Commission for
Communications Regulation

Mobile Data Traffic Forecast in Ireland (2024-2028)

A report by Frontier Economics

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Date:	12/07/2024

frontier economics

MOBILE DATA TRAFFIC FORECASTS IN IRELAND 2024-2028

Final report

10 JULY 2024

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Summary of forecasts

The use of mobile networks continues to evolve. Originally built to provide voice communication on the move, they have been upgraded and now provide voice and data communications for all our portable devices, increasingly alongside many business and industrial uses. In recent years mobile network operators ("MNOs") have upgraded their networks to offer 5G services - the latest evolution of mobile technology – and a substantial amount of additional radio spectrum has been assigned by the Commission for Communications Regulation ("ComReg") to provide additional network capacity for existing services and support the deployment of new mobile services.

In this context, and to assist ComReg and other parties (i.e. the MNOs) in their planning for the provision of mobile services to users, ComReg commissioned Frontier Economics to forecast the likely growth in mobile data traffic[1] in the period 2024 to 2028. This builds on the previous mobile data traffic forecast for the period 2018 to 2022[2] and supports ComReg in accomplishing:

- a work plan item listed in its Radio Spectrum Management Strategy Statement for the period 2022-2024 (ComReg Document 21/136)[3]; and
- an action of this year's work programme for the Mobile Phone and Broadband Taskforce[4].

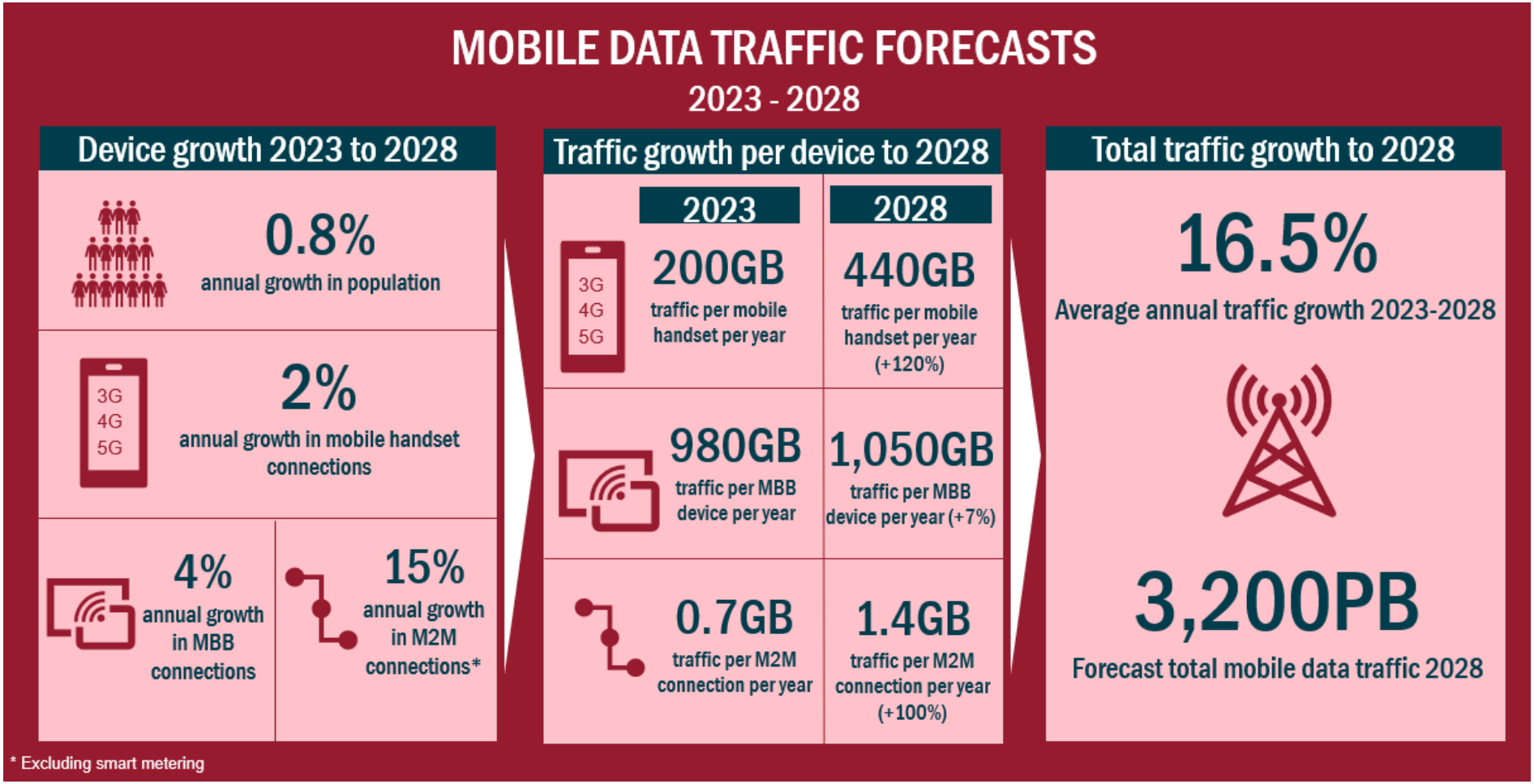
This report sets out our findings.

1 ComReg draft data dictionary Mobile available for download here.

2 ComReg18/35, Mobile Data Traffic Forecast in Ireland, 2018

3 ComReg 21/136, Radio Spectrum Management Strategy Statement 2022 to 2024 , 2021

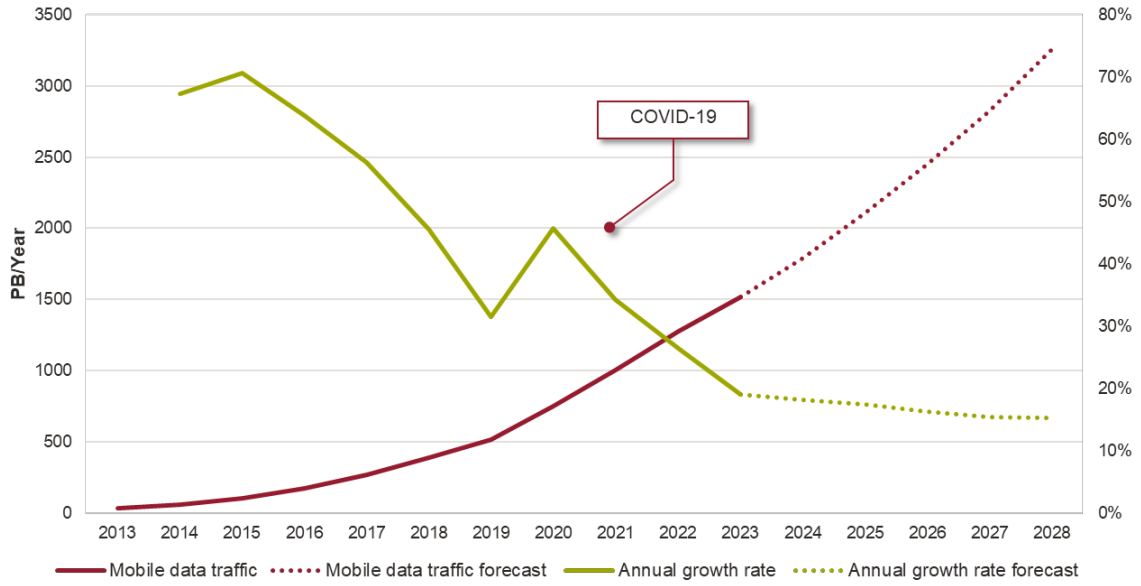
4 DECC, Mobile Phone and Broadband Taskforce, 2023


MOBILE DATA TRAFFIC FORECASTS
2023 - 2028
Device growth 2023 to 2028
0.8%
annual growth in population
3G
4G
5G
2%
annual growth in mobile handset connections
4%
annual growth in MBB connections
15%
annual growth in M2M connections*
Traffic growth per device to 2028
2023
2028
3G
4G
5G
200GB
traffic per mobile handset per year
440GB
traffic per mobile handset per year (+120%)
980GB
traffic per MBB device per year
1,050GB
traffic per MBB device per year (+7%)
0.7GB
traffic per M2M connection per year
1.4GB
traffic per M2M connection per year (+100%)
Total traffic growth to 2028
16.5%
Average annual traffic growth 2023-2028
3,200PB
Forecast total mobile data traffic 2028
* Excluding smart metering

Summary results

Taking demand-side and supply-side factors into consideration (as summarised below) and applying the approach described later in this report, for the period 2024-2028 mobile data traffic is forecast to continue to grow at an average of 16.5% per year (for the central forecast).

