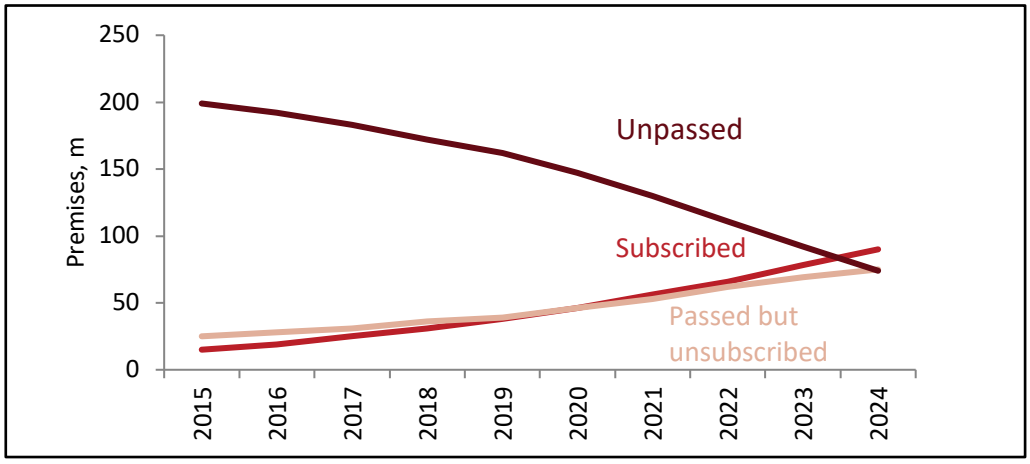
Regarding FTTP, Connect Europe has noted:

> *"Fiberising fixed access networks is a huge undertaking and represents the largest single investment in networks for a century"*[20]

However, precisely because the deployment of FTTP is a once-in-multiple-generations investment, when it is complete, capex can be expected to fall appreciably. Analysys Mason says:

> *"fibre build has a one-off quality; you build it once and you can leave it – it has a very long, useful asset life"*[21]

Figure 3.1: EU27+UK FTTP availability & adoption[22]



Fibre deployment is not yet complete across Europe, but it is rapidly approaching that point. Figure 3.1 shows the number of premises in the EU27 plus UK that are unpassed.[23]

This figure has fallen rapidly as fibre deployment has accelerated, and as of September 2024 just 74m premises remained unpassed.

Further, the number of premises that have been passed by fibre but that have not yet subscribed exceeds the number of unpassed homes. This highlights the substantial latent

[20] Connect Europe, State of Digital Communications 2025, January 2025

[21] Analysys Mason, The end of big capex in telecoms: causes and implications, 28 February 2025

[22] FTTH Council Europe, FTTH/B Market Panorama in Europe, September 2024

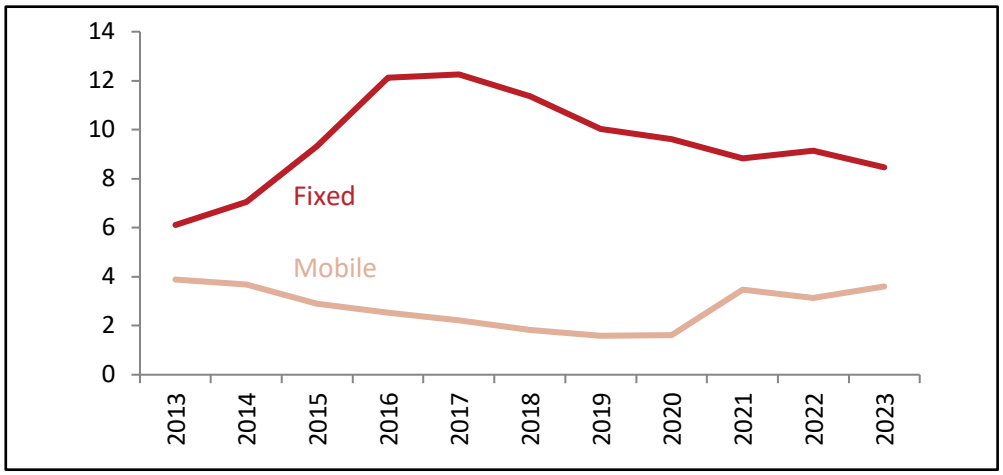
[23] A home is passed when fibre has been brought to the immediate vicinity (for instance, a cabinet in the home's street) but no further. When a home subscribes, it is then connected with a final 'drop' to the house of (typically) tens of metres or less of fibre

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potential for revenue in the fibre that has already been deployed. Further, connecting the remaining premises as they subscribe involves less work and will be high margin.

Peak capex is likely to occur some years before reaching 95% coverage. For example, for incumbents in France, Spain and Sweden peak capex for FTTP is already some years in the past (see figure 3.2 for Sweden). Orange said in 2022 that there would be a "significant decrease" in capex, because the "FTTH deployment peak [has] passed".[24] Telefónica reported its "3-year investment programme passed its CapEx peak in FY 21",[25] and since then capex has fallen by 13% (even before adjusting for inflation).[26] PTS, the Swedish regulator, reports "investments in fixed broadband networks increased from 2008-2017 and fell thereafter due to the increased coverage of fiber infrastructure."[27]

Figure 3.2: Capex by type, Sweden (bn kr)[28]



This decline in fixed capex is particularly important because fixed investment has historically been such an important part of total capex. For example, in Sweden spend on the fixed network has been more than triple that on the mobile network, 2013-2023 (Figure 3.2).[29]

3.1.2 Mobile capex

As with FTTP, operators are a substantial way through the cycle of investment for 5G. The roll-out of 5G coverage is mostly complete across Europe, with the great majority of countries already having achieved 95% population coverage or more. That said, there is a possibility of further upgrades to the mobile networks, and standards for 6G are already being developed. However, deployment is not expected before 2030.[30]

Further, there is some doubt that operators will see a strong business case for 6G, particularly given that 5G has generally been a financial disappointment.

Juniper Research has noted:

> *"The expected revenue boost from 5G has yet to materialise, with many operators still struggling to secure a return on their 5G investments; a mistake they cannot afford to repeat with 6G."*[31]

According to Analysys Mason:

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[24] Orange, Orange financial results, H1 2022, 28 July 2022

[25] Telefónica, Results January-December 2021, 24 February 2022

[26] Telefónica financial statements. Figure is for operations in Spain

[27] PTS, Telecommunications operators and yield on investment, 22 April 2025

[28] PTS, Uppföljning av regeringens bredbandsstrategi 2024, 20 June 2024

[29] See also for Italy, AGCOM, Relazione annuale 2025 sull'attività svolta e sui programmi di Lavoro - Appendice statistica, 24 July 2025 (Table A1.8)

[30] Qualcomm, Leading the technology revolution to 6G [accessed 29 August 2025]

[31] Juniper Research, What Do Trump's Tariffs Mean for Telecoms & 6G?, April 2025

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> *"there's little appetite for a major RAN refresh in 6G, and therefore, we don't expect a cyclical rebounding capex."*[32]

Orange's CTO Laurent Leboucher has said

> *"I personally believe that 5G is the last G and we're moving beyond Gs,"*

Orange, alongside other members of the Next Generation Mobile Networks Alliance (an association of leading MNOs) are strongly advocating that 6G should primarily occur through software upgrades, rather than the much more expensive hardware refresh required for previous Gs.[33]

In addition to generational upgrades, mobile capex may be driven by traffic growth, which may require network densification or upgrades to electronics. However, as discussed below in section 4, traffic growth has slowed appreciably, and is generally expected to slow further. This slower growth will also contribute to reduced mobile capex. Indeed, the incremental capacity provided by the natural replacement cycle – whereby end-of-life equipment is replaced with more modern equivalents – will increasingly cover demand growth, without the need for further spend specifically for traffic growth.

3.1.3 Spectrum investment

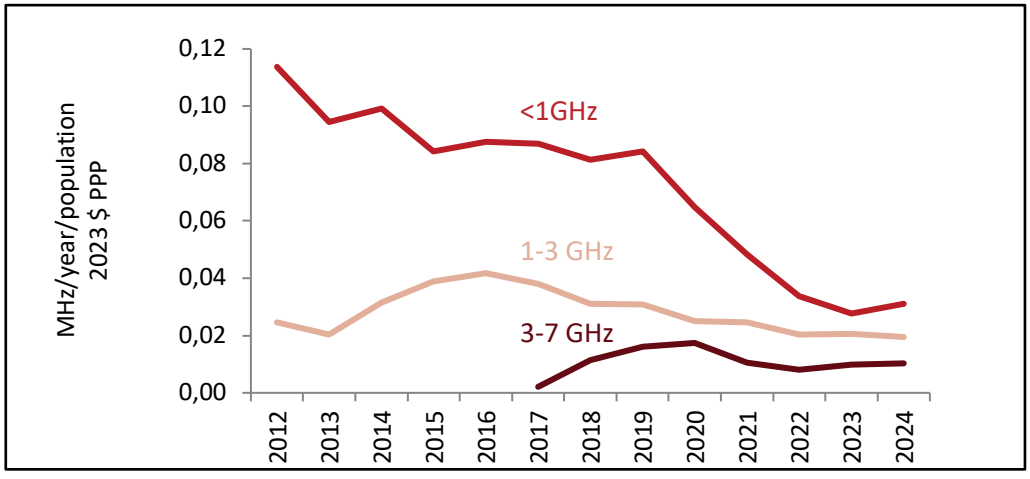
In the past, a major recurring cost for telcos has been the periodic purchase of blocks of spectrum via auction. However, there are several reasons to expect this cost to be lower in the future. Firstly, lower traffic growth is likely to mean less spend on spectrum. Additional spectrum will have much lower marginal value if traffic growth is modest enough that it can primarily be handled via equipment upgrades.

Secondly, spectrum valuations have already been on a long-term downward trend for quite some time. As Aetha have noted:

> "*Mobile operators' expectations of spectrum supply, technological advances and traffic growth are continually evolving. In recent years, the impact of each of these changing expectations has overwhelmingly been to reduce spectrum value."*[34]

The unit price of Sub-1 GHz spectrum fell by over 50%, 2020-2024, for example (Figure 3.3). Particularly given continuing traffic growth declines, there is every reason to expect this to continue.

Figure 3.3: Global spectrum prices[35]



[32] Analysys Mason, The end of big capex in telecoms: causes and implications, 28 February 2025

[33] NGMN, 6G key messages– an operator view, 28 May 2025

[34] Aetha [for BT], Why spectrum values are falling, 25 February 2025

[35] GSMA, Global Spectrum Pricing, May 2025. Figures are rolling 3 year average

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3.1.4 Implications for future capex

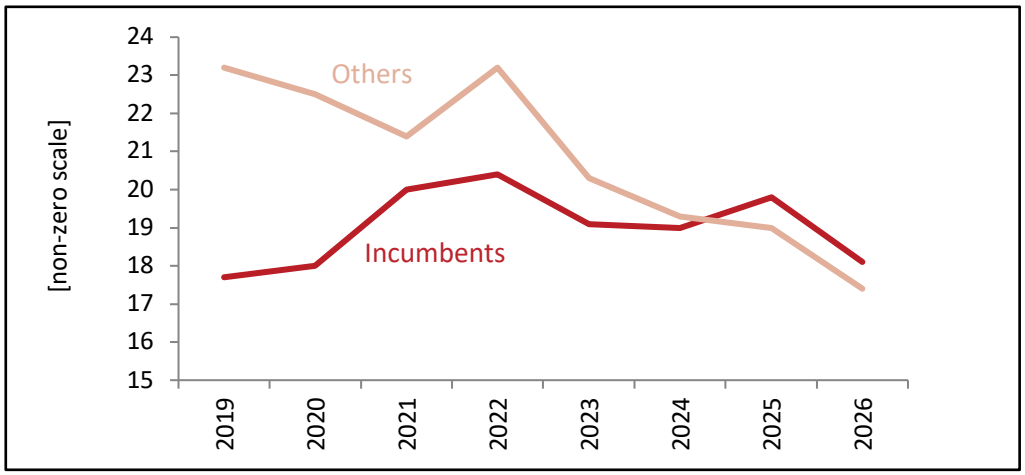
Thus, market developments across fixed and mobile capex and spectrum purchases all point to a need for considerably lower investment in the years ahead. Among the industry at large there is consensus that the capital intensity of telecoms (the portion of revenue that is spent on capex) is likely to fall around the world and in Europe in particular.

According to Analysys Mason (writing in July 2024):

> *"The telecoms industry can afford to keep up with changes in demand (and at much lower capital cost than in the past 30 years). This is because telecoms networks are close to delivering enough infrastructure for foreseeable future use … the capital cost of optimising the utilisation of already-built assets is a fraction of the cost of building them."* [36]

According to ratings agency Fitch, capital intensity in Western European telcos is already well down from its peak, and is expected to fall further in the years ahead (Figure 3.4).

Figure 3.4: Capital Intensity (%), Western European telcos[37]



S&P take a similar view:

> *"After remaining chronically elevated for a decade due to 4G rollouts and long-term densification, and then fiber and 5G rollouts, capex dropped sharply in 2023 … We expect the fall will continue through 2026."* [38]

According to Accenture:

> *"It's safe to say that, at a European level, we've reached peak CAPEX."* [39]

According to EY:

> *"Capital intensity [for European telcos] is continuing to moderate as 5G and fiber rollouts progress"* [40]

At a national level, the picture is of course more complex. 'Fibre-laggards', such as Germany, Belgium and the UK, are likely to continue to have elevated capex until deployment completes.

However, numerous operators are indicating that they expect capital spend to moderate:

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[36] Analysys Mason, A crisis of overproduction in bandwidth means that telecoms capex will inevitably fall, 10 July 2024

[37] Fitch, Western European Telecom Trends Diverge with Incumbents Faring Better, 9 January 2025

[38] S&P, Telecoms - Stronger signals for the sector, 14 January 2025

[39] Accenture, Reinventing European telcos: The path to profitable growth, 19 December 2024

[40] EY, Top 10 Risks in Telecommunications, January 2025

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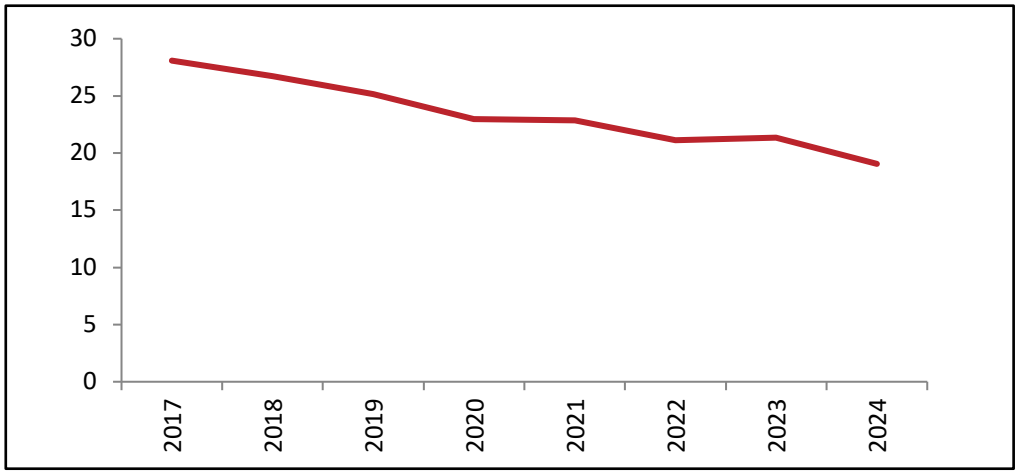
- Telefonica has noted declining capex intensity[41]
- TIM anticipates a 1.9 percentage point drop in intensity for its Italian operations, 2024-27
- Telia's capex has already fallen 18% in the last two years[42]
- KPN expects a 20% fall, 2025-27.[43]

The trends in Europe are consistent with those globally. Analysys Mason expects telco capital intensity globally to "fall from about 19–20% to around 11 or 12% by 2030."[44]

3.2 Future opex

Telcos have a long history of steady cost reduction, which for many has manifested through steady reductions in staff. By way of example, Figure 3.5 shows Telefonica Spain's employees over time. They have fallen by 24% over the last five years, and (according to press reports) further substantial reductions may be ahead.[45] DT shows a similar contraction, with employment in Germany down 21% over the same period.[46]

Figure 3.5: Employees ('000), Telefónica Spain[47]



This form of steady cost reduction has a very long history in telecoms – at the start of privatisation in 1987, Telefónica had over triple the number of employees in Spain that it has today.[48]

However, beyond this 'standard' cost discipline, there are two factors that will particularly support further opex reductions for European telcos in the years ahead – copper switch-off and AI.

3.2.1 Copper switch-off

In most of Europe, copper and fibre networks are currently being run in parallel. A significant number of customers remain on copper in many locations, and thus telcos must carry the cost of the two networks. However, as customers migrate to fibre – either of their own volition, or as a result of a mandated copper switch-off – the copper network can be retired.