Figure 1 Central forecast of mobile data traffic and annual growth rate



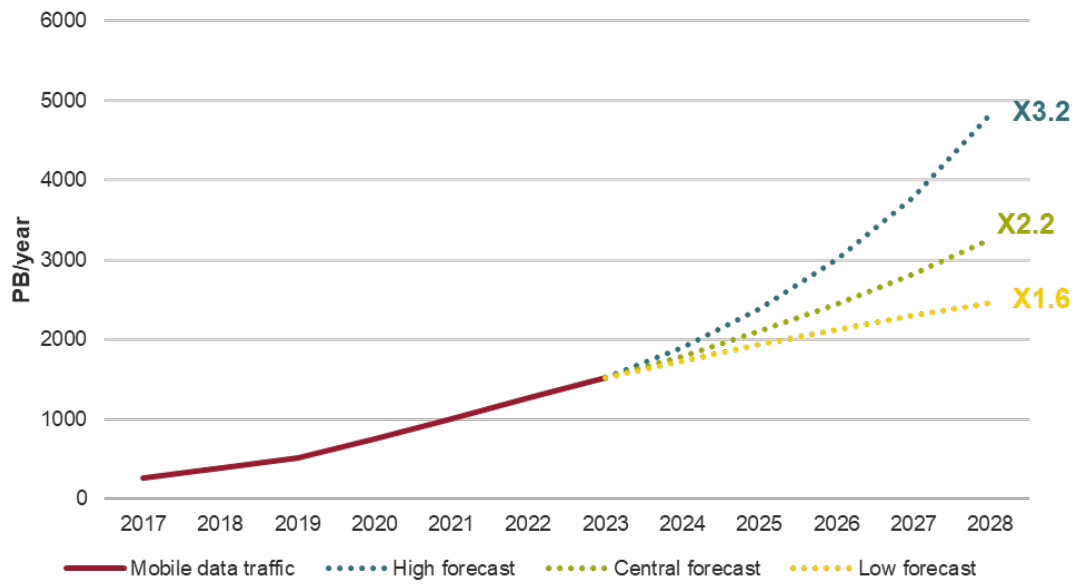
Source: *Frontier Economics*
Note: *Note that mobile data traffic is on the left axis and growth rate is on the right axis*

Data traffic on mobile networks has grown strongly in the last decade. Mobile data traffic volumes in Ireland are increasing each year, with the annual rate of traffic growth is moderating. The rate of growth of mobile traffic has been declining, with the exception of an increase in the rate of traffic growth in 2020 (likely related to COVID).

Under the central scenario in this forecast, total mobile data traffic is expected to grow by 2.2 times in 2028 compared to its 2023 level: from 1,500 petabytes (PB)[5] per year in 2023 to 3,200 PB in 2028. Mobile data traffic in Ireland is forecast to grow at an average of 16.5% per year up to 2028, though the rate of annual growth is forecasted to slow during the forecast period, as indicated by the dotted green line in Figure 1 above.

[5] 1 petabyte = 1,000,000 gigabytes

Figure 2 Total mobile data traffic (low, central and high forecast)



Source: Frontier Economics

Given the range of factors which can influence mobile data usage, there is inevitably a high degree of uncertainty over any forecast (see Figure 2). This is reflected in scenarios in that range from 4,800 PB of data in 2028 in the high scenario (x3.2 growth), down to 2,500 PB of data in the low scenario (x1.6 growth). These scenarios are covered in section 4.

Demand-side and Supply-side factors

Both demand-side and supply-side factors were taken into account in setting out our findings.

On the demand-side, there are a variety of factors that will directly influence demand for mobile data in the coming years including:

- Ireland's population is expected to increase by almost 4% between 2023 and 2028.
- Compared to previous years, more users now tend to have more than one mobile subscription (whether for work and personal use, or additional connections for other connected devices such as smart watches). Mobile penetration, which is defined as number of mobile subscriptions per capita has increased from 1.01 in 2017 to 1.07 in 2023.[6]
- Users increasingly use a mobile device to consume data intensive activities such as social media; streaming HD content and video calling. Multiplayer interactive gaming that was once available on consoles is now often done on mobile devices.

6 This excludes M2M and MBB subscriptions.

- Improvements in mobile networks, advances in mobile device technology, and the apps and content that they deliver, will iteratively increase demand for mobile data.
- There are ever more commercial use cases that rely on mobile networks across a variety of sectors, including (and without limitation) farming, logistics, manufacturing and the smart meter roll-out in Ireland.

There are also a number of supply related factors that will likely increase the level of mobile data traffic.

- Operators now are able to use much more spectrum than was available previously (in general the greater the amount of spectrum deployed the greater the network's capacity). In 2017, ComReg assigned 350 MHz of spectrum in the 3.6 GHz band (an 87% uplift in volume of usable spectrum), and in 2023, 465 MHz of spectrum was assigned (a further 46% uplift in volume of usable spectrum), following the second Multi-Band Spectrum Award (MBSA2 award).
- To date, this additional spectrum has enabled mobile operators to upgrade and improve the capacity and performance of their 4G and 5G networks. However many of these spectrum bands, such as the 2.3 GHz, 2.6 GHz and 3.6 GHz bands, are currently under-utilised when compared to other more-established spectrum bands, such as 1.8 GHz and 2.1 GHz bands, indicating that there is considerable scope for further network capacity increases as spectrum is deployed at more sites.
- While 4G is important to driving mobile data traffic and will continue to support a significant proportion of mobile traffic throughout the forecast period, 5G offers further iterative improvements in both the performance and the efficiency of mobile networks and opens the door to many new commercial and industrial use cases. 5G may also provide opportunities for mobile operators to offer wireless connectivity at a fixed location. Some commentators see this use case as a significant opportunity for mobile operators.[7]
- Against this, the gradual roll out of fibre broadband in rural areas could reduce demand for mobile data services. In particular the NBI programme to roll out fibre broadband in rural areas may moderate demand for mobile data traffic, as some users that currently rely on mobile networks to provide connectivity at a fixed location can switch to broadband provided on NBI's fibre network - although we note that this effect is tempered somewhat given the improved connectivity offered by mobile broadband and 5G in particular.

[7] See for example: Ericsson (2024) Six actionable insights to capture the value of 5G FWA , Ookla (2023) The Rise of 5G FWA & The Battle for Fixed Broadband Customers

International comparisons

The forecast presented in this report is broadly consistent with that of other available forecasts, albeit a direct comparison is not possible as other forecasts address different time periods, and the mobile data traffic characteristics of each country will naturally be somewhat different (see Section 4.4).

1 Introduction

The Commission for Communications Regulation ("ComReg") is responsible for, among other things, managing Ireland's radio frequency spectrum and ensuring the effective management and efficient use of same. To assist ComReg and other parties (i.e. the MNOs) in their planning for meeting the increasing demand for mobile services, ComReg commissioned Frontier Economics to forecast the likely growth in mobile data traffic[8] in the period 2024 to 2028.

This work builds on the previous mobile data traffic forecast set out for the period 2018 to 2022[9] and supports ComReg in accomplishing:

- a work plan item listed in its Radio Spectrum Management Strategy Statement for the period 2022-2024 (ComReg Document 21/136); and
- an action of this year's work programme for the Mobile Phone and Broadband Taskforce[10].

1.1 Structure of this report

The structure of this report is as follows.

- Section 1 introduces the report and summarises the forecasting approach used.
- Section 2 discusses the profile of data usage in Ireland up to 2023 and compares previous forecasts published by ComReg against outturn.
- Section 3 discusses the factors that are driving changes in mobile data traffic.
- Section 4 presents the central forecasts and scenario analysis.

1.2 Forecasting approach used in this report

The forecasts in this report are based on assumptions about consumer and businesses' future use of mobile devices in Ireland. These include dynamics that directly affect demand such as services used by consumers (e.g. video, streaming, gaming etc), as well as supply related factors that affect the performance of connectivity services such as size of network and availability of spectrum which can therefore influence the volume of traffic. These are considered in section 3.

8 ComReg draft data dictionary Mobile available for download here.

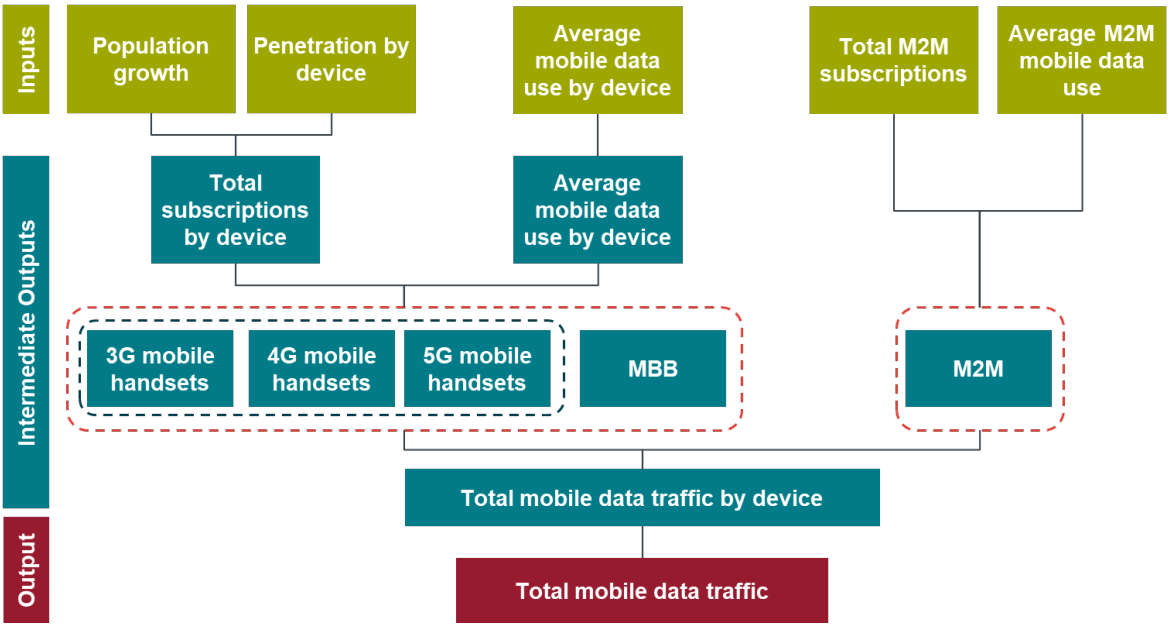
9 ComReg18/35, Mobile Data Traffic Forecast in Ireland, 2018

10 DECC, Mobile Phone and Broadband Taskforce, 2023

To forecast mobile data traffic for the period 2024-2028, the model disaggregates current usage by device type and projects forward usage of each device type. Based on recent usage trends in Ireland, the model projects device penetration and data usage per device, which together form the total traffic generated by devices. The projections reflect total traffic carried on mobile networks (both download and upload).[11]

A high level schematic of the model structure is set out below in Figure 3.

Figure 3 Overview of model structure



Source: *Frontier Economics*

Note: *2G mobile handset traffic has not been included as a separate category. This is not expected to affect results as number of 2G handsets (i.e. handsets that do not have 3G, 4G or 5G capabilities) is small; and the data traffic per 2G device is very low.*

As noted in Figure 3, the model forecasts penetration and average data usage per device category and aggregates mobile data traffic by device. These forecasts are prepared for each category of device (mobile handsets, MBB devices and M2M devices).

The projection of consumer device connections (3G/4G/5G mobile handsets and MBB) partly reflect population growth in Ireland, adjusted for recent trends in device penetration. Alongside consumer devices, M2M connections from businesses and smart metering are expected to continue to increase. However, M2M connections are not assumed to relate to population growth (since they are not consumer devices).

The model projects data use per device for different types of devices (mobile handsets, MBB and M2M). Data usage per mobile handset has represented a large proportion of mobile data

[11] ComReg draft data dictionary Mobile available for download here.

traffic generated in Ireland. Data use of MBB devices is the second largest share of total mobile data traffic in Ireland. These are explored in Section 2.

There are inherent uncertainties in forecasting usage in this fast moving and dynamic market. During the forecast period the sector will be adapting to the new innovation and opportunity which results from the investments in the latest generation of 5G mobile technologies. This necessarily adds a degree of uncertainty in the forecasts, as the pace of 5G roll out and adoption of new technology is unknown. This uncertainty is reflected in the model developing a range of forecasts, based on high and low values for certain parameters.

2 Profile of historical data usage in Ireland

Ireland, similar to many other countries, has seen a significant increase in mobile data traffic in recent years. Traffic growth has been broadly in line with forecasts published by ComReg. This section analyses these recent trends. In doing so, it assesses the degree to which the 2018-2022 forecasts published by ComReg reflected actual outturns[12] (comparing outcomes with the central, high and low forecasts).

It considers in turn:

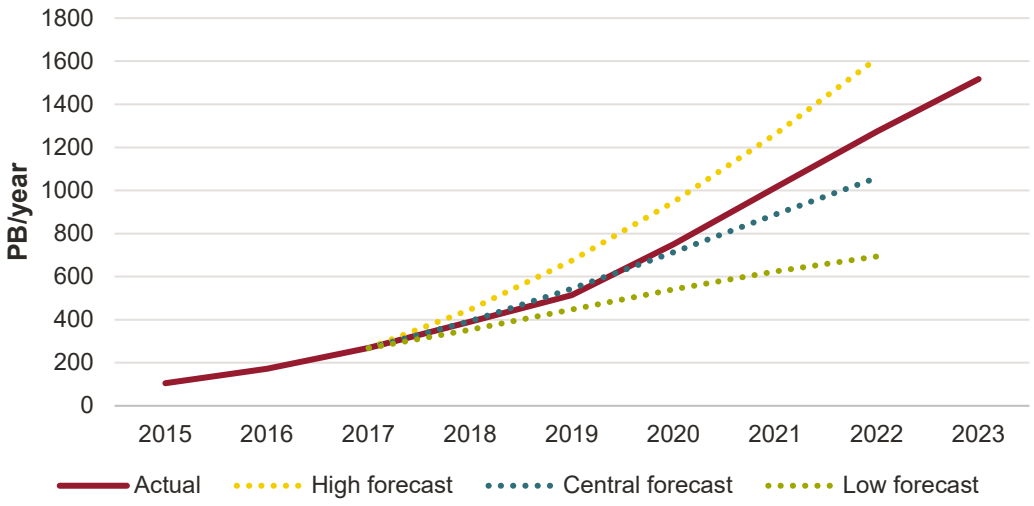
- total mobile data consumption in Ireland;
- device penetration; and
- mobile data usage per device.

2.1 Mobile data traffic growth

2.1.1 Total mobile data traffic growth

Investments by MNOs in their networks, as well as growing demand for connectivity, has seen mobile data traffic increase to 1500 PB in 2023, an almost four-fold increase in just the last five years and a 14 times increase since 2015.