This has multiple benefits:

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[41] Telefónica, Presentation: Q1 2025 results, 14 May 2025

[42] Telia, Telia Company Q2 2025, 18 July 2025

[43] KPN, Q2 & H1 results, 23 July 2025

[44] Analysys Mason, The end of big capex in telecoms: causes and implications, 28 February 2025

[45] Reuters, Telefonica evaluates cutting 4,000 to 5,000 job in Spain, El Confidencial says, 5 May 2025

[46] BNetzA, Datenportal>Digitales & Telekommunikation [accessed 4 September 2025]

[47] Telefónica Annual Reports

[48] Telefónica de España., 1987 Annual Report, 28 April 1988

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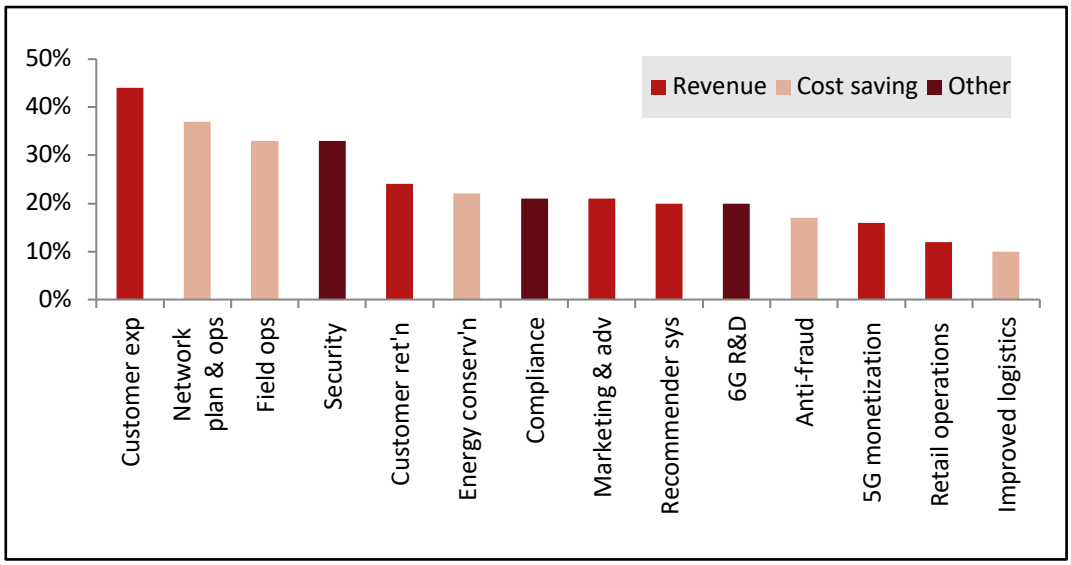
- It saves the (substantial) power and maintenance cost of the copper. According to Connect Europe, "opex per line on FTTP is about 50% that on copper"[49]
- It simplifies network operations, since there is only one access network to monitor and maintain
- It reduces the number of required telephone exchanges, potentially by 90% or more.[50] In the years 2024-26, Telia anticipates proceeds of SEK1bn from selling technical buildings as its copper network is turned off[51]
- It allows telcos to sell the copper metal. For example, in September 2024, BT secured a £105m upfront payment for the sale of the copper it will extract from its legacy network[52]

Spain and Portugal have been leaders in this area. Telefónica closed its last copper exchange in May 2025, and reports that copper switch-off has improved EBITDA margin by one percentage point.[53]

3.2.2 AI

AI is transforming industries, enabling revenue enhancement and cost reduction. Telecoms is no exception, with operators around the world implementing AI in a wide array of areas, notably customer experience and network & field operations:

Figure 3.6: Global telco implementation of AI by activity, 2024[54]



A McKinsey survey of telcos found that they had moved well beyond the exploratory phase with AI, with 64% reporting they had moved on to scaling their AI implementations.[55] DT has 400 AI projects up and running, and says:

> *"[AI] is improving the speed of our organization. It's improving the efficiency in a lot of routine areas. It's improving the quality of our networks".*[56]

[49] Connect Europe, State of Digital Communications 2025, January 2025

[50] Telefónica, Report – Q1 2025 results, 14 May 2025

[51] Telia, Investor update, 26 September 2024

[52] Guardian, BT pockets £105m in first ever recycling deal for surplus copper cables, 29 September 2024

[53] Yahoo! Finance, TELEFONICA,S.A. (TEF.MC) Q2 FY2025 earnings call transcript, 30 July 2025

[54] NVIDIA, State of AI in Telecommunications: 2025 Trends, 2025

[55] McKinsey, Scaling the AI-native telco, 27 February 2025

[56] Deutsche Telekom, Q2 2024 Earnings Call, 8 August 2025

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AI supports revenues by improving customer service (and hence customer satisfaction), by enabling more targeted customer offers, by improving targeting of advertising and so on.

In the network, it is improving traffic management, predictive maintenance and network self-healing, reducing both network operations costs and downtime.[57] DT anticipates use of AI could lead to a 20–30% improvement in productivity for network planning & operations.[58]

AI is expected to be transformative for the Radio Access Network (RAN) - 45% of MNOs see AI tools as 'absolutely critical' to optimise the RAN, and a further 48% see it as quite important.[59] More than half are already using AI in this area, with an additional 19% planning to do so in 2025. Benefits may be in the short term (such as fault detection and anomaly resolution) and in the medium term (such as more accurate local traffic forecasts enabling more efficient targeting of investment). An example of the latter is O2 Telefónica's work with Google Cloud using AI to predict mobile data usage patterns. This has proved significantly more accurate than previous techniques, and delivers forecasts in days, not weeks.[60]

A number of European operators are already reporting quantified benefits:

- Orange reported that AI generated €200m of value (incremental revenue and reduced costs) in 2024.[61]
- BT's AI agent Aimee has halved the need for human agents for certain customer interactions[62]
- Elisa has seen a greater than 10% improvement in marketing effectiveness.[63]
- Another European operator has seen a 5% to 15% uplift, depending on segment.[64]

Nonetheless, we are still in the early stages of telcos exploring AI's potential. Overtime, broader and deeper savings and revenue enhancements are likely to be seen.

Implications for future opex

Telcos have shown considerable diligence in driving down costs over many years. For the years ahead, further cost reduction is likely to be supported by the two 'step changes' represented by the shutdown of the copper network and the advent of AI.

3.3 Future revenues

3.3.1 Fixed

As FTTP coverage has become widespread, telcos have increasingly turned their attention to capitalising on that investment. As Telecompaper puts it (in a paper for the Dutch Ministry of Economic Affairs), full fibre:

> "*provides a basis for innovation with higher customer satisfaction, lower churn and higher ARPUs.*"[65]

The most direct route to this increased Average Revenue Per User (ARPU) is by upselling customers to higher speed connections. Figure 3.7 shows the proportion of broadband connections in the EU that have speeds of 1 Gbps or more – it is rising by about four percentage points per year, and currently stands at 22%. The figure is far higher in certain markets. In France, for example, 59% of connections are 1 Gbps or more. (Lines with speeds of 100 Mbps plus are also increasing).

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[57] GSMA, Telco AI: State of the Market, Q1 2025 AI and networks, March 2025

[58] Deutsche Telekom, Group Strategy, 10 October 2024

[59] Telecom TV, AI's impact on the radio access network, September 2024

[60] Telecom TV, How AI is helping O2 Telefónica, 27 January 2025

[61] Orange, Annual Results presentation, 13 February 2025

[62] BT, BT Group leans on AI to transform customer service experience, 12 December 2024

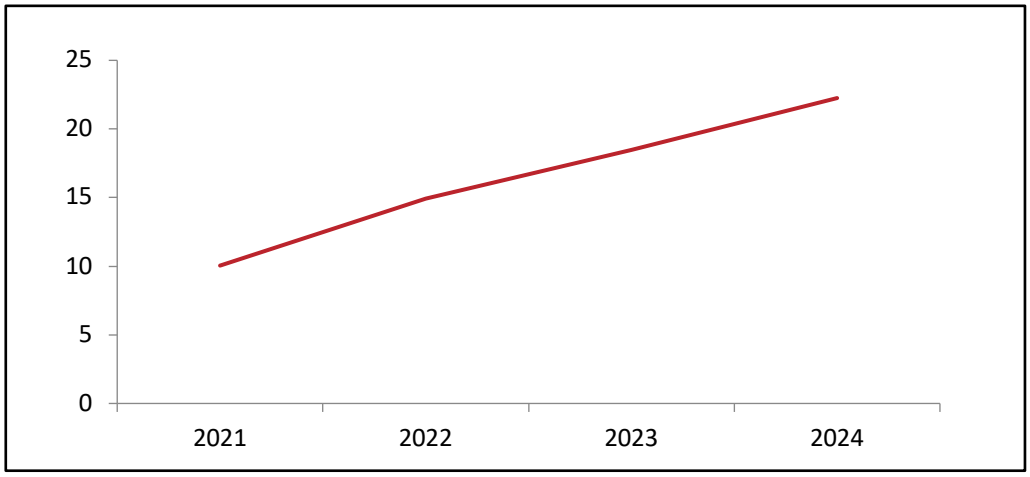
[63] Elisa, Financial overview, 6 March 2025

[64] McKinsey, Scaling the AI-native telco, 27 February 2025

[65] Telecompaper [for Dutch Ministry of Economic Affairs], The Financial Health of the European Telecoms Operators, 24 June 2024

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Figure 3.7: Share of EU fixed broadband subs that are 1Gbps or more (%)[66]



These faster connections come at a premium cost to consumers, and hence generate more revenue for operators. Orange, for instance, attributed a 5% increase in fixed broadband ARPU to fibre adoption.[67] Further, since these higher speeds have no incremental cost (once the wiring is in place), this additional revenue drops straight to profit for telcos.

That said, it does not necessarily follow that fixed broadband ARPUs will necessarily increase.

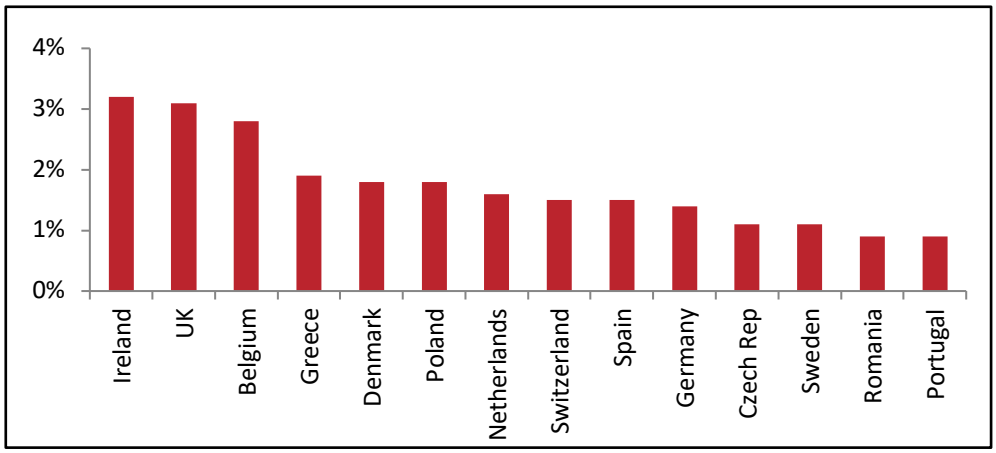
The change in mix of lines to higher speeds may be offset by deflation of prices across all line speeds, due to competitive pressure. However, according to Goldman Sachs:

> *"CEOs and CFOs of some of the most important European telecom companies ... [say] that the acceleration — the higher rate of growth they've been delivering — is sustainable into 2025. This is because they have seen increasing pricing power in fiber broadband, thanks to deregulation".*[68]

3.3.2 Mobile

The GSMA forecasts 1.6% annual revenue growth for European mobile operators to 2030.[69] PWC forecasts a similar rate, albeit with considerable variation by country (Figure 3.8). Once again, this points to the importance of local variation – there is not a consistent pan-European picture.

Figure 3.8: Mobile revenue CAGR, 2023-28[70]



[66] EC, DESI 2025

[67] Investing.com, Earnings call transcript: Orange sees growth in 2024, AI partnerships boost, 13 February 2025

[68] Goldman Sachs, European telecom companies poised for growth amid deregulation, 3 October 2024

[69] GSMA, The Mobile Economy Europe 2025, January 2025

[70] PWC, Perspectives from the Global Telecom Outlook 2024-2028, 28 February 2025

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Mobile adoption is near 100% in many markets. Thus, revenue growth is likely to come from upselling existing customers, price increases, or new services. While there are opportunities in newer services such as IoT, the scale may be modest. Regarding upselling to larger data packages, the increasing prevalence of unlimited packages and the decline of traffic growth make this challenging. Thus, price increases may be the most likely path to revenue growth. This of course depends on the competitive dynamics of the market in question.

3.3.3 Implications for future revenue

The pivotal issues for revenue growth in the telecoms sector are competition and (related to this) regulation. European telecoms operate under a highly pro-competitive regulatory framework. This includes limits on mergers, wholesale access remedies, interventions to facilitate switching, and a wide array of other measures. These have supported market entry by challengers to incumbents.

This has been very beneficial for European consumers, who enjoy a good choice of providers and significantly lower prices than some other markets.

However, competition inevitably suppresses some returns for telcos. For example, it means opex savings (say via copper switch off, or the use of AI) are likely to be competed away, and passed through to consumers. Those operators with lowest share will be tempted to use savings to undercut larger players (rather than retain them), in order to gain share. This in turn invites a pricing response from the larger players.

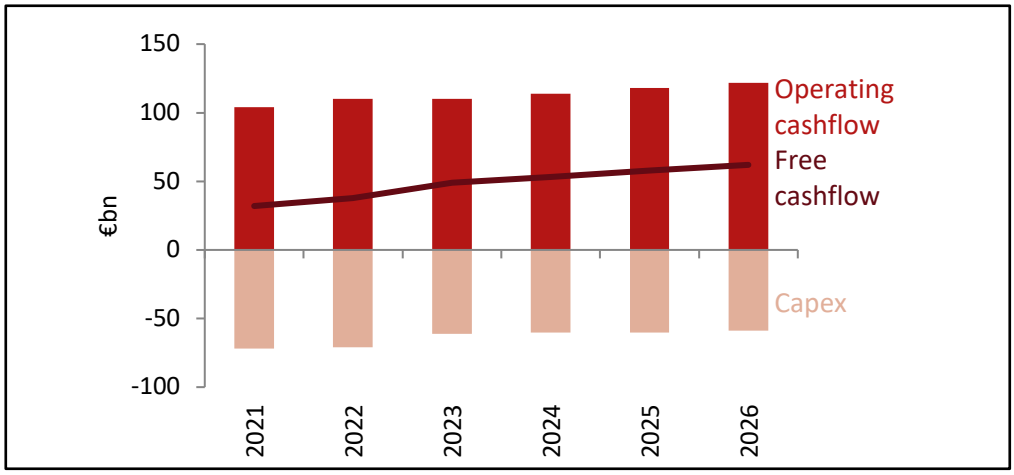
By itself, this is no bad thing – one of the fundamental reasons that competition is seen as beneficial is that it ensures value flows to consumers rather than being captured by providers.

However, some argue that European telcos are making insufficient returns. If this is seen as a policy problem, then the fundamental issue to wrestle with is the degree of competition. Interventions that (say) transfer value into telcos from other sectors will only improve telco returns if that value isn't simply passed on to consumers. But high competitive intensity means that such a pass-through is a likely outcome.

3.4 Future cashflow

Notwithstanding the risk that lower costs are competed away to some extent, analysts' expectations are that European telcos' cashflow will substantially improve.

Figure 3.9: European telcos cashflow[71]



Barclays anticipate a 1.6 percentage point increase in operating free cashflow margin (to 24.9%) for European incumbents, 2025-2027. For European challengers, they expect a 1.2

[71] S&P, Telecoms - Stronger signals for the sector, 14 January 2025

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percentage point improvement. This is consistent with S&P's view, who expect a continuation of the trend of improving free cashflow for European telcos (Figure 3.9).

Thus, Europe's telcos appear to be headed to their best financial position for many years.

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4 Impact of traffic growth on network CAPEX

This chapter considers the impact of growth in fixed and mobile data usage on telecoms networks. It starts by looking at the rate of growth, and showing that this is slowing, with a plateau in mobile data usage likely in the coming years. It then looks at how fixed and mobile networks meet increasing data demands and shows that this is mostly through core network upgrades on fixed networks, and increased spectrum deployment on mobile networks. Then the cost of these upgrades is considered and shown to be a small percentage, typically less than 1%, of annual network capital expenditure. Finally, the chapter considers whether future applications and technologies such as AI might change this conclusion by stimulating more data growth and concludes that this is unlikely.

The key message from this chapter is that the impact of traffic growth on network CAPEX is minimal, even insignificant.

4.1 Data growth

4.1.1 Growth is dominated by video

To understand the growth in data usage it is firstly helpful to understand what the data is being used for. It has long been reported that data consumption is dominated by video. For example, in 2022 Ericsson reported[72] that video represented 71% of all mobile data and that percentage was forecast to rise to 88% by 2028. Values are similar on fixed networks.

A few simple calculations make it clear why this is. An hour of HD video equates to around 10Gbits of data[73]. By comparison browsing the Internet uses about 400Mbits/hour[74] (depending on the content and speed of clicking) – less than 4% of HD video. At present, there is no content that comes close to video in terms of the data volumes per hour of usage coupled with the hours of usage[75].

The implications of this are that there is an upper limit on data usage since there is only so much video we can realistically watch (assuming streamed video or that downloaded video is all watched at some point).

The actual volumes of data depend on the resolution of video. In mobile networks video resolution is low since screens are small. In fixed (home) networks video rates can be higher as High Definition (HD) is standard with 4k availability becoming the norm for new movies and sports. However, pervasive use of 4k seems unlikely, for example Omdia reported[76] that when consumers are asked why they subscribed to a particular video service, less than 10% say it is because UHD content is important. Expansion to 8k seems even less likely, with extremely limited content and little apparent interest from consumers or broadcasters in moving to substantial 8k usage. This is readily explained by the fact that few consumers have screens and viewing environments where the difference between 4k and 8k would be significant. Indeed, much streaming takes place on phones, where 4K brings no meaningful benefit over HD.

Over time we have seen a number of trends related to video:

- On mobile devices users have spent more time watching video, often in the form of short video clips on platforms like TikTok. Video has also become a key part of social media feeds, often auto-playing as the feed is scrolled.
- In the home the total amount of video watched has remained relatively constant but its source has progressively moved from “broadcast” (e.g. received over the air or via

[72] https://www.ericsson.com/en/reports-and-papers/mobility-report/reports - see November 2022, pp25

[73] Derived as 3Mbits/s * 3600 seconds in an hour.

[74] https://uw.co.uk/mobile/guides/how-much-mobile-data-do-i-need

[75] Video game downloads result in sustained high data rates, sometimes for hours, but happen relatively infrequently. After download the game is typically played for many tens or hundreds of hours with little more data traffic, bar the occasional patch or update.

[76] https://omdia.tech.informa.com/om022206/uhd-video-content-is-more-important-to-consumers-than-ever-before

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broadcast cable) to “streamed” (e.g. delivered over a broadband network to the home). This has increased the volume of data consumed over broadband networks.

- Mostly in the home, but also in some cases on the mobile, video resolution has increased, with HD content becoming standard and 4k (or UHD) available for a growing percentage of the content.

For all these trends there are natural limits. On mobile devices it is the amount of time people are willing to spend watching video. On fixed networks it is the point at which all video is transferred via streaming. Video resolution also has a limit at the point that subscribers notice no material improvement both because their display devices are limited and their eyes have a fixed resolution.

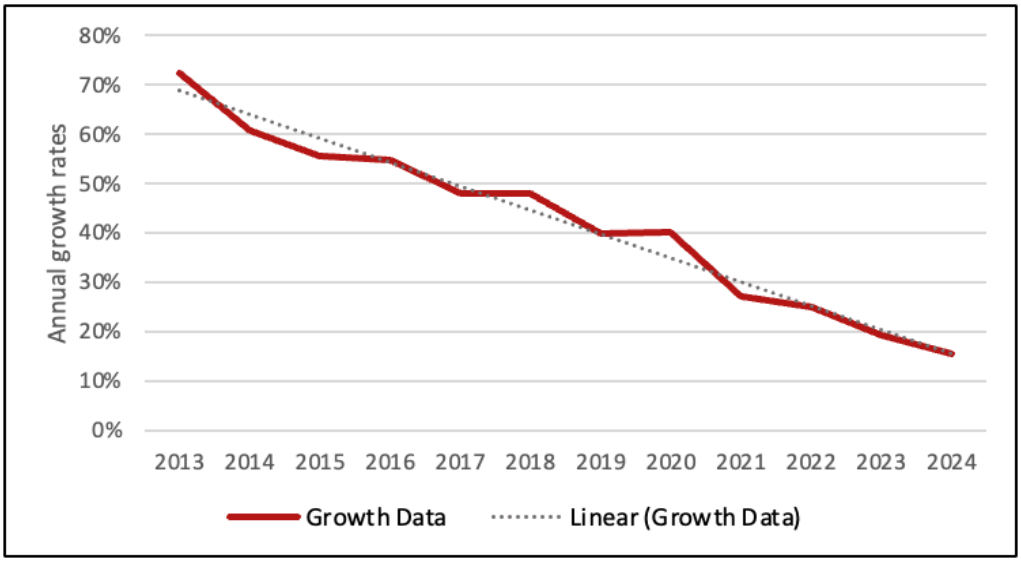
Given both mobile and fixed data is dominated by video and given that there have been strong drivers for growth in the past but limits are increasingly being approached, logically we might expect to see a slowing growth in data usage, reaching a plateau when video consumption is satiated. Further, the data rates needed to send a given quality of video are falling, as set out in the Annex, which will further slow data growth and could even cause data usage to fall.

4.1.2 Mobile data growth

Mobile traffic was dominated by voice and text messaging, until the launch of smartphones in the late 2000s. Since then, mobile devices were increasingly used to access the internet and then to consume video, make video calls, and participate in virtual meetings. This led to an increase in mobile data use and growth has continued for the last 18 years.

Figure 4.2 shows the average growth in global mobile data usage between 2013 and 2024 assembled from a range of sources.

Figure 4.2: Average mobile data growth[77]



From this it is clear that:

- For the 10 years since 2013 there has been a very clear and inexorable downward trend in data growth rates closely tracking a straight line and falling by around 5%-6% per year.
- There is a very small Covid-related spike in 2020.
- Notably, there is no “5G effect”. The introduction of 5G has not led to more mobile usage than would have been predicted had it not been introduced.

[77] The End of Telecoms History, Webb, 2024

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There are many other data sources all pointing in the same direction. For example, Analysys Mason provided the following[78]:

Figure 4.3: Global mobile data growth rates (including FWA) [79]

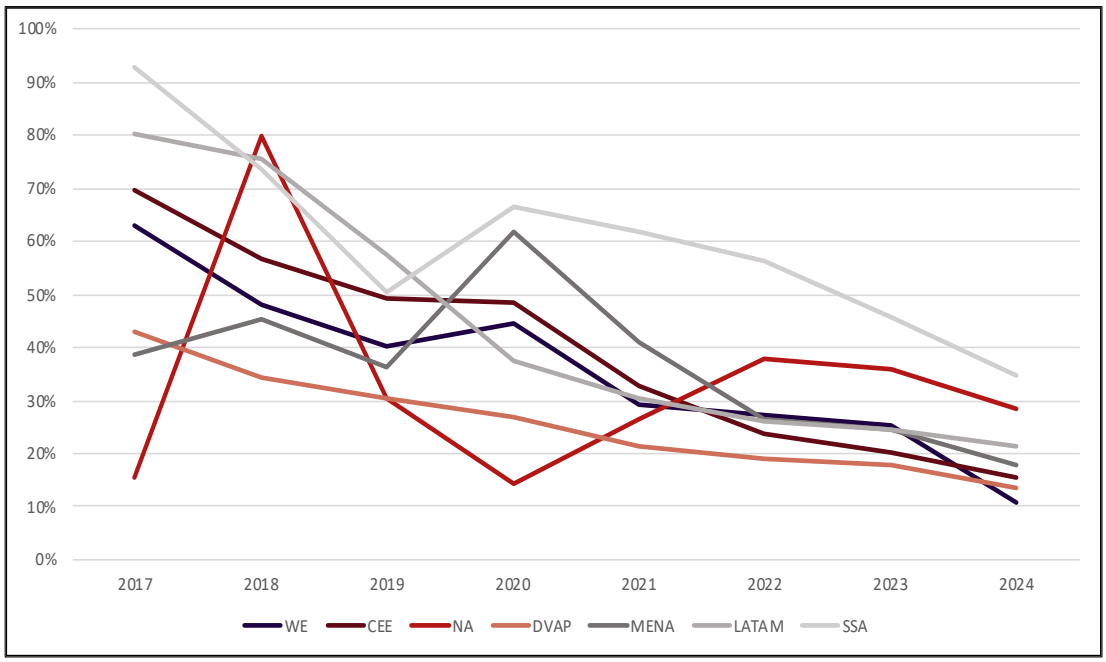
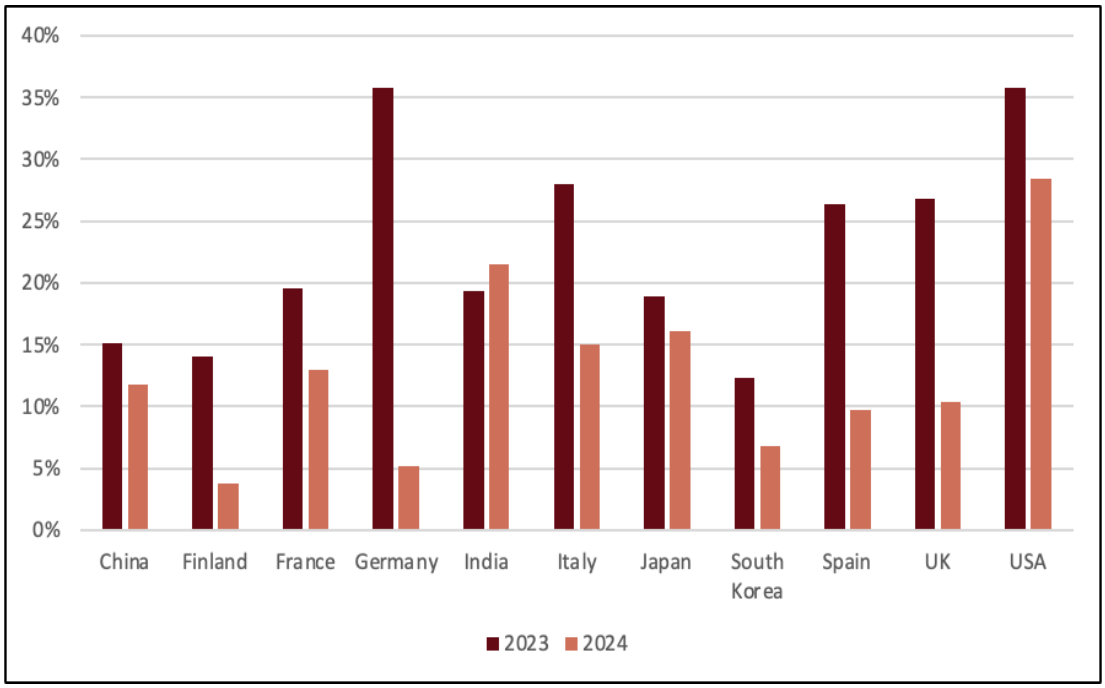


Figure 4.3 shows that much of the world is following the same downward trajectory in growth rate. Only sub-Saharan Africa stands out as being materially different and even there, growth rates are falling rapidly[80]. Selected country data points the same picture as reported below.

Figure 4.4: Selected country mobile data growth rates (including FWA) in 2023 and 2024[81]



[78] Wireless network data traffic: worldwide trends and forecasts 2023–2029. Access to the original data is behind a paywall.

[79] Analysys Mason. CEE = Central and Eastern Europe, DVAP = Developed Asia-Pacific, EMAP = Emerging Asia-Pacific, LATAM = Latin America, MENA = Middle East and North Africa, NA = North America, SSA = Sub-Saharan Africa, WE = Western Europe

[80] This can be somewhat explained by the relatively lower mobile data usage starting point for this region and the catch-up effect that would be anticipated over time.

[81] Analysys Mason

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This shows a significant reduction in annual percentage growth in mobile data usage in most countries between 2023 and 2024[82].

If we forecast forwards on the assumption that mobile data growth rates will continue to decline by around 5%/year as they have done for the last 11 years, then growth rates will approach zero for mobile network traffic in the next five years, sooner in some countries.

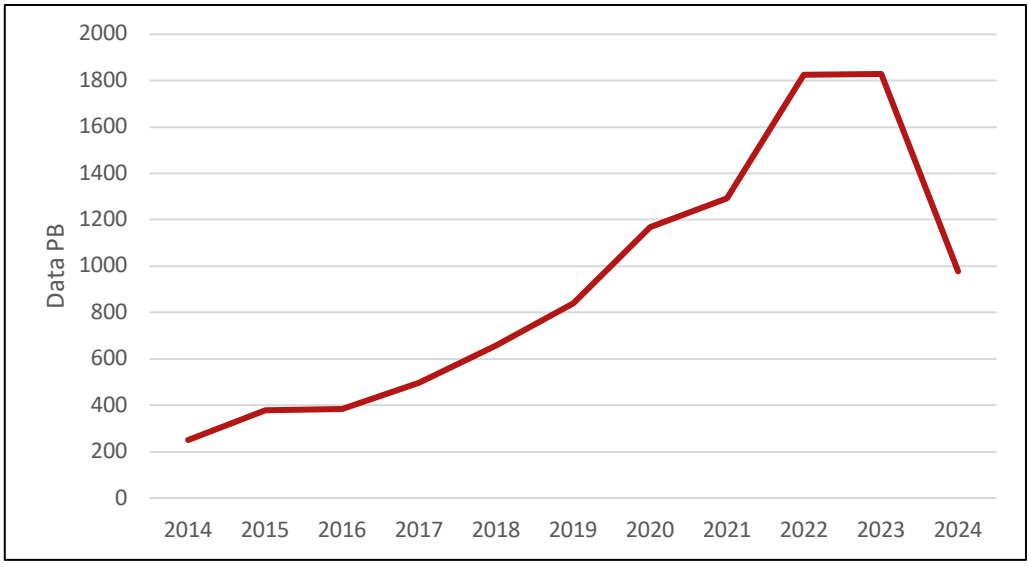
In the analysis above we have concentrated on percentage growth rates. Some have noted that although the percentage growth may be slowing, because it is a smaller percentage of a larger number, the absolute growth is still significant. This is true to some extent but in the last two years or so this trend has reversed.

In June 2025 Tefficient reported[83]:

> *"22 of 40 countries had slower usage growth [in GB] in 2024 than in 2023, 10 of 40 countries had faster usage growth [in GB] and 8 of 40 countries haven't yet reported 2024. So regardless of how one presents it, the mobile data usage growth is decelerating in a clear majority of countries. This happens although FWA traffic is included for 33 of these 40 countries, i.e. even FWA appears to be an insufficient compensation for the weakening demand of additional mobile data. This is water to the mill for the believers of the S-curve theory."*

The chart below based on Ofcom data shows that annual incremental data increases plateaued in the U.K. in 2022/3 and have fallen significantly in 2024.

Figure 4.5: Absolute data volume increases in UK (PB)



Source: Ofcom (consolidated quarterly data usage reporting)

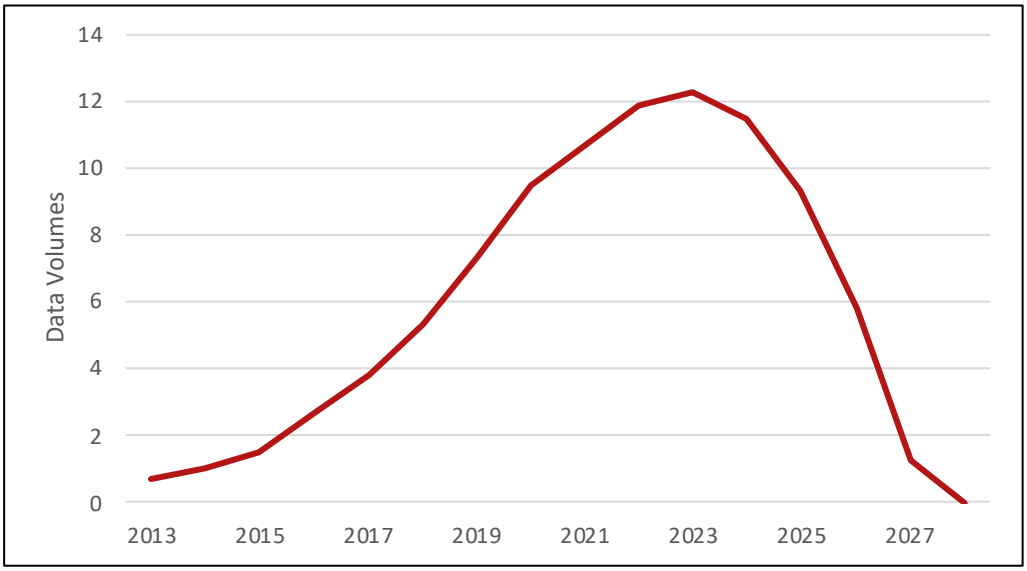
Using the trendline fitted to global usage data from Figure 4.2, and extrapolating that trendline forward at a reduction in growth rates of 5%/year, the chart below shows the increase in absolute data volumes (actual to 2024 and predicted beyond that).

[82] The only exception is India where the inclusion of fixed wireless access (FWA) results in more rapid growth (we will discuss FWA later). Without FWA, growth in India is falling rapidly and is currently at around 10%/year for traditional mobile traffic.

[83] https://tefficient.com/wp-content/uploads/2025/06/Tefficient-industry-analysis-1-2025-mobile-data-usage-and-revenue-full-year-2024-per-country-excl-M2M-9-Jun-2025.pdf

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Figure 4.6: Absolute increase in data volumes (PB)[84]



As can be seen, this peaks around 2023 and will likely fall rapidly to near zero over the next few years.

4.1.3 Fixed data growth

Fixed data requirements are following a similar curve to mobile, albeit with a significant "blip" around the Covid era – indeed growth rates are lower and heading towards single figures. Communication Chambers provide a detailed annual assessment of global fixed line traffic growth. The global average is shown below.

Figure 4.7: Average global growth in traffic per fixed line[85]



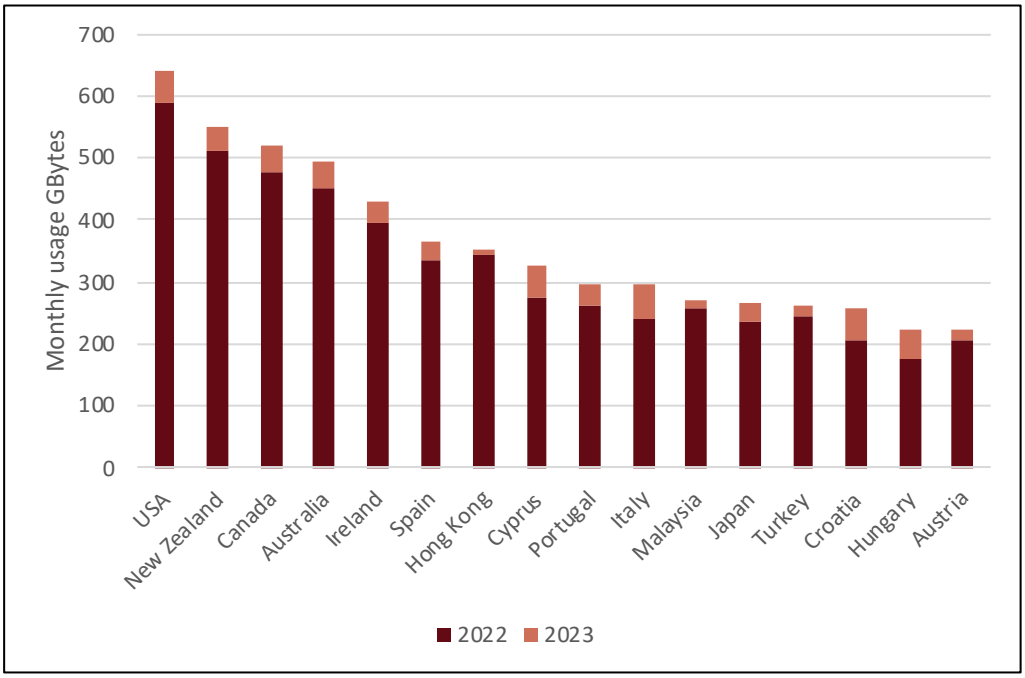
The Covid19 spike is very obvious, as is the downward trend that preceded and followed it. However, since 2022 the decline in data growth rates appears to have stopped, levelling out at least for now at around 10%/year. Absolute levels differ significantly across countries as shown by the figure below.