Figure 4 Total mobile data traffic (GB/year)



Source: ComReg QKDR and Frontier Economics
Note: Frontier forecasts were made for the period 2018-2022

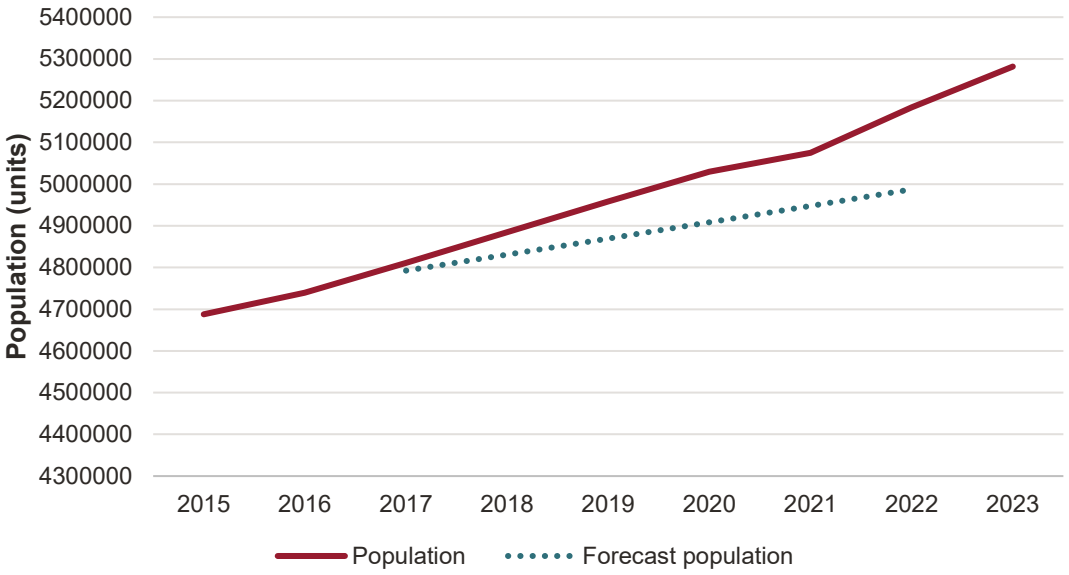
[12] Outturn data is available up to full year 2023.

Figure 4 sets out Frontier's forecasts for the period 2018-2022 and compares this to the actual total mobile data traffic for the period 2015 to 2023. Figure 4 shows that data traffic volumes were broadly consistent with the central forecasts in 2018-2019, then above the central case forecast from 2020, though below the high scenario forecast. In 2022, total mobile data traffic was 1270 PB (approx. 20% above the central forecast).

2.1.2 Population growth

Ireland's growing population has contributed to the increasing mobile data traffic.

Figure 5 Forecast vs actual population

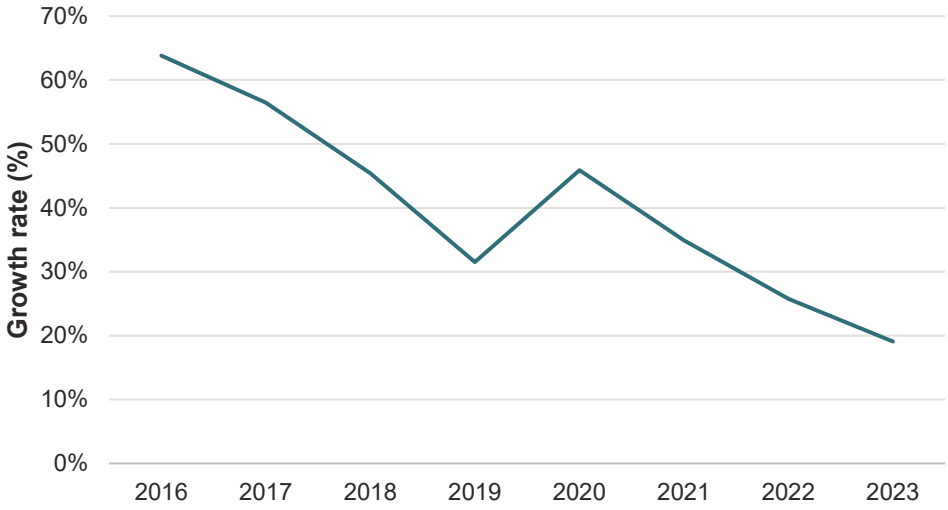


Source: CSO
Note: The forecasts shown here are CSO population forecasts made in 2017. Note that the axis begins at 4,300,000.

Previous mobile data forecasts used the population projections from Central Statistics Office (CSO). However, Ireland's population grew faster than forecast by CSO (Figure 5). In 2022 total population was 5.18M, approximately 4% more than the projection used in the forecasts.[13] In 2022, faster than expected population growth explains approximately a quarter of total variation between outturn mobile data traffic and forecast.

[13] In the 12 months to the end of April 2023, population rose by 97,600 people which was the largest 12-month increase since 2018.

Figure 6 Annual growth rate of per capita mobile data usage



Source: ComReg QKDR

It is notable that mobile data usage per capita has been growing *at a declining rate* (see Figure 6). It grew at a more rapid pace in 2020, potentially as a result of increased usage during the Covid pandemic. However, a longer-term trend of declining rates of growth is evident: in 2016 the annual growth rate of traffic per capita was 64%, but this had fallen to 19% by 2023.

2.2 Use of devices in Ireland

There are a number of different device types that use mobile data networks.

- **Mobile handsets** are used for voice calling alongside other activities that use mobile data such as social media, streaming music and videos, gaming, video calls, browsing the internet, emailing and controlling smart devices. All these activities require the downloading of data from the MNO's network to the device (to stream a movie for example) and/or uploading of data from the device to the network (to upload a post to social media for example). Mobile handsets can be categorised as "smartphones" which are devices that can be customised by downloading apps; and "featurephones" that are more limited in their capabilities and are less customisable. They can also include some wearable devices that supply mobile connectivity and voice calling (such as some smart watches).

  In 2023, traffic on mobile handsets was approximately 75% of total mobile data traffic in Ireland.

- **Mobile Broadband (MBB)** devices include mobile dongles, data only sim cards, mobile broadband routers and mobile hotspots. These devices provide internet access via mobile networks but unlike handsets, they are not used to provide voice services.

Connections to MBB services can be used in different ways. They can provide mobile broadband on the move via a mobile "dongle" (usually for one device); or they can be used to provide mobile broadband connectivity at a fixed location (for example at home) as a potential alternative for a fixed broadband connection.

In 2023, traffic from MBB devices accounted for approximately 25% of total mobile data traffic in Ireland

- **Machine to Machine (M2M)** connections provide connectivity to devices that do not require human interaction. These connections are used for Internet of Things (IoT) e.g. tracking and monitoring, smart metering, medical devices etc. Typically, individual M2M devices have a very low data demand, and while there are an increasing number of devices and subscriptions, the overall data requirements on mobile networks is also low

  In 2023, M2M devices accounted for approximately 0.1% of total mobile data traffic in Ireland.

Mobile handsets are used in many different ways

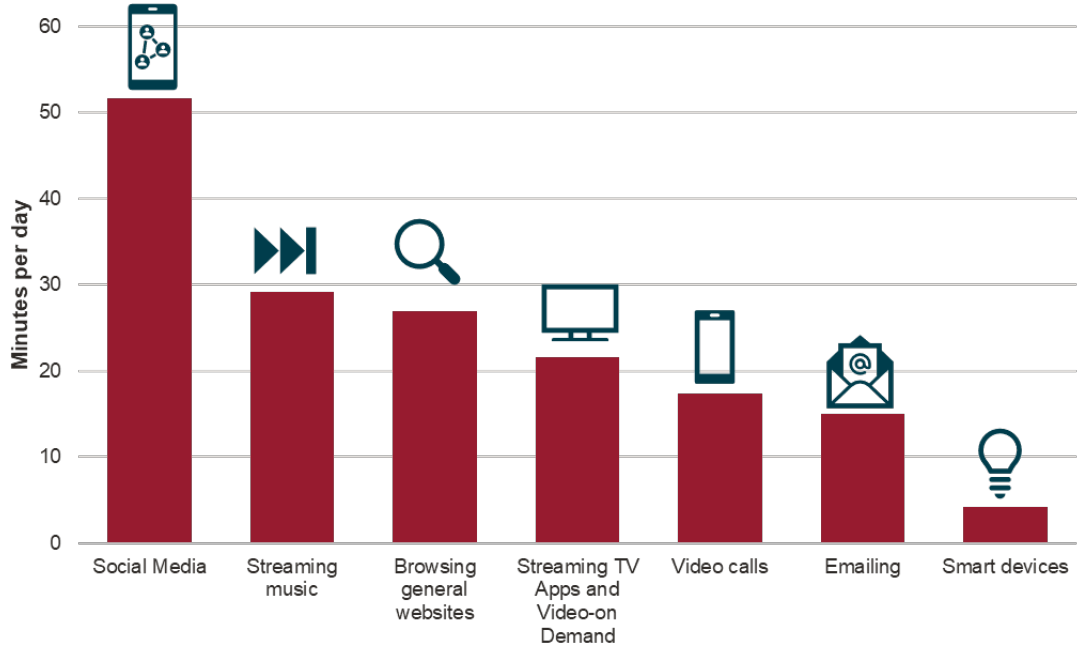
Mobile handsets are being used increasingly for sophisticated and high mobile data demand activities such as streaming video-on-demand (VoD) content and gaming. Smartphones have become increasingly sophisticated with increases in storage capacity, processor speed, battery life, and display resolution accompanied by improvements to the software inside the phones. All these advancements ultimately provide a richer consumer experience for services that consume data.