[84] The End of Telecoms History, Webb, 2024

[85] https://www.commcham.com/pubs/2024/11/13/patterns-of-fixed-traffic-growth-2024.html

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Figure 4.8: Fixed traffic levels per line in selected countries[86]



One reason traffic growth is modest is that improved access speeds do not in fact lead to greater traffic. Econometric analysis of granular Ofcom data for speeds and per-line traffic in the UK shows that traffic is overwhelmingly driven by household demographics (household size, age, and so on). Line speed explains only 1-3% of the variation in household traffic.[87]

4.1.4 Peak data capacity

The previous section discussed average traffic levels. In practice, there are occasional events that result in significant traffic peaks well above the average traffic levels, such as shared video-related events such as major football games, or the release of a new video game with resulting large downloads.

In this section we look at whether the need to dimension for peak loading will result in greater demands on network expansion than the need to dimension for average traffic load. That is, will peak demand grow more rapidly than average demand?

Fixed networks

The UK's main fixed network operator, Openreach, reported[88] a peak loading of around 40% higher than the average, but that this peak loading is only growing slowly. Analysys Mason reported in 2023[89] that these peaks were only growing by 10%/year, less than the growth rate of the average. That is, network traffic is becoming more uniform.

This is to be expected as traffic grows. For example, if households are already streaming video throughout the evening, then a widely watched sporting event will not add to the loading, it will just result in many watching the same stream rather than different ones[90].

Core networks will typically already be appropriately sized to handle peak loading. Given the likelihood that the peak will grow less quickly than the average, then this suggests that core network upgrades will be smaller in percentage terms than the growth in average traffic. For example, if we expect a total growth in traffic of 30%, we might only need to see half that growth in core network capacity since the peak traffic growth will be lower.

---

[86] Communications Chambers, ibid.

[87] Robert Kenny, Charles Kenny & Zack Gehan, "What drives broadband traffic?", Telecommunications Policy, October 2023. Note that higher speed lines do on average have higher traffic, but this appears to be because those with more traffic choose higher speed lines, not because the speed itself increases traffic

[88] https://www.telecoms.com/fibre/uk-broadband-traffic-jumped-10-last-year

[89] https://www.analysysmason.com/contentassets/1d7e13ed1dba4cc6917daa023f27834b/analysys_mason_fibre_in_europe_may2023.pdf

[90] And approaches such as multicasting can further reduce the traffic levels associated with such streams within the core network.

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Mobile networks

Traffic peaks on mobile networks tend to be less pronounced than on fixed networks at a national level, although extreme at a local level.

At a network-wide level, there are few drivers for significant traffic peaks. The drivers that apply to the fixed network such as sporting events and game download tend to be less significant on mobile networks (eg because of a preference to watch sporting events on large screens)[91]. Instead, peaks tend to be localised, caused by events such as a major concert, a major traffic disruption or similar. Mobile operators tend not to dimension the network to accommodate all these localised peaks – to do so would be very expensive and result in capacity that was very rarely used. Instead, they accept congestion in these cases and tend to throttle usage so that subscribers have to fall back to lower bandwidth applications (eg voice rather than video call). Only if the traffic pattern becomes "normal", such as at a major railway station during commuting hours, is sufficient capacity installed to meet demand.

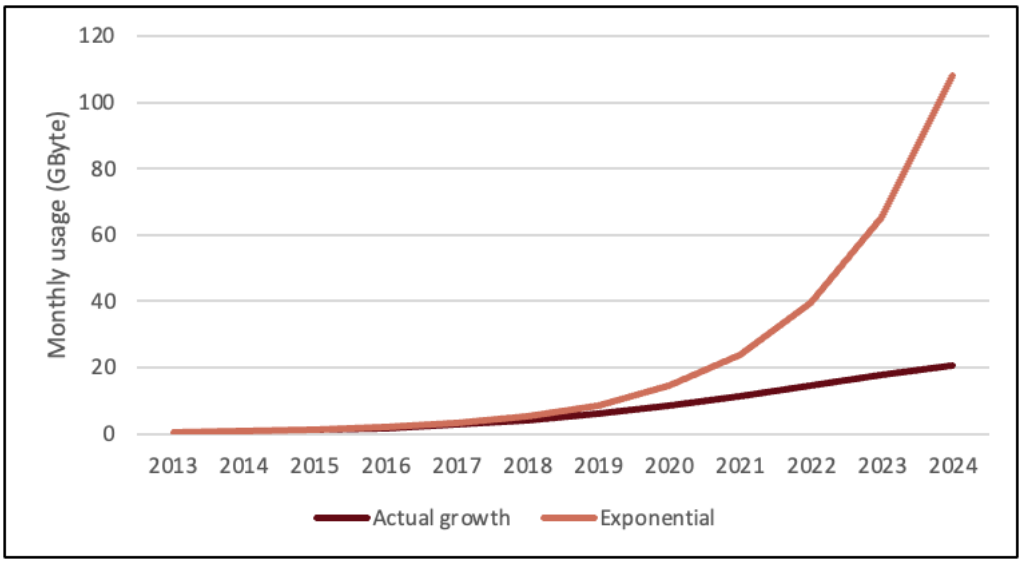
Hence, peak loading will not make a material difference to the need for capacity enhancement driven by increases in average usage.

4.1.5 Growth is not exponential, indeed the opposite

Exponential growth describes a situation where a quantity increases at a rate directly proportional to its current size. This means the absolute growth accelerates over time, leading to faster and faster increases in magnitude, like a population that doubles at a fixed interval[92].

The chart below shows global mobile data growth since 2013 and a curve representing the lowest level of growth that would qualify as "exponential" since then.

Figure 4.9: Actual versus exponential growth (traffic per SIM)[93]



As can be seen, since around 2019 growth has deviated hugely from exponential.

4.2 Network capacity is mostly sufficient

In this section we look at the implications of the remaining limited growth on fixed and mobile networks, and conclude that there is sufficient capacity in most networks to accommodate this limited growth.

---

[91] There have been some exceptions. Key football games that occur during the working week and in daytime can result in peaks as employees surreptitiously watch on their mobile while at work!

[92] As we have shown, an S-curve provides an excellent fit to mobile and fixed data usage over time. At the start of the S-curve, it does indeed look like a J-curve and growth is exponential. But as the S-curve reaches its mid-point, growth declines as a percentage of size – the opposite of exponential growth. We have been on this decline for over a decade now and will soon reach a point of zero growth.

[93] Various analyst data as explained in "The End of Telecoms History", Webb, 2024

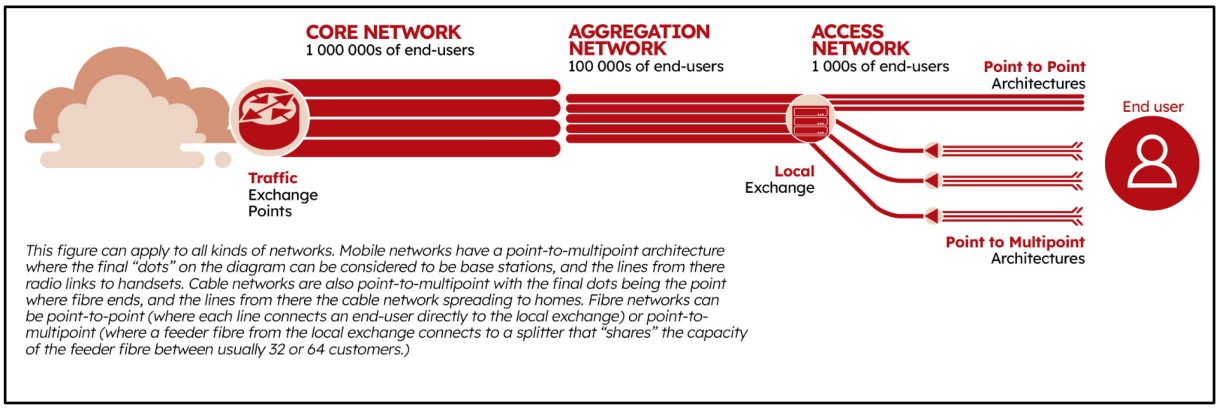
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4.2.1 There is modest traffic growth left on both fixed and mobile networks

As the previous section showed, growth is declining. On mobile networks it was on average around 15%/year in 2024 and falling at 5%/year. A simple extrapolation suggests 10% growth in 2025, 5% in 2026 and then minimal levels after that. This would imply as little as 15% total growth from current levels. On fixed networks there is a 10%/year growth that is in part sustained by a one-off transition from broadcast TV viewing to streaming. This section looks at whether fixed and mobile networks have the capacity for this growth and if not, what actions need to be taken. The next section will look at the costs of these actions.

We will discuss capacity and costs in connection with various parts of the networks, the core, the aggregation and the access. Simplistically, this network architecture is shown below.

Figure 4.10: Schematic view of network architecture[94]



4.2.2 Mobile networks

Mobile Network Operators (MNOs) typically deploy network capacity in response to demand. In the Annex we set out the various ways that they can increase mobile capacity and the costs associated with this leading to the table shown below which provides cost estimates for a typical European mobile network for various levels of assumed growth (to a plateau of usage at some future point)

Table 4.1: Mobile network costs for varying levels of traffic growth[95]

Assumed growth	Cost €m
15%	53
30%	72
50%	100

Hence, our estimate is that for a typical network in a country the size of the UK, a modest overall traffic growth of 15% might be met with an upgrade cost of approximately €50m. A doubling to 30% growth would require around €72m upgrade costs.

Overall, these costs are very low both on an absolute and per subscriber level as we will explore in a subsequent section.

4.2.3 Fixed networks

We discuss various types of fixed networks and how costs might be calculated in the Annex. For most networks including FTTP and copper networks there is no impact of traffic growth on the access segment (the "last mile") as shown in the earlier schematic. That is because subscribers can use up to the maximum data rate of the line for as long as they wish with no impact on others.

[94] Fiberevolution
[95] Authors' calculations

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Higher traffic levels will increase the demand on the shared backhaul (or aggregation and core network) connections such as from the local exchange back to hub points (aggregation), and on inter-city backbone routes (core network). For most links there will be ample spare capacity to accommodate say a 30% increase in traffic, but a subset will exceed their threshold and need an additional link. These costs are effectively spread across a large number of subscribers (eg all those connected to the affected local exchange) and might amount to a 1.5% increase in overall costs.

Cable networks share the capacity of the cable among a number of homes. Where they become congested cable operators often decide to move directly to full fibre provision costing ~€100 per premises passed.

We discuss the impact of these costs in later sections.

4.2.4 FWA

We only cover FWA briefly here as it is not extensively used in Europe, with a few exceptions such as in Italy. Detailed calculations for FWA are provided in the Annex. FWA networks have similar characteristics to mobile networks in that capacity is shared, networks are often capacity constrained, and the solutions to increasing capacity are the same as for mobile networks. For dedicated FWA networks such as that deployed by Eolo in Italy the cost of upgrade to handle predicted traffic increases will be around €20m.[96]

Where FWA is offered on mobile networks it tends to be used to fill up spare capacity, while delivering at least some revenue, albeit much less than would be the case were there multiple mobile subscribers needing that capacity. As a result, we would not expect MNOs to expand their network capacity if the requirements from FWA subscribers grew, instead they would either restrict FWA usage (as happens, for example, with T-Mobile in the US), throttle by restricting data rates, or reduce the number of FWA customers that they serve. This would result in a slight loss of revenue.

4.2.5 Interconnect, peering and transit

Traffic delivered to a subscriber will generally come from outside of the network that the subscriber is attached to. It may be delivered from a different network via private peering, from a content delivery site also using peering, or may arrive via transit.

Peering links will not generally carry a charge for the access network provider. Indeed, in some cases the access provider may be charging the content provider for the link. The physical cost of the connection is usually trivial - the parties are typically already both present at an Internet Exchange Point and simply run a short cable between their routers.

Peering - paid or settlement free - will address the great majority of most network's traffic, since they are usually directly connected to the major content providers (including content distribution networks).. However, a small percentage of traffic will travel over 'transit links'. These are charged connections to the rest of the internet (not covered by a network's peering agreements). However, unit costs are low, and thus these costs are not material.

4.3 Costs are very low in comparison with overall capex

We have derived costs for each of the different network types. We now compare these costs with annual capex and opex to place them in perspective.

[96] Note that covering new areas with FWA is substantially more expensive, requiring new masts to be constructed and customer premise equipment (CPE) installed. This cost relates purely to capacity expansion for existing customers.

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Table 4.2: Costs for a typical European-sized network needing to cope with remaining traffic growth[97]

Service	Anticipated upgrade cost	Location of cost	Typical annual capex	Typical annual opex
Copper/fibre networks	1.5% of annual costs	Core and aggregation	€3bn[98]	€2.5bn
Cable networks	N/A (upgrade will occur in any case)	Access	N/A[99]	N/A
Mobile networks	€50-75m	Access	€1.3bn[100]	€4bn[101]
FWA	€20m	Access	€100m[102]	€100m

The table shows that in all cases the upgrade costs required to deliver around 15%-30% additional network capacity are in the region of 1% of typical network capex. And given that these costs may be spread over multiple years they will effectively be less than 1% on an annual capex basis.

These are much smaller cost increases than would be caused by effects such as global tariffs on the cost of imported telecoms equipment, for example. As an example, for mobile networks, the costs listed above would equate to around €3-4 per subscriber.

4.4 Emerging technologies are not likely to lift data requirements

While the evidence strongly suggests that data usage is slowing, some may argue that new applications will lift growth. In this section, we summarise why this will not be the case. A more detailed argument for each potential new application is provided in the Annex:

4.4.1 AI

Since the advent of large language model (LLM) based systems like ChatGPT, it seems that not much additional traffic has been generated across the access networks, both fixed and mobile. We can see this both by observation and deduction. There is no indication that a sudden expansion in AI use will have a material impact on telecoms access networks. At best, it may increase traffic on data-centre links and on Internet backbone traffic.

This has not stopped some from postulating[103] that AI is on the cusp of generating vast traffic[104] to fixed and mobile devices. But their claims are vague. Take, for example, Guillaume Boudin, CEO of Sofrecom Group who said[105]:

> *"The development of multimodal AI, able to manage images, video, and sound, will also see data traffic rise exponentially. The use cases are numerous: from virtual or augmented reality applications to smart cities and their networks of continuously streaming video cameras."*

[97] Authors' calculations

[98] https://www.openreach.com/content/dam/openreach/openreach-dam-files/new-dam-(not-in-use-yet)/documents/regulatory-compliance/Openreach-Annual-Review-2024-V2-online.pdf

[99] There are few pure cable networks, so the finances for cable operators tend to include significant fibre network deployment and operation.

[100] https://www.vodafone.com/news/corporate-and-financial/completion-of-vodafone-and-three-merger-in-the-uk . See slide 8, approximate opex taken as total revenue less EDITA and capex.

[101] https://investors.vodafone.com/~/media/Files/V/Vodafone-IR/documents/performance/financial-results/2024/vodafone-uk-and-three-uk-investor-presentation.pdf

[102] https://www.fitchratings.com/research/corporate-finance/fitch-affirms-eolo-spa-at-b-outlook-stable-22-11-2024

[103] https://www.nokia.com/blog/the-ai-revolution-preparing-for-a-surge-in-5g-uplink-traffic/

[104] https://www.ericsson.com/en/reports-and-papers/mobility-report/articles/genai-impact-on-mobile-network-traffic

[105] https://www.telecomreview.com/articles/reports-and-coverage/8647-networks-for-ai-telecoms-networks-facing-the-boom-of-artificial-intelligence-uses

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Looking at his use cases:

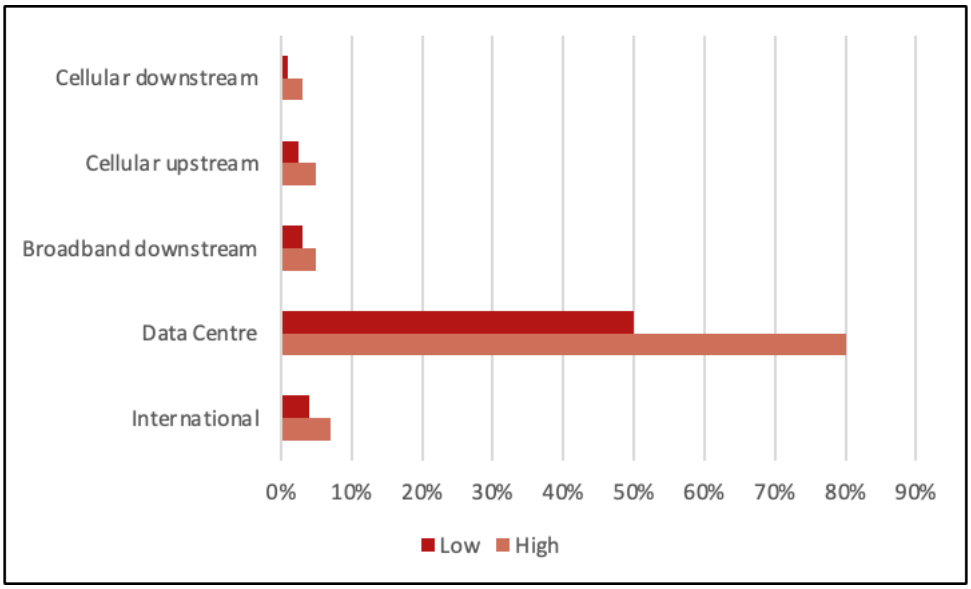
- Virtual and augmented reality. We discuss this in the next section.
- Smart cities. Applications to enable "smart cities" have been postulated for many years. There are some smart applications that have been deployed such as smart street lighting (which can be turned off, for example, where there is nobody in the street) in large cities typically using low-power IoT networks. The business case and even the clear need for vast sensor deployment has been elusive and the addition of AI into the mix is unlikely to change this. Even if this were to happen, it is doubtful that this would have a significant impact on the wired or wireless networks.
- Streaming video cameras. We already have millions of CCTV cameras installed in cities around the world. Most of these have a wired connection and their impact on fixed networks is already included in the data rate numbers. Those that are wireless tend to send video when they detect something unusual, such as movement. If anything, AI might be deployed within the camera to even more precisely determine what is worth sending thereby further limiting the video that is sent.

Analysts, generally, are more restrained. New Street Research wrote[106]:

> *"As long as AI is mostly text-based, the impact on mobile networks will be **pretty small.** At some point, if everyone is wearing the equivalent of Meta Ray Bans powered by AI, and video content is being sent back to data centers for processing, it could have a profound impact on uplink traffic. This would be a new thing for wireless networks which have been predominantly downlink loaded historically."*

Note the "pretty small". Connect Europe, in a report authored by consultancy Analysys Mason provided the following summary chart showing that they predict little increase in access network traffic (both fixed and mobile), but a substantial increase in data centre traffic.

Figure 4.12: Predicted impact of AI traffic, CAGR uplift 2023-29 (High and low scenarios)[107]



So, to summarise, the suggested AI-related applications are not going to lead to materially more traffic. Indeed, since AI tends to make things more efficient, it is possible that AI might reduce traffic on access networks.

[106] https://www.lightreading.com/ai-machine-learning/mwc-s-dirty-little-secret-a-traffic-slowdown-will-ai-help-

[107] https://connecteurope.org/news/eu-tech-sovereignty-new-digital-communications-report-underlines-need-act-now

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4.4.2 XR/VR

VR headset sales are around 7m/year and falling. To put the VR sales volume into perspective, the global handset market is about 1.2bn units per year[108]. VR headsets sales are less than 1% of handset sales and those that have been sold all work using Wi-Fi. Smart glasses sales are not much larger, and data traffic levels generated equate only at most to a few minutes of video a day for those wearing them, which is likely to be much less than 1% of the population.

It is very hard to imagine that visions of ubiquitous XR devices being worn and used will come to fruition. But even if they do, the high-bandwidth applications suggested will very likely use Wi-Fi rather than cellular as their local link, adding traffic to the fixed network that is already over provisioned in much of the developed world rather than the more constrained mobile network.

4.4.3 IoT and digital twins

Internet of Things (IoT) is growing steadily and there are many use cases that could bring significant benefits across a range of industry verticals such as crop monitoring and smart cities. This has been the case since about 2010 when the initial enthusiasm for IoT first developed. The key constraint on IoT growth is not connectivity but the willingness and ability of organisations and industries to embrace the change in working practices needed to realise the benefits from IoT solutions. This ability is unlikely to change rapidly, and hence IoT adoption and growth will not be affected by 5G or 6G.

The latest hope is that digital twins will somehow invigorate the IoT marketplace. A digital twin is broadly a simulation of a working system such as an airport, where the simulation is fed real-life information in real time from sensors and hence can predict forwards to future states based on a good understanding of the current state. Digital twins can be used in multiple environments, but the data flows from the sensors needed are generally minimal – sensing number of people, temperature, number of items (e.g., trolleys) and so on. Such sensors send very little data – just a few bytes for each reading. Even with a very large number of sensors total traffic volumes are tiny compared to a video stream.

Overall IoT connections are around 18 billion – about 2 for every cell phone. Connections are forecast to double over the next ten years. But around 90% of these are on non-cellular networks and hence will not affect traffic levels on mobile networks.

IoT is a mature technology with well-established growth and use cases. Therefore, significant changes in data capacity growth and usage levels are highly unlikely.

[108] https://canalys.com/newsroom/worldwide-smartphone-market-2024

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5 Investor perspectives

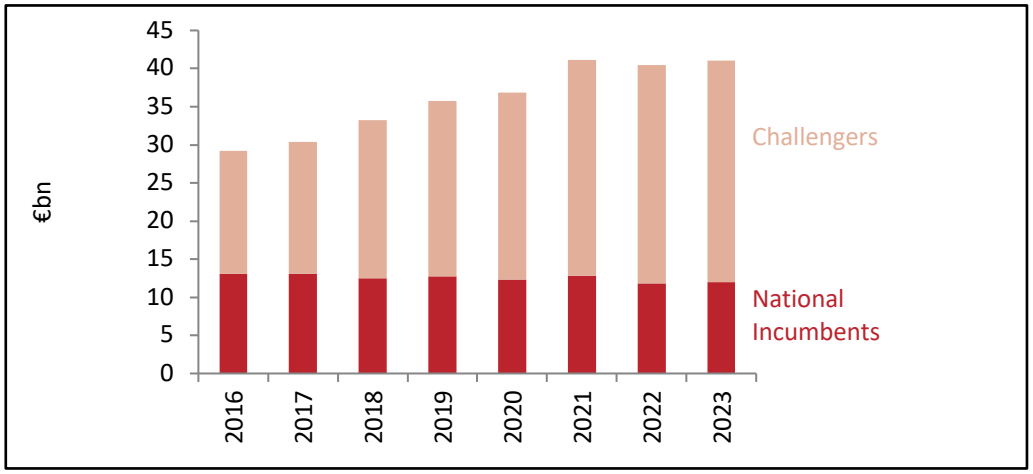
We now turn to investors' perspective on European telecoms. Clearly it is important that European telcos be able to attract capital for value-creating investments. This section shows that:

- There has been an increase in total capex over the last decade, showing that it has been possible to attract capital for investments.
- Operators have had very varied shareholder returns over the last five years. Some have outperformed the Nasdaq, others have generated negative returns. The variation is across countries, suggesting it is national policy rather than EU policy that impacts returns.
- The credit rating of operators remains strong.

5.1 Recent investment by telco type

The first thing to note is that telcos have been able to fund a substantial increase in capex over the last decade. Figure 5.1 shows telecoms capex in the EU's four largest markets. This has seen strong growth, albeit with a slowing since 2021 as FTTP capex has eased in France and Spain as deployment has approached completion. (By contrast, German capex has continued to grow, up 30%, 2021 to 2023).

Figure 5.1: Total telecoms capex, DE, FR, ES, IT[109]

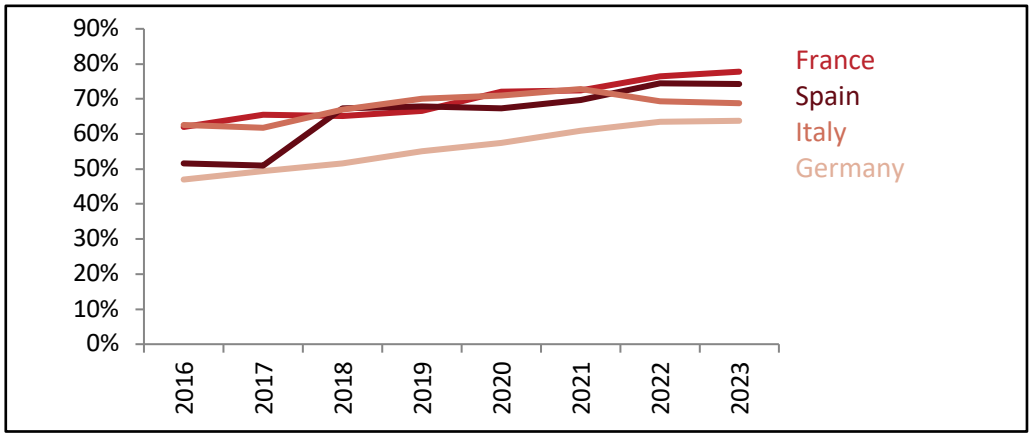


Also evident in this chart is the importance of investment by challengers (which includes incumbents operating outside their home markets, such as Orange in Spain). While incumbent investment has been broadly flat, these newer players have brought in capital to support network enhancement and competition. Thus, while appropriate incentives for investment by incumbents are important, they are not uniquely so, and it is at least as important to support investment by challengers.

[109] Ibid

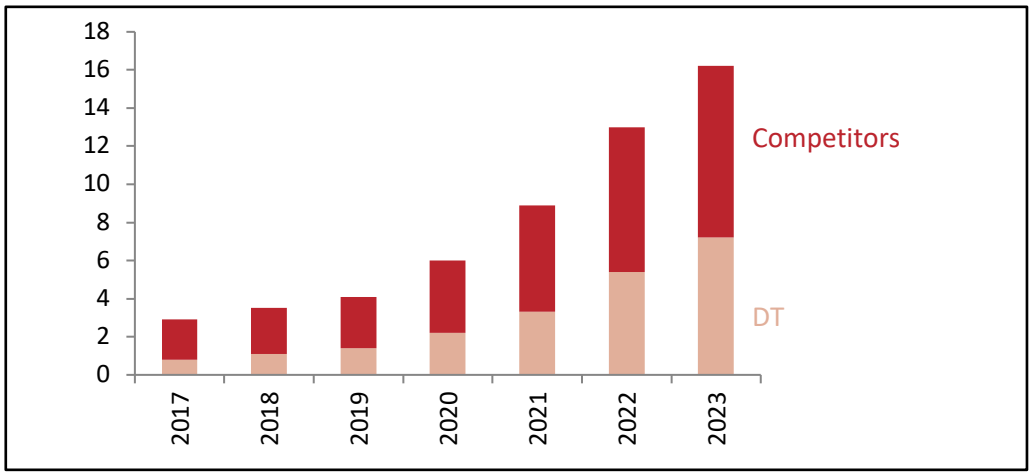
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Figure 5.2: Challenger telco share of telecoms capex[110]



This aggregate pattern across the four member states assessed above is repeated in each of them. As Figure 5.2 shows, challengers (including non-incumbent MNOs) have come to dominate spend in all four markets. In aggregate, they now represent over 70% of capex in these markets, up from 55% in 2016. This too points to avoiding undue focus on investment incentives for the national incumbents - they are not the most important investors.

Figure 5.3: Fibre homes passed, Germany (m)[111]



This same pattern is evident in spend on particular types of network. For example, in Germany DT represents just 39% of homes passed by fibre. Competitors such as Deutsche Glasfaser and Infrafibre have raised billions of Euros to deploy FTTP, and have been significantly more aggressive in their roll-out.

[110] Excludes spectrum licence charges. Figures for Orange in France are 'eCapex' for 2019 onwards (see filings for definition). BNetzA, Datenportal>Digitales & Telekommunikation [accessed 4 September 2025; Arcep, Observatoire des marches des communications electroniques, 12 December 2024; Orange, KPI reports; CNMC, Telecomunicaciones Anual Datos Generales [accessed 4 September 2025]; AGCOM, Relazione Annuale 2024, 18 July 2024

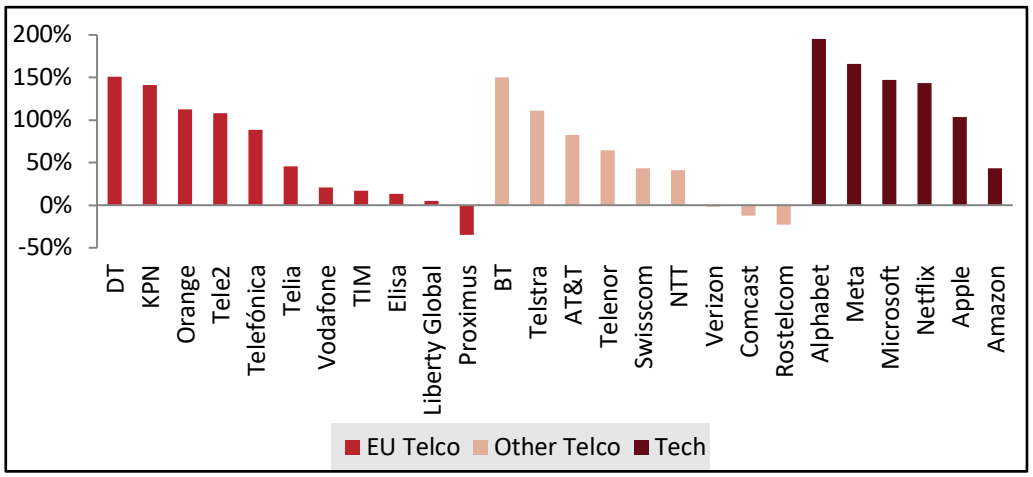
[111] Monopolkommission, Telekommunikation 2023: Gigabit-Ziele durch Wettbewerb, 2024

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5.2 Public markets perspective

Focusing for the moment on EU listed telcos- primarily, but not entirely the incumbents - we consider how they have performed for their investors. (Equivalent figures are unavailable for private companies). Figure 5.4 below shows the total shareholder return, comprising share price appreciation plus dividends, for a set of EU and other telcos, with leading tech companies for comparison.

Figure 5.4: Five-year shareholder return (%), EU & other listed telcos, and techcos[112]



The first thing to note is the significant variation – even within EU listed telcos, there is an extraordinary range of returns. This suggests that drivers are likely to be primarily national, or related to the strategies of the individual companies, rather than driven by the macro European policy environment.

Moreover, returns are generally robust. For example, Telefónica's annualised return was 13.5%, a figure slightly above the return of the NASDAQ index over the same period.

Further, the EU listed telcos have, on a simple average, been stronger performers over the last five years than the non-EU telcos show. Again, this suggests that the macro policy environment in the EU is not an undue challenge. (Note though that DT's share performance is heavily influenced by its stake in T-Mobile USA).

It also suggests that many of the listed telcos have been well able to provide a sufficient return on investment to attract shareholders.

Telcos have had a somewhat lower return on average than the tech companies, but on the other hand they are lower risk investments, with steady and predictable cashflows. Lower returns might be expected for such investments. A key measure of risk for investors is a stock's beta. All the telcos in our sample have a beta of less than one. All the techcos have a beta of greater than one, underlying their greater volatility, for which investors would *expect* higher returns.

Finally, we note that the incumbents in the four largest EU markets paid total dividends of €9.6bn in 2024.[113] Dividends are an important part of the total returns they have been providing to shareholders. However, this means that if these telcos were confident that additional value-creating investments were available to them, in theory they would not need to seek outside capital, they could simply reduce dividend payments to fund them.

That said, we recognise that telcos' shareholder bases are yield-focused and expect robust dividends.

[112] Koyfin. Total shareholder returns, 5 years to 5 September 2025

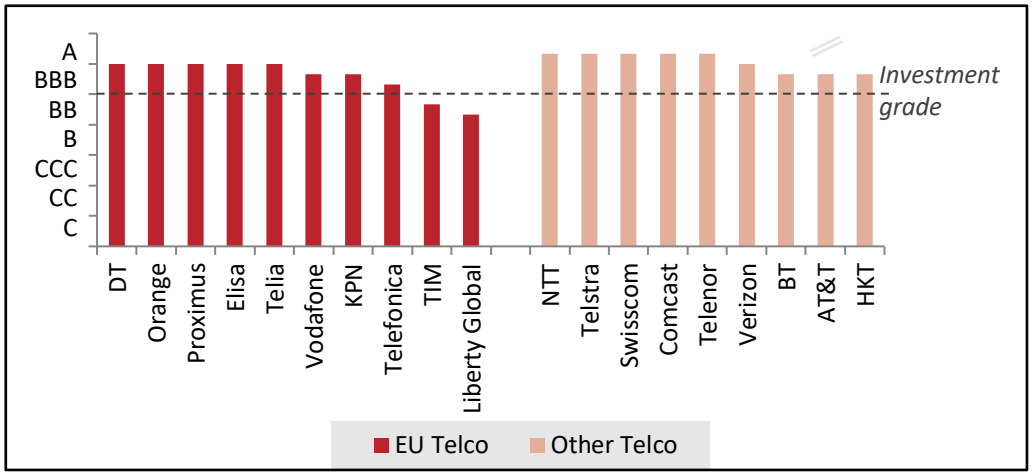
[113] Annual reports of DT, Orange, TIM, Telefónica

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5.3 Debt markets perspective

Credit ratings provide a further perspective on investment capacity and the sustainability of European incumbents.

Figure 5.5: Credit ratings, EU and international telcos[114]



With the exception of TIM and Liberty Global, all Europe's leading telcos have investment-grade credit ratings. That said, even excluding these two outliers, the EU average rating (BBB) is slightly below the international comparators shown (BBB+).

Credit ratings are determined by a company's ability to meet its debt obligations, after funding the operational needs of the business. Ratings agencies see (most) EU incumbent telcos as a good credit risk, implying that they are in no financial danger, and will be able to fund necessary future capex.