Average minutes spent watching VoD using mobile data have increased from 9.5 minutes per day in 2017 to 21.5 minutes per day in 2022.[14] Mobile gaming is also on the rise with more players entering the market in Ireland. For instance, PlayerUnknown's Battlegrounds (PUBG) and Clash Royale, the world's largest mobile esports open competition, came to Ireland in 2024 for the first time.[15]

[14] ComReg 22/83, Mobile Consumer Experience, 2022

[15] Dublin Live, *"Red Bull Mobile Esports Open is coming to Ireland as gamers will have amazing opportunities"*, 2024

Figure 7 Average number of minutes spent using mobile data per day by mobile handset users

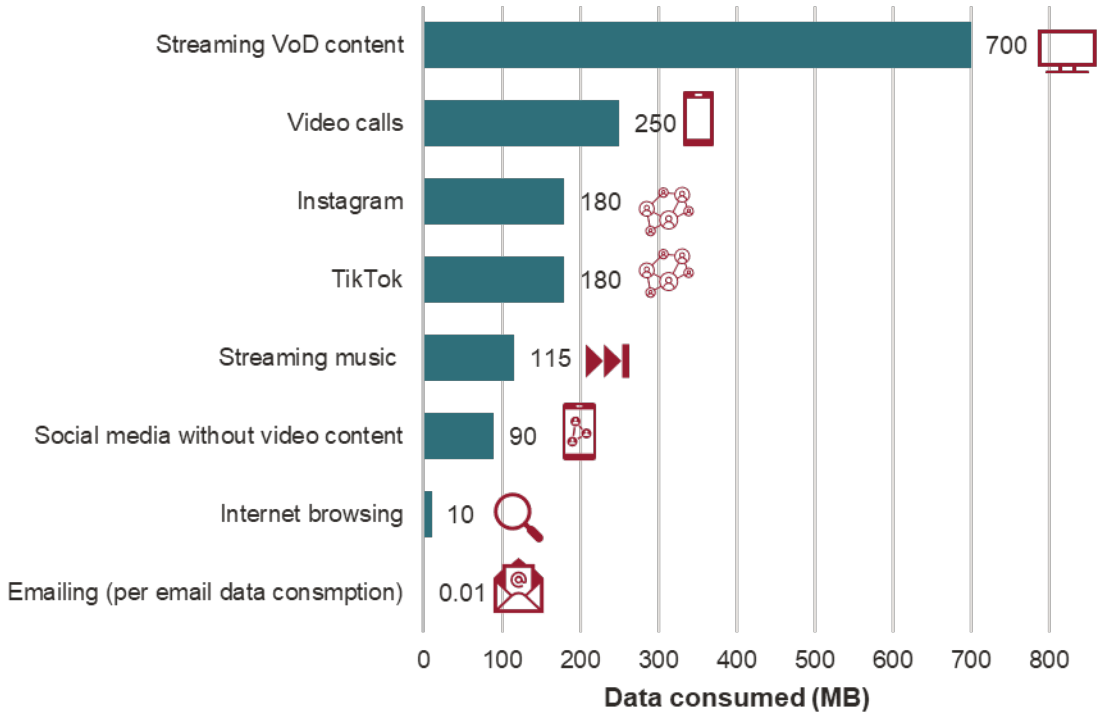


Source: *ComReg 22/83*

Note: *This survey does not collect data on gaming. "Smart" home devices (that give you control wirelessly via your mobile phone) are defined as devices which assists with the Accessibility of your home such as smart light bulbs (e.g. Philips Hue), smart kettle, smart power switch, smart washing machine, smart home security etc. Gaming was not included in the survey.*

Figure 7 shows that engaging with social media (of which a proportion is streaming video) is the single biggest activity, in terms of time spent, on mobile handsets (52 minutes per day). The second and third biggest use cases, in terms of time spent, are streaming music (almost 30 minutes per day) and internet browsing (27 minutes per day).

Figure 8 Mobile data consumption by activity per hour usage



Source: *Each data source referenced in accompanying text.*

Note: *These are all estimates and mobile data consumption from these activities may vary. Note that for Streaming VoD content, chart shows maximum not average.*

Different use cases use require different volumes of data (see Figure 8). [16]

- Social media has the highest per day usage and consumes an average of 90 MB per hour without video content.[17] Instagram and TikTok consume a larger amount of data (180 MB per hour) due to the higher volume of video content that consumers watch on these platforms, compared to others.[18]
- Streaming music may consume different quantities of data depending upon the sound quality. Streaming music on Spotify for an hour uses approximately 115 MB of mobile data.[19]

16 Statistics on mobile data traffic generated from different use cases have been referenced from sources in Europe and UK. This is likely broadly representative of usage in Ireland, though it may be affected by both supply and demand factors discussed in Section 3.

17 ComReg, "How much data am I likely to use", 2021

18 ESIM Europe, "*How much data does TikTok use?*", 2023

19 Vodafone UK, Data calculator

- Streaming VoD content is a data heavy mobile data use case. The usage depends upon the definition of the video content (i.e., whether it is Standard Definition (SD) or High Definition (HD)). Streaming SD videos consumes up to 700 MB per hour.[20]
- Similar to streaming HD VoD, video calls also have a similar data consumption of 200-300 MB per hour.[21]
- Internet browsing of text and graphic (i.e. not video streaming) is a low data demand activity using approximately 10 MB per hour.[22]
- Emailing is a lower data consumption activity with approximately 20KB consumed per email sent.[23]

2.3 Total device penetration

This section sets out the recent trends in device "penetration" (i.e. number of devices per head of population) of mobile handsets, MBB and number of M2M connections.

2.3.1 Mobile handsets

Mobile handsets penetration (3G/4G/5G)

Mobile handset penetration is high in Ireland and has been growing. Mobile handset penetration (defined as handsets with 3G, 4G or 5G capabilities) grew from 94% in 2017 to 107% in 2023. Some of this growth likely reflects the gradual upgrade of legacy 2G handsets (capable of voice calls and SMS, but only very basic data functions). Mobile handset penetration above 100% is common in more developed countries as some individuals have more than one mobile handset subscription (see section 3.1.2).

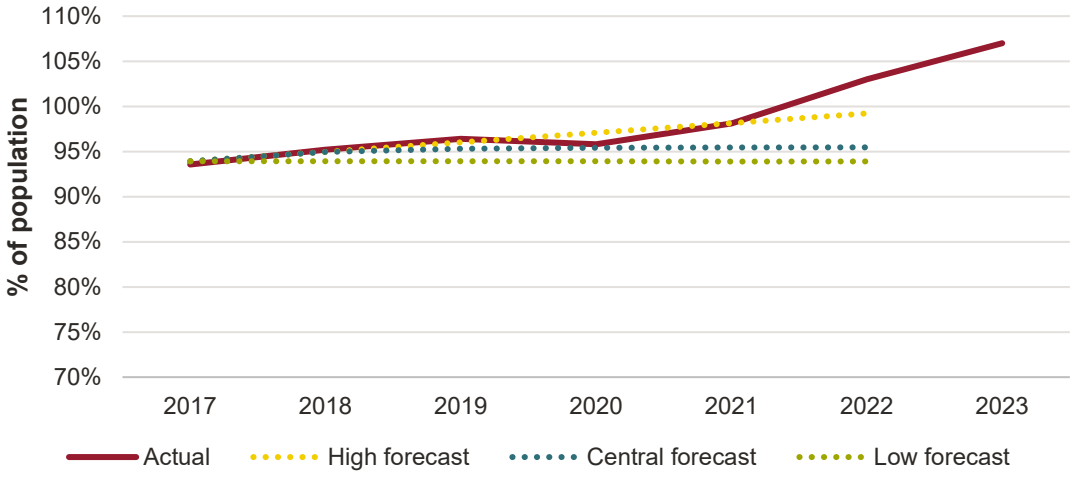
20 ComReg, "How much data am I likely to use", 2021