An implication of these high credit ratings is that the leading incumbents have ample capacity to borrow more if they wished. According to ratings agency Fitch:

> *"Incumbent operators, including DT, Orange, KPN and Vodafone, will retain significant leverage headroom with EBITDA net leverage averaging about 2.6x over the next three years [2025-27]."*[115]

Debt is widely available to challengers as well as incumbents. For example, new debt issuance by European FTTX builders totalled €18.1bn in 2024. Figure 5.1 shows a selection of debt raised by these companies in 2024, across a range of European countries.

[114] S&P Global ratings, for local currency long term debt. As of 29 August 2025

[115] Fitch, Western European Telecom Trends Diverge with Incumbents Faring Better, 9 Jan, 2025

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Table 5.1: Select FTTX debt transactions, 2024[116]

Telco	Country	Loan amount (€m)
XP Fibre	France	5,800
euNetworks	UK	1,265
Deutsche Glasfaser	Germany	1,250
Glaspoort	Netherlands	1,200
Vauban	France	950
Zayo	UK	760
FibreHost	Poland	644
Glasfaser	Germany	600
KCOM	UK	512
Speed Fibre Group	UK	366
Quickline	UK	288
Altitude Infra (ex Altitude THD)	France	250
ielo	France	208
Deutsche GigaNetz	Germany	200
Glide	UK	198
TNG	Germany	175
Hyperoptic	UK	173
Netomnia	UK	170
Netomnia	UK	169
Community Fibre	UK	144
Fibrus	UK	115
GlasDraad	Netherlands	112
GVG Glasfaser (Glasfaser-Verbands Gruppe)	Germany	85
Ogi	UK	52

As might be expected, equity investors in telecoms would like to see higher returns – just as conversely consumers would like to see lower prices. However, over the last five years, many EU incumbents have been able to provide solid returns to their shareholders. They also have access to debt markets though investment grade credit ratings. Private companies also have funds available. In addition to equity investment, they have been able to issue many billions of euros of debt per year.

This does not mean there are no issues with future investment in networks in Europe, but it does suggest they are likely to relate to investment incentives, not investment capacity. Availability of funds will not ensure delivery of the Digital Decade goals if these goals would

[116] FTTH Council Europe, Overview of fibre financing transactions in selected European countries, March 2025

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require investment in unprofitable areas. Operators would decline to make these value-destructive investments, regardless of their available funds.

This dynamic is of course not new – it is precisely the reason that regulators and policy makers have generally relied on targeted subsidies for remoter areas, rather than (say) allowing higher prices for the incumbent's services nationwide. The latter approach would increase the incumbent's funds but wouldn't materially change investment returns in the remote areas, and thus would not increase coverage.

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6 Policy Considerations

As stated in the introduction, this paper is not primarily about policy but about the rationale behind policy changes being considered. However, it is sometimes difficult to untangle what is driven by policy and what leads to policy decisions.

This is particularly true in the context of the Digital Decade policy program and the associated discussions around the Digital Network Act (DNA) because the Commission is not just building a set of policy tools, its intention is to structure the industry going forward. Against this background, and the lack of evidence for either a dramatic failure to meet the connectivity targets or for financial ill-health of telecom operators, we believe the following policy issues are worth consideration:

- the evolution of technologies since the targets were implemented, that may offer alternative solutions for the small gap between the likely 2030 situation and the targets;
- the absence of rationale for an unofficial extension of the targets, particularly when it comes to mobile connectivity;
- the strong policy focus on the welfare of incumbents despite the meaningful contributions of their competitors to infrastructure investment and connectivity;
- the strong policy focus on short term outcomes as opposed to long term infrastructure benefits.

6.1 Alternative approaches to bridging the limited anticipated 2030 connectivity gap

In 2018 when the targets were first discussed, and even in 2023 when they were adopted, there seemed to be few viable technological approaches to delivering speeds above 100Mbps as a fixed service. More crucially, neither VDSL nor coaxial were likely to deliver any service in rural areas, hence the focus on 100% FTTP. The cost of deploying FTTP will easily reach several tens of thousands of euros per home in remote rural areas. Even with public subsidies, the FTTP option may not be an attractive investment for operators to consider in deep rural areas, especially if they are looking at other, more profitable ways to allocate their CAPEX.

Since then, however, new options have surfaced that could deliver service maybe not on the level of 1 Gbps, but certainly in the range of 300-500 Mbps at a fraction of the cost of deploying FTTP in deep rural territory. Fixed-Wireless Access (FWA) and/or Satellite may deliver most of the benefits of gigabit broadband at costs in the low thousands of euros per home.

Therefore, it is possible that setting such ambitious targets overall in Europe actually slowed down the deployment of other technology solutions that could have delivered reliable and efficient broadband below 1 Gbps in rural areas. For example:

- Fixed Wireless Access solutions are now mature and can consistently deliver service of at least 200Mbps using sub 6GHz spectrum, and speeds above 500Mbps using MIMO solutions. Such technologies cannot be deployed universally, because they depend on terrain, vegetation and weather constraints, but they are applicable to large parts of the rural territories of Europe at unit costs of around 2000 EUR per home connected, which is very significant, but also much cheaper than the numbers for FTTP deployment in similar rural areas.
- Satellite solutions, especially Low Earth Orbit, can deliver services around 100Mps reliably. While performance may degrade when too many users are on at the same time), these solutions can still provide a comparatively affordable solution for the remotest of homes that need broadband.

Instead of treating universal full fibre coverage as the only fixed connectivity goal for the Digital Decade, the European Commission could possibly recognise the positive contributions that other technology solutions may offer to enable participation in the digital economy and society by rural communities without considering that to be a failure. Indeed, pulling back from

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an absolute focus on FTTP may encourage quicker and cheaper FWA deployment, since the prospect of eventual overbuild by FTTP may be having a chilling effect on FWA investment.

6.2 Questioning the rationale for informal 5G Standalone coverage targets

As we have already established in section 2, in its own publications the European Commission states that the Digital Decade targets for 5G mobile coverage will be met. However, in the public discourse in the last few years the Commission seems to focus on 5G Standalone as being the target when in fact this is not the case. Operators have been quick to point out that 100% 5G Standalone would require significant additional investment which might prove challenging to fund.

There is no official position on the need for universal 5G Standalone in Europe that we are aware of, and yet informally that seems to be the Commission's measure of both progress in mobile connectivity and international comparisons.

Known capabilities that can be delivered only with 5G Standalone are low-latency communications and network slicing:

- low-latency communications allow for much faster response times between device and network, but they require additional allocation of spectrum resources. As such, they are not (to our knowledge) deployed by default but only for specific applications and (primarily) specific locations;
- network slicing enables the provision of a quality-guaranteed end-to-end tunnel of communications (as long as there is sufficiently good coverage) that will not be affected by other traffic on the public mobile network. Most of the existing commercial cases for slicing are niche, addressing small market segments in volume, despite strenuous efforts to find them by operators that have deployed SA.

Neither of these use cases represent significant revenue today, which goes a long way to explain why telecom operators have been deploying 5G Standalone cautiously. There is steady progress in 5G SA coverage[117], and it can be deployed relatively fast once the decision is made, but the lack of universal coverage is due to operators' lack of commercial appetite more than a lack of investment capability.

When the commission discusses the future of networks, it tends to focus on two use cases that could require universal 5G SA to function. In both instances, there is at least limited short term viability to these cases:

- Remote surgery is often used as an example of what 5G SA could enable[118], but the practicalities of the use case are hard to imagine: would the surgeon be remote, in which case why would they rely on a mobile network? Surely being in a secure and stable fixed environment would be more meaningful? Or would the patient be remote, in which case the equipment needed to perform complex surgery is likely not found in the field? In any case, it seems likely an extremely rare scenario to be building an entire Europe wide network business case on.
- Driverless cars are also used as an example of the need for 5G SA, but existing driverless cars do not rely on 5G SA, but rather on 4G or 5G NSA connectivity (and this only for software updates and the like, not for driving). Furthermore, there are many other hurdles in the way of a generalisation of driverless cars, in terms of road safety, car manufacturer strategies, lack of appetite from end-users, etc. Again, it seems like a very niche and remote scenario to be building a Europe wide coverage argument on.

There is little doubt that 5G SA will generalise in the not-too-distant future, but it will happen because the use cases and commercial opportunities that arise will drive the investment.

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[117] https://gsacom.com/paper/5g-standalone-august-2025/

[118] In "How to master Europe's digital infrastructure needs?", European Commission, 2024: "Only with the highest performance of such infrastructures, for example, will doctors be able to care for patients at a distance rapidly and safely…"

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6.3 Incumbent operators are not the sole contributors to investment and connectivity

Incumbent telecom operators argue there is too much competition in the European market. It is not for this paper to decide whether that is correct, but as we have shown in part 5, challenger contribution to investment is actually larger than incumbent contribution. This should at least give pause to those who claim that there is too much competition.

In many markets it has been an initial move by a challenger (to deploy 5G or deploy FTTP) that has led the incumbent to react. In fact, we see this in contrasting ways in two markets we have discussed here: in Italy, it was the creation of Open Fiber and its subsequent deployment of FTTP that led Telecom Italia to start its deployment of FTTP in earnest. In Germany, where competitive deployment of FTTP was limited until recently, we are only now seeing this dynamic play out, which explains the sudden influx of investment in infrastructure in Germany.

A de-emphasis on competition could in fact hinder the path to targets set by the Commission, by alleviating the competitive pressure that is pushing the investment forward. It might be argued looking (again) at Germany that the pressure of the Digital Decade targets on their own is not sufficient to accelerate deployment.

6.4 Policy makers may be underestimating the long-term value of infrastructure investment

In most European markets, the brunt of infrastructure investment was undertaken by retail operators. This is not true everywhere, and increasingly we see a distinction between the long-term infrastructure assets (towers, fibre, etc.) which require heavy investment that takes up to a decade to pay back for itself and short-term service enabling technologies which require lower investments that pay back in a few years at most.

Retail operators that invest in infrastructure are straddling both these short-term and long-term business models, which in large part explains why they go through a profitability trough that may last a few years. This is particularly true on the fixed side, but mobile investment in 5G has taken longer to recover its costs due to a lack of commercial appetite from end-users.

On the fixed side though, unquestionably, this is a once in a generation investment. The most pessimistic estimates are that the FTTP plant will last at least 25 years, with 40 years a more likely outcome. In this period, active equipment will need renewing as it ages, and as new technologies emerge that deliver additional benefits, but the fibre plant itself will not need significant re-investment. Once the infrastructure investment has paid back for itself, margins will improve significantly and future technologies will be enabled by the existing plant.

While this was not necessarily true of mobile investment until now (a larger proportion of the mobile CAPEX goes to active equipment with shorter life cycles), the sometimes painful deployment of 5G has led to a number of telcos asking vendors for a shift in mobile technology development cycles, with a higher focus on software upgrades and a more stable (and modular) equipment design. As we approach 6G, it will become clearer how much of that has been taken into account and which benefits can be expected from it, but it is likely that the investment cycles in mobile will space out.

Policy makers in Europe may have been focusing too much on the amount of investment required in the short term to deploy these connectivity infrastructures without always factoring in the considerable life span (and associated revenues) that they will generate. Furthermore, certain regulators have encouraged infrastructure sharing over infrastructure competition, thus making the financial burden much easier on telcos in these countries (France is a good example). Policies that either factor in the different timespans of infrastructure and services or facilitate infrastructure asset utilisation over the multiplication of competing assets could be very effective at addressing the financial pains of the telecom sector without reducing competition or increasing infrastructure funding.

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7 Conclusions

The above analysis demonstrates that the incumbents' narrative of recent years – to argue for radical changes in policy – is not supported by current market reality:

1. Europe is not lagging behind in digital infrastructure investment, and certainly not when it comes to connectivity. The Digital Decade targets are hugely ambitious, and will be very close to being met by 2030. The gap between the aspiration and the reality will largely be due to a small number of countries having, for various reasons, decided not to prioritise FTTP deployment;
2. Telecom operators, both incumbents and new entrants, have been investing massively in connectivity infrastructure in the last 10 years, but it looks now like the peak of that investment is behind most of these players. These investments are now generating increased revenues and while this may have taken longer than the operators hoped for, the perspective is positive. Coupled with falling opex, accelerated by copper switch-off on the fixed side, the financial position of these operators is the best it has been in years and set to further improve in the next few years;
3. There is no massive investment gap on the connectivity side. A few countries, most notably Germany, are behind, which explains most of the so-called gap. But this is not for lack of investment capacity or funding availability, it is primarily because German market players, and incumbent player Deutsche Telekom in particular, have chosen to focus on their legacy copper plant;
4. Arguing that further investment is needed to handle exponential increases in IP traffic is disingenuous at best: not only is the rate of traffic growth slowing down (and far from exponential), but existing network capacity in fixed and mobile networks is more than sufficient to handle predicted traffic growth. Furthermore, any incremental investment that would hypothetically be necessary is marginal in terms of overall CAPEX spending. New applications such as artificial intelligence and virtual reality are either happening much slower than expected or unlikely to impact access networks that operators manage;
5. Investors have not soured on operators. Shareholder returns for European operators has been a little higher than in other geographies, infrastructure funding has not been hampered in Europe with projects finding the funding at affordable rates, and credit ratings for European telcos are on par with those of their peers in other regions;
6. Hence, there is not an issue here. Network investment is in line with need, is expected to fall in the future, and funding is readily available. European networks do not lag other countries in areas where it matters.

This shows that, to a large extent, the narrative used by the European incumbents and their representatives to push for sweeping changes in European telecom policy is not supported by the current market situation. Since the European Commission seems to have adopted many aspects of this narrative to propose substantial changes to its policy approach for the upcoming Digital Network Act, there is legitimate concern that this may be misaligned with reality.

We believe any policy changes should be based on a diagnosis that matches the reality of the market. Hopefully, on the basis of the fact-based analysis we have presented, the ongoing conversations about telecom policy can progress in a manner that maps to reality in the field.

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Annex

A. Data Growth

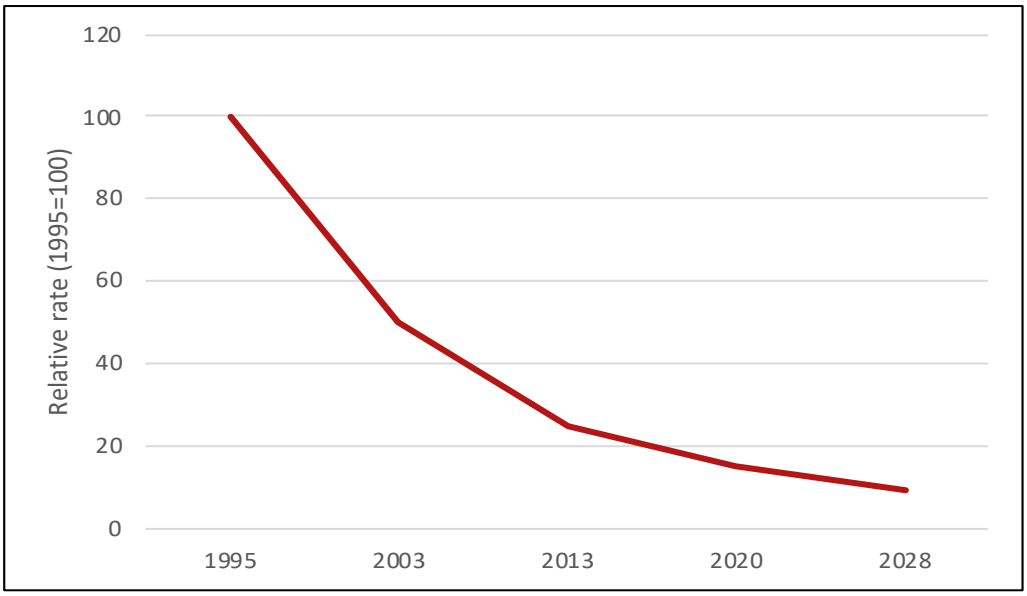
A.1 Video coding rates

With video forecast to be nearly 90% of the content on mobile networks, and around 70% on fixed networks[119], the data rate (e.g., the number of Mbits/s) associated with that video has a key bearing on the overall data volumes. Data rates could:

- Increase if higher resolution formats are consumed such as moving from HD to 4k resolution.
- Decrease if the video codecs which compress the video information prior to transmission see an improved ability to compress the video data, reducing the data rates needed for a given resolution.

The figure below shows how coding rates for HD quality video have fallen over time, with 1995 set to 100. It shows rates halved by 2003 and are expected to be only 10% of the 1995 level by 2028.

Figure A.1: Relative video coding rates over time[120]



This curve can be modelled very well by a 7%/year decline.

New techniques such as the application of AI to image generation could potentially allow for very dramatic further reductions in data rates. Fundamental to this approach is the idea of local regeneration of images at the receiver rather than transmitting all the bits that compose the image over the network. Even without AI, codecs in development such as AV1[121], can reduce 4k video rates from today's 15Mbits/s to 8Mbits/s. Hence, significant falls in the data rates for video seem very likely in the coming years. For example, were AV1 applied to all HD and 4k content then there might be a near 50% fall in data volumes transmitted.

A.2 Mobile network Capacity Calculations

There are three ways to increase mobile capacity all of which apply to the access network:

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[119] See Sandvine's 2024 Global Internet Phenomena Report, and aggregating video, apps and broadcast traffic categories. https://www.applogicnetworks.com/phenomena

[120] Authors' own data

[121] https://engineering.fb.com/2025/09/24/video-engineering/video-streaming-with-av1-video-codec-mobile-devices-meta-white-paper/

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- Add more spectrum. Capacity increases linearly with spectrum (ie double the spectrum doubles the capacity).
- Improve technology. Each mobile generation results in more bits/second/Hz of spectrum. A doubling in spectrum efficiency doubles capacity. There have been very large improvements in efficiency moving from 2G to 4G but more recently material improvements have proven hard to find.
- Deploy more cells. The capacity of a network is approximately proportional to the number of cells. If twice as many cells are deployed across a city, then the capacity would, in principle, double within that city. However, this assumes all the previous cells are removed and a new evenly spaced set of cells is deployed, which is far from what happens in reality. As a result, gains tend to be much less than the cell multiple.

Until the deployment of 5G, while all of these factors were important, it was cell deployment that led the way in capacity increases. But with 5G it has been the additional spectrum, predominantly at 3.4-3.8GHz that has provided capacity uplift as technology improvements have proven hard to find and new cells, especially in congested areas, are expensive and difficult to site in a way that results in even loading. MNOs are now calling for more spectrum, such as the upper 6GHz band, to enable further capacity enhancement.

It is also worth noting that:

- Around 80% of all traffic on mobile networks is generated indoors[122] and if anything, this will increase since most of the innovative new uses discussed are inherently indoor, such as VR headsets.
- Around 80% of the traffic from a mobile handset does not travel over mobile networks but uses Wi-Fi.

This leads to another solution to mobile network congestion which is to off-load more traffic onto Wi-Fi networks. If 25% of indoor mobile network traffic moved to Wi-Fi this would create all the capacity needed for any likely growth in mobile data usage. This could be facilitated by MNOs embracing auto-attach mechanisms, such as OpenRoaming and similar, that allow handsets to automatically connect to available Wi-Fi networks without user intervention.

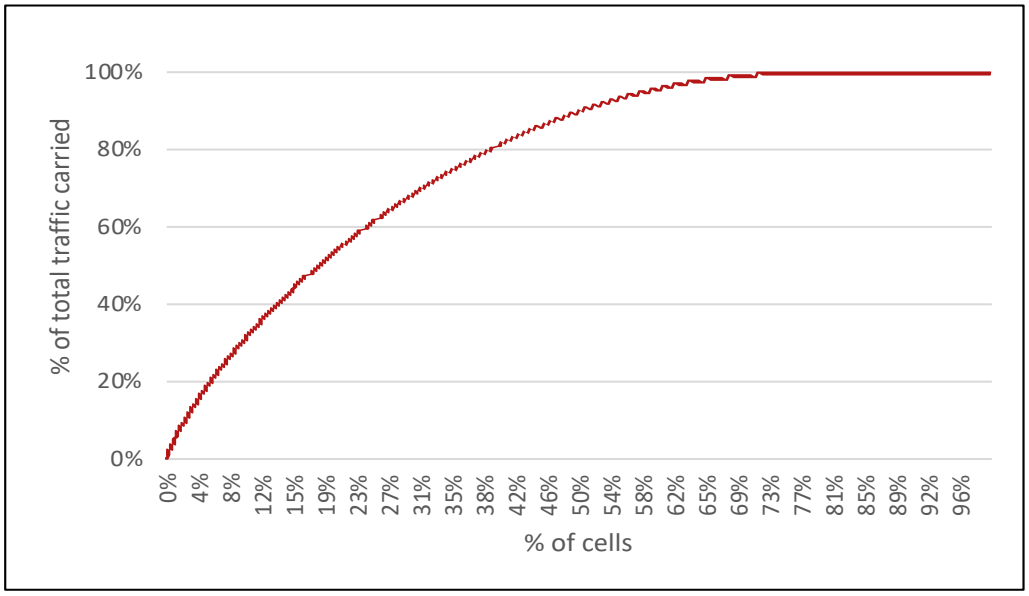
Many MNOs might still have spare spectrum. Often, they deploy only a fraction of their mid-band spectrum (ie 3.4-3.8GHz) initially since there is a cost associated with deploying more spectrum. Traffic may not have grown yet to the point where the remaining spectrum needs to be deployed. This would provide a relatively simple upgrade path.

Another important point to note about mobile networks is that demand is very unevenly distributed across the network. It is high in dense areas such as city centres, and very low in rural areas where signal is provided for coverage purposes. The chart below has been assembled by the authors from information across multiple mobile networks and shows the cumulative capacity versus cell count.

[122] See https://www.analysysmason.com/contentassets/750c9111e4ea4f07b2f653a3820711bb/analysys-mason---rethink-the-approach-to-5g-indoor-coverage.pdf, although note that it is hard to accurately measure indoor traffic and so estimates vary.

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Figure A.2: Demand versus cells in mobile networks[123]



Every mobile network will be different. For example, in dense countries like Singapore loading will be much more even across the network. However, it is clear that for this typical network load is very uneven – around 50% of traffic resides on the top 20% of cells.

If every cell was constructed to have just enough capacity for its local demand, then an increase in demand (spread evenly across subscribers and locations) would result in all cells needing to have a capacity upgrade. However, there are two reasons why many cells will have significant excess capacity.

1. The smallest quantum of capacity provision is a single 4G carrier[124] which is likely to have substantially more capacity than rural cells need.
2. In many cells 5G will have been deployed in order to meet 5G coverage objectives rather than for capacity purposes, leaving very substantial excess capacity. (Indeed, this is why MNOs can offer FWA in many areas as discussed below.)

Of the cells that do not have sufficient spare capacity and need upgrading there will be two categories:

1. Those where there is spare spectrum and so more carriers can be deployed on existing base stations, often with little cost. The costs will vary depending on what is already deployed, ability to add new cards to existing racks, whether new antennas are needed, etc, but might be of the order of €10k-25k per cell. A more major upgrade where some frequencies were refarmed from earlier generations might cost as much as €50k.
2. Those where there is no spare spectrum in which case more radical solutions such as adding additional cells will be needed. Costs can be in the region of €100k/cell, again highly dependent on local factors such as site rental, site availability and more.

Modelling the costs of adding network capacity requires an understanding of the number of cells in each of these categories. This will vary from network to network, and such data is not publicly available as far as we are aware. The following analysis is based on our experience, recognising that it lacks a widespread evidence base.

- Firstly, the minimum cell configuration can be assumed as a single 20MHz 4G carrier deployed in each of the 3 sectors. Assuming a spectrum efficiency of around 1.5bits/second/Hz each cell would have a capacity of 90Mbits/s. If we expect, for example, a 30% total increase in mobile traffic volume then cells currently handling up

[123] Authors' data

[124] Base stations broadcast a number of channels or carriers, each of a particular bandwidth (eg 20MHz). More channels can easily be added in the same frequency band (eg 3.5GHz) if there is spare spectrum at relatively low cost. If a different frequency band is to be used then new antennas may be required.

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to 69Mbits/s would not need any expansion. From our curve of demand versus cells, this is around 10,200 of the 20,000 cells.

- Secondly, we note that in the UK in 2024 there were 23,100 5G sites operational across roughly 81,000 sites in the UK, (up from around 18,500 reported in 2023)[125]. This equates to around 5,800 sites per operator. A minimum 5G site can be considered to have a 50MHz carrier per sector with 2 bits/second/Hz efficiency, delivering 300Mbits/s as well as the 4G carriers noted above providing 390Mbits/s. Applying the same logic, those sites handling less than 300Mbits/s have sufficient capacity. This equates to the sites between 1,070 and 5,800 in the ranked list.
- This leaves two areas for possible capacity expansion.
    - Sites between 5,800 and 9,800 on the ranked list might need an additional carrier which should be possible to add in their existing spectrum bands. We assume this is at the lower cost end of around €10k/site and that not all sites will need extra capacity.
    - Sites above 1,070 on the ranked list will need enhancement. Adding a second 50MHz 5G carrier increases their overall capacity to 690Mbits/s, again applying the 30% capacity enhancement logic those sites handling less than 530Mbits/s have sufficient capacity. This equates to the sites between 63 and 1,070 in the ranked list. We assume adding another 5G carrier will cost €25k/site.
    - Above this, sites will need more substantial upgrade, we assume effectively an additional base station for every site, although these may be a mix of small cells, cells deployed in the overall vicinity, etc. We assume €100k/site costs.
- The sum of all these costs is €72m per network for a 30% traffic growth. Values for a range of growth levels are shown below.

Table A.1: Mobile network costs for varying levels of traffic growth[126]

Assumed growth	Cost €m
15%	53
30%	72
50%	100

Hence, our estimate is that for a typical network in a country the size of the UK, a modest overall traffic growth of 15% might be met with an upgrade cost of approximately €50m. A doubling to 30% growth would require around €72m upgrade costs.

A.3 Fixed networks

There are broadly two types of fixed networks: dedicated networks and shared networks., Dedicated networks are those with those with dedicated capacity (point-to-point), and include copper, some fibre and mixed fibre/copper networks. Shared networks and those with shared capacity (point-to-multipoint) . Dedicated capacity networks include copper, some fibre and mixed fibre/copper networks. Shared networks are cable networks and point-to-multipoint fibre networks. (We do not consider satellite networks in this report.)

For dedicated networks there is no impact of traffic growth on the access segment (the “last mile”) as shown in the earlier schematic. That is because subscribers can use up to the maximum data rate of the line for as long as they wish with no impact on others[127]. Most fixed access lines have vast capacity. For example, a network delivering 100Mbits/s, provides

[125] https://www.ofcom.org.uk/siteassets/resources/documents/research-and-data/multi-sector/infrastructure-research/connected-nations-2024/connected-nations-uk-report-2024.pdf?v=386497

[126] Author’s calculations

[127] In copper-based networks such as VDSL there may be some increase in cross-talk as a result of higher usage that could lower the maximum data rate across lines within the same bundle, but this is likely to be of little significance since users do not generally need the maximum data rates provided.

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33,000Gbytes/month maximum capacity. Most homes use around 500-600GBytes/month. Hence, there is enormous headroom to accommodate traffic growth even allowing for the fact that traffic tends to be concentrated into 4-6 hours in a typical day.

There is a slight nuance to this in fibre networks, such as that shown below, where a fibre running from the local exchange or similar is typically split to deliver separate fibres to the home. Above this splitter, then, capacity is shared. If demand grew on the access network it is possible that lower splitter ratios might be needed, necessitating adding an additional splitter and an additional fibre to that splitter. However, in general, splitter ratios are set such that there is huge headroom on demand[128] and it is very unlikely that further splitting will be needed[129]. Fibre networks are often designed to deliver a typical shared bandwidth of 80Mbits/s (that is, if all subscribers simultaneously all demanded 80Mbits/s the network would be at capacity) but with current demand levels nearer 2Mbits/s on average[130], there is huge headroom.

Higher traffic levels will increase the demand on the shared backhaul (or aggregation and core network) connections such as from the local exchange back to hub points (aggregation), and on inter-city backbone routes (core network). This might require an upgrade from one to two 100Gbit/s fibres or similar. Capacity on these backhaul links tends to be delivered in large quantum (eg an additional 100Gbits). For most links there will be ample spare capacity to accommodate say a 30% increase in traffic, but a subset will exceed their threshold and need an additional link. These costs are effectively spread across a large number of subscribers (eg all those connected to the affected local exchange).

Core network costs tend to be relatively low. Analysys Mason state that "globally, core and backhaul costs represent 5–10% of revenue depending on the operator. In European countries, where national transmission is generally competitive, costs are at the low end of this scale."[131] A large part of these costs such as network management, fibre maintenance, etc, will be fixed, so the traffic dependent portion will be lower. Hence, assuming say, that a 30% traffic increase required a commensurate increase in backhaul costs then, taking the lower end of Analysys Mason's scale, this would cause a 1.5% increase in overall costs.

Cable networks share the capacity of the cable among a number of homes. Over time cable operators have tended to build fibre deeper into their networks so that each cable loop is shared among progressively smaller number of homes. A growth in usage could result in congestion on some of these cable loops requiring them to be split and fibre built further into the network. It is very hard to estimate how many cable loops might be impacted without having details of the network build levels.

In practice, cable operators often decide not to further split the cable but to move directly to full fibre provision. For example, Virgin Media reported[132]:

> "*By utilising the company's fully-ducted network, which are the tubes through which fibre can be laid, the upgrade will be one of the UK's most efficient fibre rollouts, costing ~£100 per premises passed. Customer installation costs will be in addition to this, with installs operated on an on-demand basis as rollout and revenue enhancement opportunities commence.This compares to approximately ~£60 per premises for an upgrade to a full DOCSIS 4 cable network and eliminates the need to invest in future versions of DOCSIS as the demand for faster speeds and capacity continue to rise.*"

Hence, a growth in demand might stimulate a fibre deployment which represents an upgrade to the access network. While this has costs it will reduce long-term operational costs and bring other benefits of lower power consumption and higher end-user speeds. It is likely that over time all cable connections will be upgraded to fibre as the cable network reaches obsolescence. As a result, we do not believe that these upgrades should be attributed to traffic growth.

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[128] For example, on a typical GPON segment, a single 2.5Gbps is shared by 32 users. If the splitter is full and all users try to use their connection at the same time, they will only be able to access an average speed of 80Mbps. See https://www.analysysmason.com/consulting/reports/netflix-open-connect/

[129] Most Western European networks have two levels of split, usually 1:16 in the field and 1:2 in the central office. This was designed to move over to 1:16 across the access network if necessary without the need to revisit the outside plant.

[130] Analysys Mason Research data shows that peak concurrent throughput across Europe per end user averaged 2Mbit/s in 2022.

[131] https://www.analysysmason.com/contentassets/1d7e13ed1dba4cc6917daa023f27834b/analysys_mason_fibre_in_europe_may2023.pdf

[132] https://news.virginmediao2.co.uk/virgin-media-o2-bolsters-future-network-with-fibre-upgrade-plan/

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A.4 FWA

We only cover FWA briefly here as it is not extensively used in Europe, with a few exceptions such as in Italy. There are two classes of FWA networks:

1. Standalone FWA deployed purely for broadband access (eg in mmWave frequency bands).
2. FWA using mobile broadband, acting as another subscriber on the mobile network.

Both have similar characteristics to mobile networks in that capacity is shared, networks are often capacity constrained, and the solutions to increasing capacity are the same as for mobile networks. A key difference with mobile networks is the volume of traffic – a typical mobile user will use around 10-20GBytes/month, whereas at typical home (which normally comprises multiple users) will use around 500Gbyes/month.

Standalone FWA

Considering one of the few mature standalone FWA networks in Europe – that of Eolo in Italy, there is around 4,100 base stations and nearly 700,000 subscribers. Assuming subscriber use 500GByte/month that leads to a peak capacity need per base station of 750Mbits/s. Eolo use technology from Intracom which uses 112MHz carriers. Assuming 4 sectors per BTS and 4bits/second/Hz efficiency then a base station capacity is around 1,800Mbits/s. Hence, most base stations will have ample spare capacity.

If there were congestion as a result of growth in demand an operator would typically aim to use more spectrum or to increase sectorisation by using narrower beam antennas at the base station. The costs of both of these are likely similar to the costs for MNOs in adding spectrum, around €25k per site. Assuming the growth in fixed traffic set out earlier, we expect that they number of site upgrades will be relatively small, perhaps around 20% of sites. Assuming 4,100 sites then this cost will be around €20m.[133] This is a cost attributable to the access network.

Mobile FWA

Where FWA is offered on mobile networks it tends to be used to fill up spare capacity, while delivering at least some revenue, albeit much less than would be the case were there multiple mobile subscribers needing that capacity. As a result, we would not expect MNOs to expand their network capacity if the requirements from FWA subscribers grew, instead they would either restrict FWA usage (as happens, for example, with T-Mobile in the US), throttle by restricting data rates, or reduce the number of FWA customers that they serve. This would result in a slight loss of revenue. Indeed, the presence of mobile-delivered FWA implies that there is spare capacity on some parts of the mobile network (typically suburban areas) that can be used to accommodate growth in subscriber traffic.

[133] Note that covering new areas with FWA is substantially more expensive, requiring new masts to be constructed and customer premise equipment (CPE) installed. This cost relates purely to capacity expansion for existing customers.

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B. Emerging technologies

In this section, we consider some of the most discussed applications and their likely impact on data usage. We cover:

- Artificial intelligence (AI).
- Various forms of virtual and augmented reality (VR and AR) often collectively known as XR.
- The Internet of Things (IoT) and associated digital twins.

B.1 AI

An important point we will return to later is that much of what we think of as AI now is not conceptually new given the long history of AI, but just better technology. AI based tools like Google Lens, Siri and Alexa have been around for years, in some cases decades. Speech recognition has been in place for decades as has Internet search, both of which depend on a certain level of AI. Language translation has been effective for perhaps five years or more.

What is different is both the magnitude of the computer resources being applied and the maturing of the software algorithms that allow for these new applications.

Since the advent of large language model (LLM) based systems like ChatGPT, it seems that not much additional traffic has been generated across the access networks, both fixed and mobile. We can see this both by observation and deduction.

- Observed traffic flows. Across both fixed and mobile networks data traffic has followed a trend of declining annual growth. Had AI generated significant traffic, this trend would have been disrupted with growth rates levelling or growing, especially in recent years (i.e., post 2022) as the use of ChatGPT and its various competitors has grown.
- Deduced traffic flows. Most of our human interactions with AI occur at a very low bandwidth. We send text prompts to LLMs like ChatGPT and voice commands to Siri or Alexa. We upload the occasional photo to Google Lens. In return we get sent text or perhaps an image. One image represents around one second of video streaming. If we stop browsing social media with its embedded video feeds to spend 10 seconds interacting with ChatGPT, our data usage will have fallen by 10%.

There is no indication that a sudden expansion in AI use will have a material impact on telecoms access networks. At best, it may increase traffic on data-centre links and on Internet backbone traffic.