21 3G UK, Data calculator

22 Bonkers.ie, How much data do I need

23 Bonkers.ie, How much data do I need

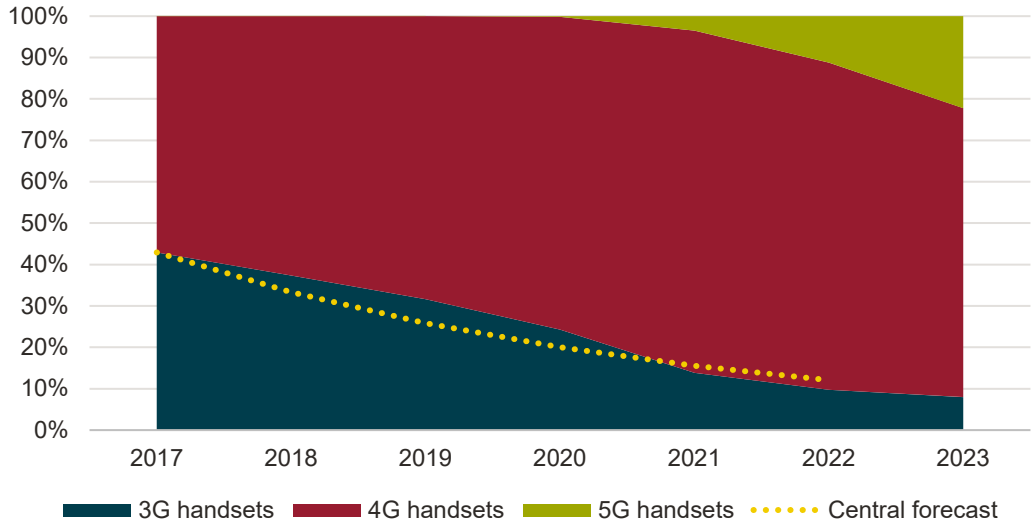
Figure 9 Mobile handsets (3G/4G/5G) penetration (%)



Source: *ComReg QKDR and Frontier forecasts*
Note: *Axis starts at 70%. Penetration has been estimated by dividing total connections by the population of Ireland.*

Mobile handset penetration has been growing over the last 5 years, albeit with a small dip in 2020 which was potentially related to the Covid pandemic and lock down restrictions (Figure 9). Since 2020, growth has been particularly strong. Comparing the outturn to forecasts made in 2017, mobile handset penetration remained higher than the central forecast throughout the forecast period and, until 2021, tracked the previous high forecast. By 2022, penetration was 12 percentage points higher than the high forecast scenario. A contributing factor is upgrading from 2G to higher, usually 4G/5G subscriptions.

Figure 10 Mobile handsets by technology



Source: *ComReg QKDR*

Note: *The yellow line shows the central forecast for proportion of 3G handset subscriptions made in 2017. The remaining subscriptions were forecast to be 4G (as 5G was not launched).*

Figure 10 shows the distribution of mobile handset subscriptions by technology. Most modern mid- and high-end handsets come with 3G, 4G and 5G capabilities.

Consumers will tend to upgrade their device for a number of reasons. First, devices may have a natural upgrade cycle,[24] and consumers will replace their devices as they are damaged or lost. Second, iterative improvements in device technologies (such as screen resolution, chipset performance, camera, battery and audio) will drive demand for new devices. Third, network upgrades may offer a pull factor for consumers as network performance is complementary to more advanced handset features.

These patterns are reflected in a declining proportion 3G devices and an increasing take-up of 4G devices. 4G services were initially launched in 2013 and quickly grew in take up from consumers. 4G offered significant performance uplifts (in network capabilities) which enabled incrementally improved performance of services. 5G was initially launched at the end of 2019, increasingly taking up a share in mobile handset subscriptions. By 2022 (eight years after 4G launch[25]) 4G and 5G devices amounted to 90% of all subscriptions.

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24 Almost 3 in 5 handset owners' devices are 2 years old or less, according to the mobile consumer experience survey 2022. See here https://www.comreg.ie/?dlm_download=mobile-consumer-experience-2022-survey-results page 30.

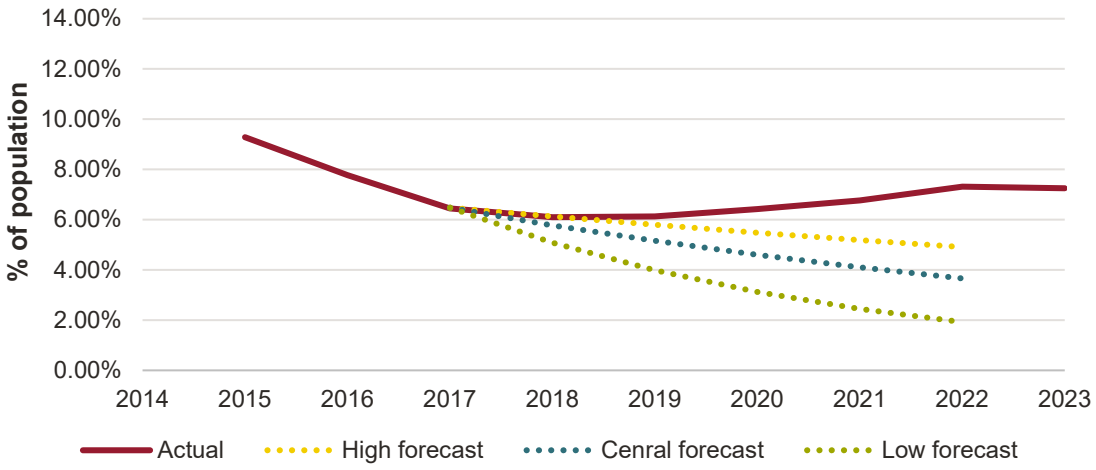
25 Eir was the first network to launch 4G services in some parts of Ireland September 2013. Vodafone launched services in October 2013 and 3Ireland followed in January 2014. https://www.eir.ie/opencms/export/sites/default/.content/pdf/IR/news/eircom_launches_irelands_first_4g_service.pdf; https://irishtechnews.ie/vodafone-to-start-rolling-out-4g-services-from-monday/ ; https://www.capacitymedia.com/article/29ot672nu98y0er0qaha8/news/3-ireland-to-launch-4g-services

The forecasts were broadly accurate in projecting the split of devices (dotted yellow line in Figure 10 shows the forecast decline in proportion of 3G devices). 5G subscriptions were not launched when the previous forecasts were made so were not specifically modelled.

2.3.2 MBB

MBB penetration was declining until 2018 but then started rising again to reach 7.3% in 2023.

Figure 11 MBB pentration (%)



Source: *ComReg QKDR*
Note: *Penetration of devices is estimated by dividing total device connections by population.*

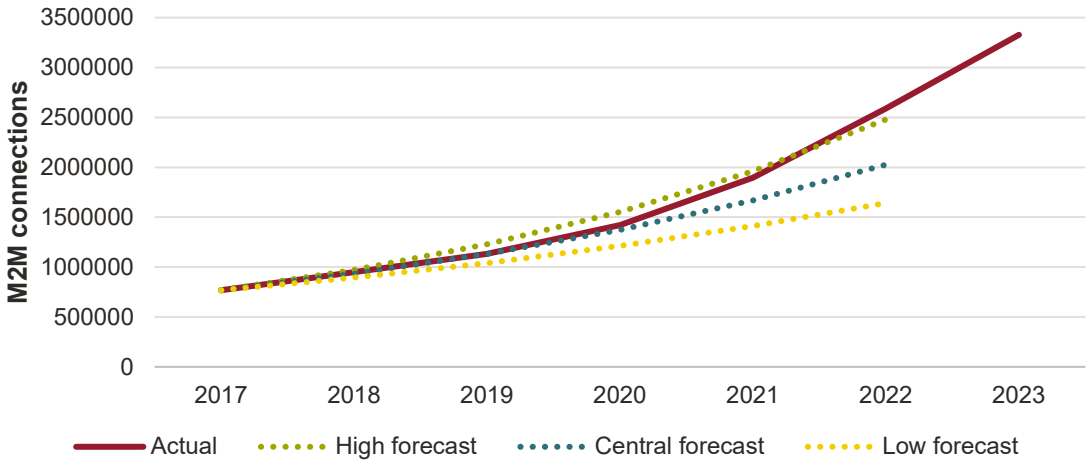
The fall in MBB penetration in the period up to 2018 likely reflected the declining use of "mobile dongles" i.e. data specific subscriptions that enabled connectivity for a laptop on-the-move. Increasing availability and quality of public Wi-Fi (in offices, food and leisure outlets, and transport) limited the demand for mobile dongles. Furthermore, mobile handsets allow tethering, whereby a different device can use a mobile handset for connectivity, which meant that a separate MBB subscription was not needed. These trends form the basis of the 2018-2022 projections which forecast that MBB penetration would continue to decline.

However, in the period since 2018, MBB penetration has risen. Comparing to the 2018-2022 forecasts, outturn MBB penetration was higher than even the high forecast, which projected that penetration would decline at approximately 5% each year. The rise in MBB penetration since 2018 likely reflects the increasing use of MBB devices as a potential alternative to a fixed service and improved offering of MBB devices and plans (including those aimed at offering a services at a fixed location), especially since the introduction of 4G (see section 3.2.1). Sections 3.2.1 and 3.2.4 looks at factors which may affect this in the future.

2.3.3 M2M

M2M connections in Ireland have been rising, reaching 3.3m in 2023. Much of the recent growth in M2M connections can be attributed to the roll out of smart metering[26] in Ireland with approximately 1.5m of 3.3m M2M connections in 2023 being smart meter connections. Smart meters rely on 2G connections to transmit a small amount of data periodically. [27]

Figure 12 M2M connections



Source: *ComReg QKDR and Frontier forecasts*

Note: *For M2M devices, we focus on the number of connections instead of penetration. Frontier forecasts were made for the period 2018-2022.*

The growth in M2M corresponded to the central forecast until 2020, before accelerating beyond the high forecast (partly as a result of the growth in smart metering).

2.4 Data consumption per connection

As well as growing penetration of mobile devices, increases in the amount of data that each device uses have driven the increase in total mobile data traffic. This section sets out the trends in data use per mobile handset connection, MBB connection and M2M connection.

2.4.1 Mobile handsets

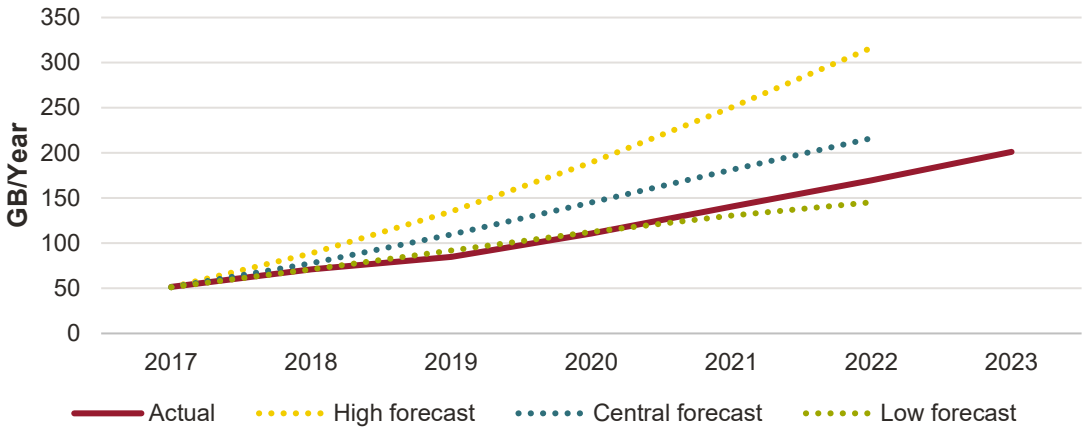
Mobile data usage per mobile handset increased from approximately 50 GB per subscription per year in 2017 to over 200 GB per subscription per year in 2023. Over this period most of

[26] A smart meter is a device which is used to capture accurate and real time data of electricity usage. In Ireland, smart metering is expected to be completed by 2024.

[27] ESB, ESB Network installs 1.5 million smart meters nationwide as part of the National Smart Metering Programme, 2023.

this increase was driven by increased usage on 4G handsets (see Figure 17) as it provides much better performances compared to 3G.

Figure 13 Mobile handset mobile data usage per connection (GB/Year)



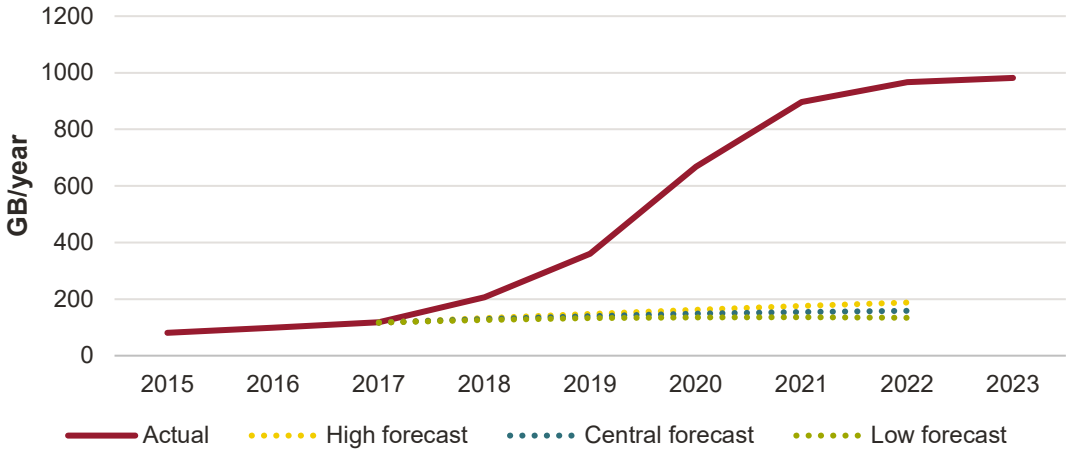
Source: ComReg QKDR and Frontier forecasts
Note: Frontier forecasts were made for the period 2018-2022.

As can be seen in Figure 13, mobile data consumption per handset corresponded to the low scenario forecasts until 2020 and then between low and central scenario for the remaining forecast period.

2.4.2 MBB

MBB mobile data use per connection has been increasing at a fast pace between 2017 and 2021 and at a slower pace more recently. MBB data consumption has reached almost 1000 GB per year in 2023.

Figure 14 MBB mobile data usage per connection (GB/Year)



Source: ComReg QKDR and Frontier forecasts
Note: Frontier forecasts were made for the period 2018-2022.

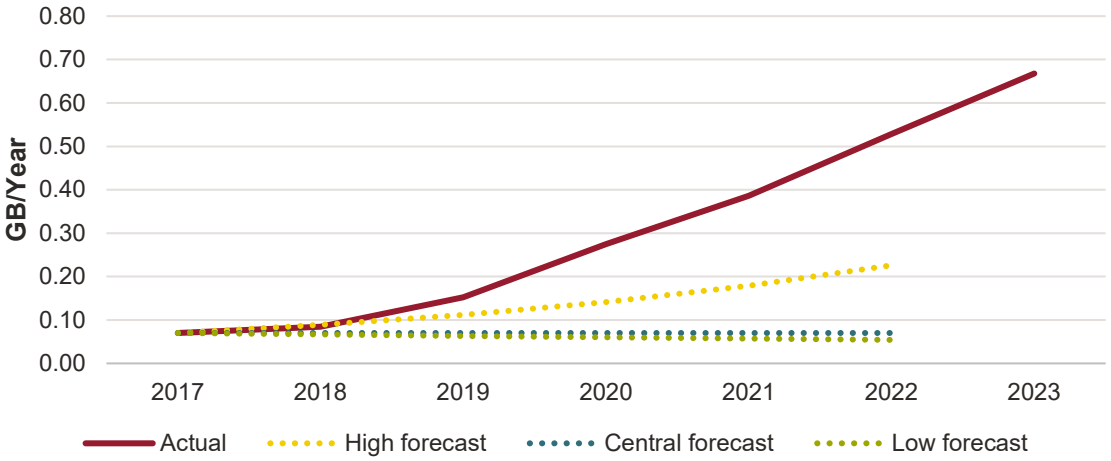
MBB mobile data usage was much higher than forecasts. This is likely due to use of MBB devices as a potential alternative for fixed access using a Wi-Fi data dongle, especially in rural areas as each Wi-Fi data dongle can connect a number of devices.[28]

2.4.3 M2M

M2M mobile data usage per connection has increased from under 10 MB per year in 2017 to over 65MB per year in 2023. Mobile data traffic generated by M2M devices is very low compared with mobile handsets and MBB because M2M connections are mostly 2G connections with low data use cases such as smart meters or logistics tracking.