This has not stopped some from postulating[134] that AI is on the cusp of generating vast traffic[135] to fixed and mobile devices. But their claims are vague. Take, for example, Guillaume Boudin, CEO of Sofrecom Group who said[136]:

> *"The development of multimodal AI, able to manage images, video, and sound, will also see data traffic rise exponentially. The use cases are numerous: from virtual or augmented reality applications to smart cities and their networks of continuously streaming video cameras."*

Looking at his use cases:

- Virtual reality. VR headset sales are in decline. The metaverse has not lived up to initial expectations[137]. And we have not seen any explanation of why AI would suddenly spur VR headset sales or usage.

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[134] https://www.nokia.com/blog/the-ai-revolution-preparing-for-a-surge-in-5g-uplink-traffic/

[135] https://www.ericsson.com/en/reports-and-papers/mobility-report/articles/genai-impact-on-mobile-network-traffic

[136] https://www.telecomreview.com/articles/reports-and-coverage/8647-networks-for-ai-telecoms-networks-facing-the-boom-of-artificial-intelligence-uses

[137] See multiple articles such as https://www.digivate.com/blog/technology/what-happened-to-the-metaverse/

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- Augmented reality. This is associated with smart glasses and similar. As will be discussed, sales of smart glasses are too low to materially change traffic, and battery life too short to allow for significant data traffic. Further, most AR use cases overlay information on top of human sight, requiring very little bandwidth.
- Smart cities. Applications to enable "smart cities" have been postulated for many years. There are some smart applications that have been deployed such as smart street lighting (which can be turned off, for example, where there is nobody in the street) in large cities typically using low-power IoT networks such as LoRa. The business case and even the clear need for vast sensor deployment has been elusive and the addition of AI into the mix is unlikely to change this. Even if this were to happen, it is doubtful that this would have a significant impact on the wired or wireless networks.
- Streaming video cameras. We already have millions of CCTV cameras installed in cities around the world. Most of these have a wired connection and their impact on fixed networks is already included in the data rate numbers. Those that are wireless tend to send video when they detect something unusual, such as movement. This is obviously much more efficient for most surveillance applications than continuous streaming which consumes power and bandwidth. If anything, AI might be deployed within the camera to even more precisely determine what is worth sending thereby further limiting the video that is sent.

Nokia[138] and others have a more prosaic prediction, that AI will allow for better personalised recommendations resulting in us watching more video content. Perhaps, but the evidence is that we already consume as much content as we have time for so better personalisation might not result in more consumption, just better content. Analysts, generally, are more restrained. New Street Research wrote[139]:

> *"As long as AI is mostly text-based, the impact on mobile networks will be* ***pretty small.*** *At some point, if everyone is wearing the equivalent of Meta Ray Bans powered by AI, and video content is being sent back to data centers for processing, it could have a profound impact on uplink traffic. This would be a new thing for wireless networks which have been predominantly downlink loaded historically."*

Note the "pretty small". Connect Europe, in a report[140] authored by consultancy Analysys Mason noted:

"In the access network, AI impact on consumer-related data traffic could be felt in a number of ways:

- Upload of TV/video/photographic content could increase due to on-device AI assisted creation. AI will make it quicker to create content (so more content will be created) and easier to create (resulting in more people creating).
- Download of TV/video content is unlikely to increase much beyond current usage growth projections (time constraints, costs and cultural factors act as a limiter), although the choices of content consumed might change due to AI enhanced recommendations.
- AI generated game environments and in game avatars will make services more attractive and more addictive. This could lead to more users and longer usage. Some of this would substitute for online TV/video consumption. The volume of access traffic will depend upon whether the rendering of the graphics happens in the cloud, at the edge, or on a local device.
- AI personal assistants could generate a traffic uplift due to continuous background collation of off-device data for on-device processing, and due to delivery of real-world

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[138] https://www.nokia.com/blog/the-ai-revolution-preparing-for-a-surge-in-5g-uplink-traffic/

[139] https://www.lightreading.com/ai-machine-learning/mwc-s-dirty-little-secret-a-traffic-slowdown-will-ai-help-

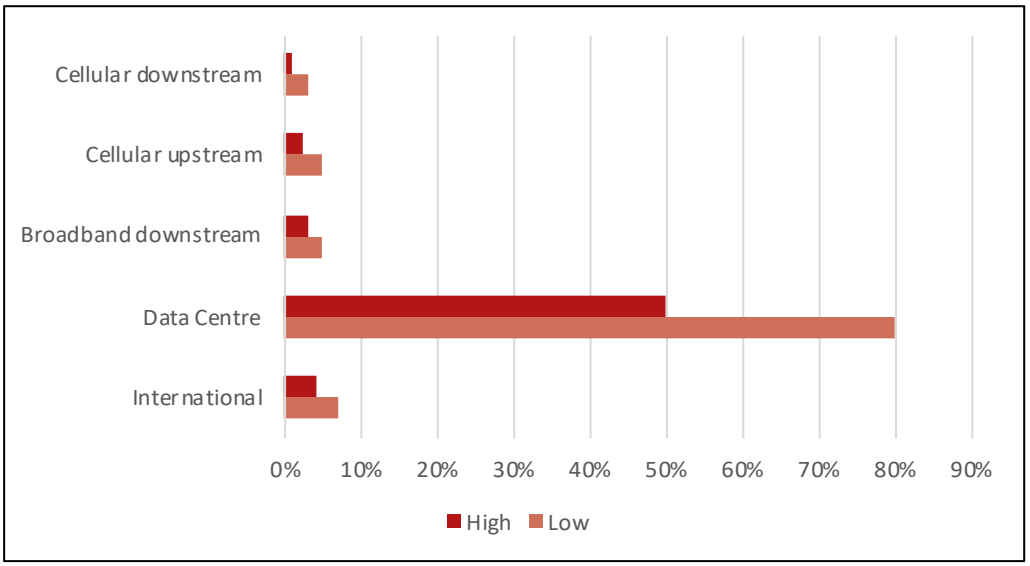
[140] https://connecteurope.org/news/eu-tech-sovereignty-new-digital-communications-report-underlines-need-act-now

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augmentation with visual data overlays – and could be linked to worn devices such as AR glasses, or HUDs in cars."

They also provided the following summary chart showing that they predict little increase in access network traffic (both fixed and mobile), but a substantial increase in data centre traffic.

Figure B.1: Predicted impact of AI traffic[141]



So, to summarise, the suggested AI-related applications are not going to lead to materially more traffic. Indeed, since AI tends to make things more efficient, it is possible that AI might reduce traffic on access networks. For example:

- If agentic AI undertakes actions on behalf of individuals, it could reduce time spent searching websites, watching product videos, etc.
- If AI enables better image compression it could reduce video bandwidth or information sent for on-line games and similar.
- AI might summarise content better, meaning we need to download less of it and perhaps upload less as well if it contributes to improved compression algorithms for our uploaded videos.
- Local LLMs or other kinds of AI systems might also mean less need to send data to and from the network.

These effects are likely relatively small but might offset any small increments due to some of the equally small AI features discussed above. Certainly, any balanced discussion of the impact of AI on access network traffic should also include discussion of the possibility of traffic reduction as well as traffic increase.

In summary, the capabilities opened up by AI are not really new, they are better, sometimes hugely better, versions of existing solutions to known problems and hence are unlikely to result in material new traffic, rather they might generate displacement traffic being used, eg instead of classic search.

B.2 XR/VR

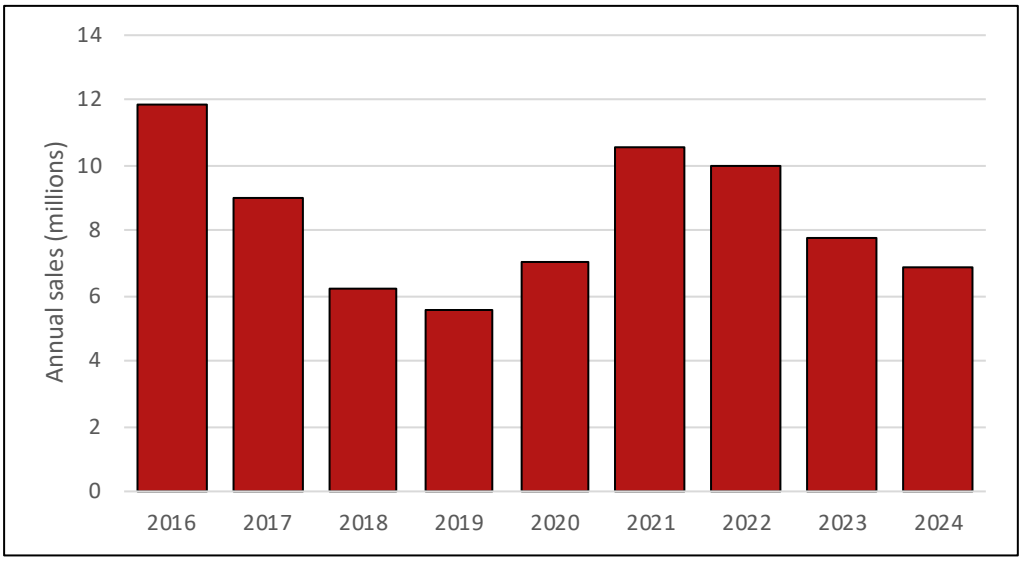
Go back a decade and XR (it was called VR/AR then) was postulated as one of the key justifications for 5G. What has happened over the last decade?

VR certainly had every opportunity to thrive, with Meta pushing hard on the concepts of an immersive metaverse, resulting in huge interest, and high expectations as many companies investigated what role the metaverse might play in their operations. Did it thrive?

[141] Connect Europe

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Figure B.2: VR headset sales[142]



The figure above shows that VR headset sales largely declined from 2016 as the market lost interest in the initial concept. Enter Meta creating a new peak at around 10m/year in 2021 as Meta heavily subsidised their headsets. The market then declined again as the Meta "hype cycle" ran its course, and the market lost interest this time in the metaverse.

To put the VR sales volume into perspective, the global handset market is about 1.2bn units per year[143]. VR headsets sales are less than 1% of handset sales. Since 2021 sales have been falling and are predicted to drop to 6m by 2025.

We discussed AR earlier where we showed that the volume of devices was far too small to make any material difference.

In summary, VR headset sales are minimal and those that have been sold all work using Wi-Fi. AR headset sales are not much larger, and data traffic levels generated equate only at most to a few minutes of video a day to those wearing them, which is likely to be much less than 1% of the population.

It is very hard to imagine that visions of ubiquitous XR devices being worn and used will come to fruition. But even if they do, the applications suggested will very likely use Wi-Fi rather than cellular as their local link, adding traffic to the fixed network that is already over provisioned in much of the developed world rather than the more constrained mobile network.

B.3 IoT and digital twins

Internet of Things (IoT) is growing steadily and there are many use cases that could bring significant benefits across a range of industry verticals such as crop monitoring and smart cities. This has been the case since about 2010 when the initial enthusiasm for IoT first developed. As was set out in "The IoT Myth"[144] the key constraint on IoT growth is not connectivity but the willingness and ability of organisations and industries to embrace the change in working practices needed to realise the benefits from IoT solutions. This ability is unlikely to change rapidly, and hence IoT adoption and growth will not be affected by 5G or 6G.

For IoT to generate material levels of traffic it would need to be sending video. But most IoT devices do not do this – they have little need for video feeds and the battery drain associated with sending video is considerable. There are possible use cases for security cameras – and indeed many home security cameras link via Wi-Fi to send video. Often they only send video

[142] https://omdia.tech.informa.com/pr/2024/dec/reality-check-for-vr-omdia-forecasts-decline-as-apples-entry-fails-to-galvanize-market

[143] https://canalys.com/newsroom/worldwide-smartphone-market-2024

[144] https://www.amazon.co.uk/dp/B086Y4TLT6/

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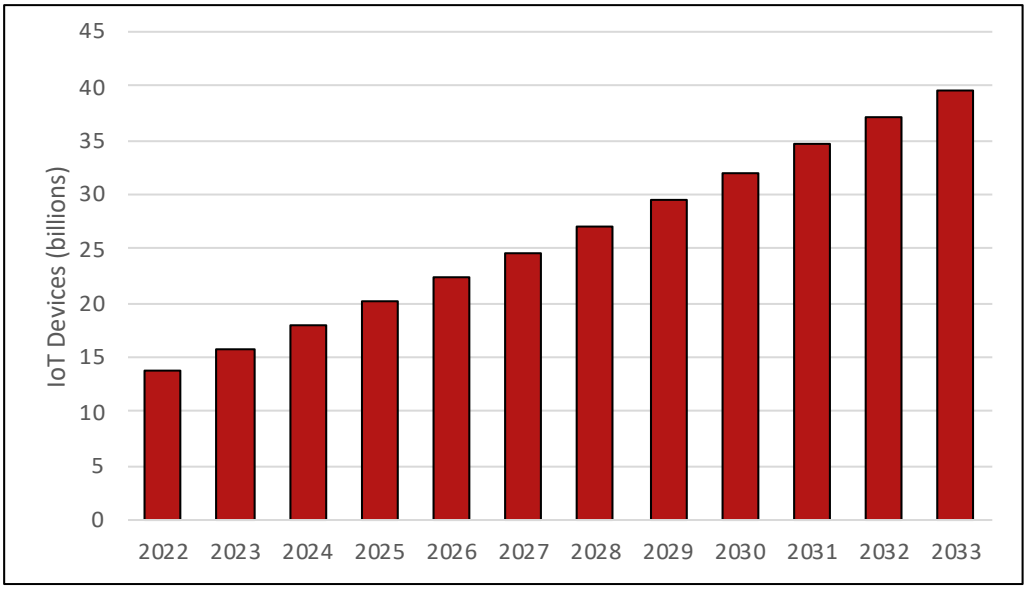
when an event triggers them such as detecting a person nearby. Most cameras as a result send around 1-2GByte of data/month[145], much less than a home's typically 300GByte monthly use.

The latest hope is that digital twins will somehow invigorate the IoT marketplace. A digital twin is broadly a simulation of a working system such as an airport, where the simulation is fed real-life information in real time from sensors and hence can predict forwards to future states based on a good understanding of the current state. Digital twins can be used in multiple environments, but the data flows from the sensors needed are generally minimal – sensing number of people, temperature, number of items (e.g., trolleys) and so on. Such sensors send very little data – just a few bytes for each reading. Even with a very large number of sensors total traffic volumes are tiny compared to a video stream.

Some protagonists stress that digital twins will need low latency. This seems unlikely for most applications – for example a twin of an airport is unlikely to need information more quickly than within a second or so. For some fast moving or rotating machinery, such as a jet engine, then some sensors may need to activate controls extremely rapidly, but there are few jet engines in the world, and it is likely that a proprietary short-range communications technology would be used within the engine or from the engine to the airplane.

The charts from Transforma[146], below, are useful in gaining a sense of perspective.

Figure B.3: IoT connections forecast[147]



Overall IoT connections are around 18 billion – about 2 for every cell phone. Connections are forecast to double over the next ten years. But the chart below shows that few of these are on cellular networks and hence will not affect traffic levels on mobile networks.

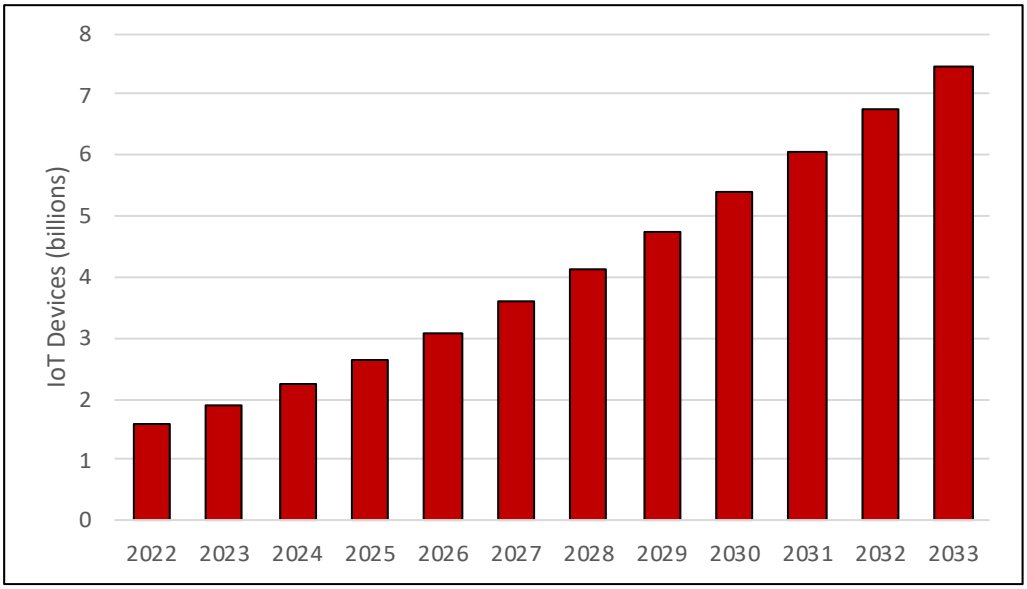
[145] https://www.kentfaith.co.uk/blog/article_how-much-wifi-does-ring-camera-use_5057 and https://www.newsoftwares.net/blog/how-much-data-does-a-ring-security-camera-use/

[146] https://transformainsights.com/research/forecast/highlights

[147] Ibid.

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Figure B.4: IoT cellular connections forecast[148]



IoT is a mature technology with well-established growth and use cases. Therefore, significant changes in data capacity growth and usage levels are highly unlikely. IoT has not shown a need for 5G levels of performance, with NB-IoT being more than sufficient for most applications. That 5G or 6G would bring about a major change in this trajectory seems very unlikely and talk of digital twins is largely a "fashionable" way of discussing more modern versions of monitoring applications and related simulation models that have long existed.

[148] Transforma Insights

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