[28] Vodafone's R219 data dongle supports up to ten devices.

Figure 15 M2M mobile data usage per connection (GB/Year)

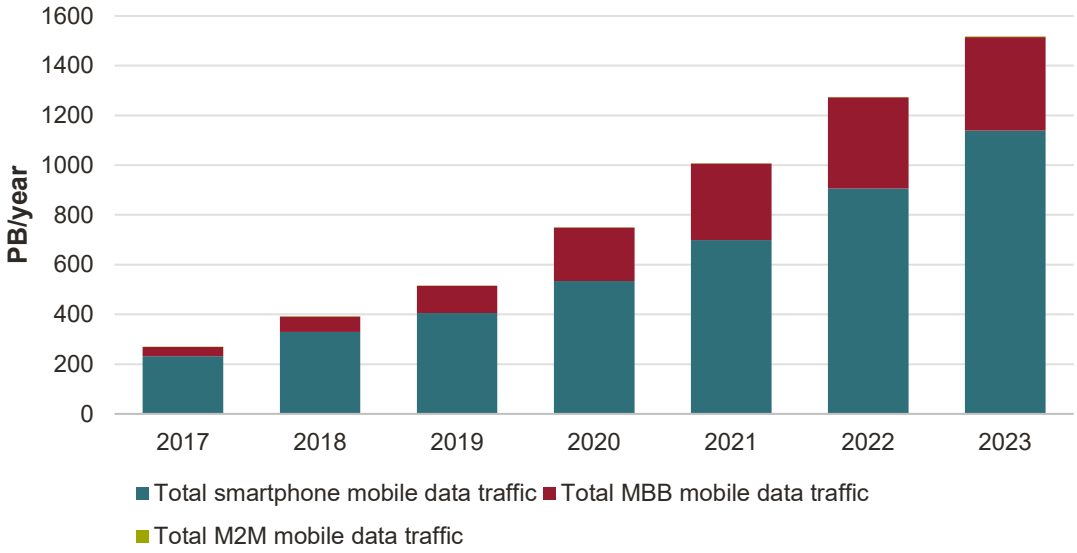


Source: *ComReg QKDR and Frontier forecasts*
Note: *Frontier forecasts were made for the period 2018-2022*

2.5 Total data consumption by device

Figure 16 sets out total mobile data traffic by device.

Figure 16 Mobile data traffic by device



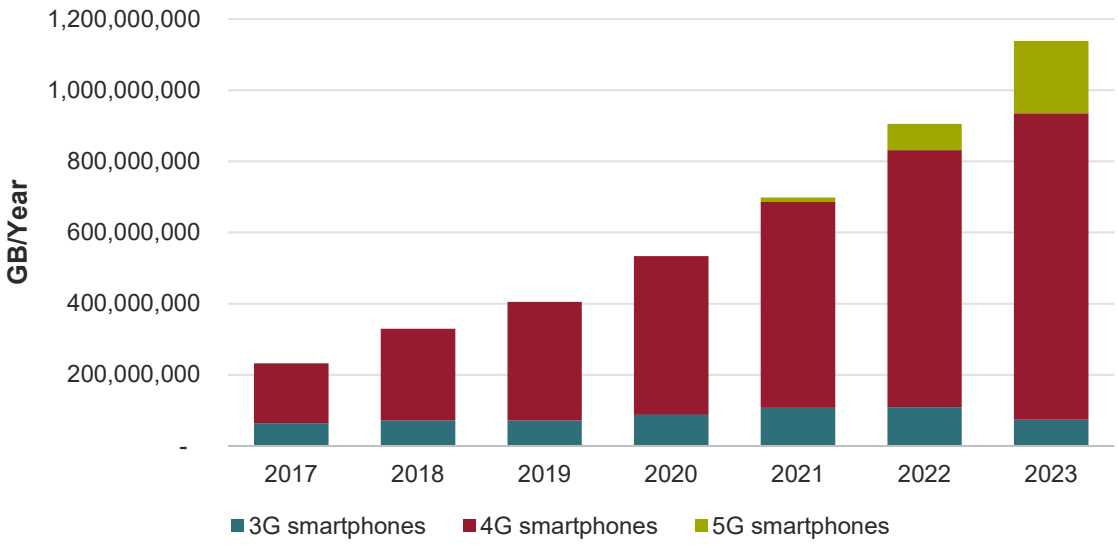
Source: *ComReg QKDR*
Note: *Note that M2M mobile data traffic is low and hence hard to see on the chart.*

Mobile handsets generate the majority of data traffic, accounting for 75% of total mobile data traffic in 2023. However, the proportion of data traffic accounted for by MBB has been

increasing since 2017, both due to increasing penetration and increasing per device mobile data usage. In 2023, it accounted for 25% of all traffic. M2M devices generate a very small proportion of total mobile data traffic, accounting for less than 1% of total mobile data traffic, despite the increasing number of connections.

Figure 17 disaggregates mobile handset total mobile data usage by generation.

Figure 17 Mobile handset mobile data traffic by generation



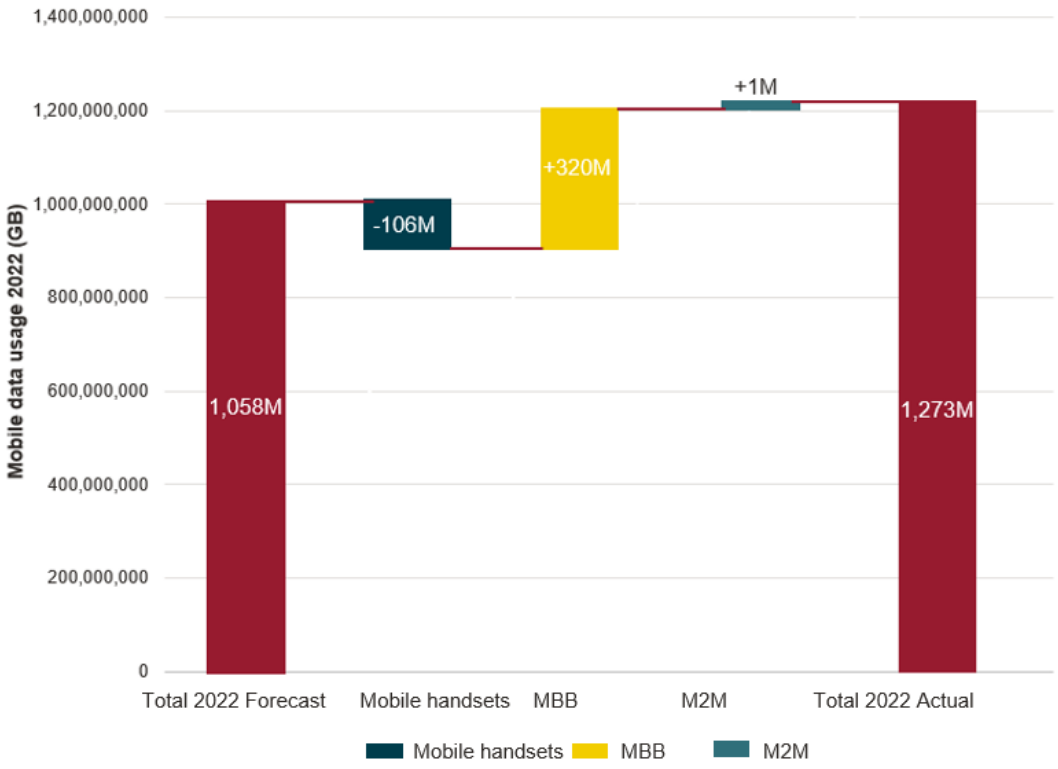
Source: *ComReg QKDR*
Note: *Data on 5G mobile data usage was first collected in 2021.*

As can be seen, 4G handsets have the largest mobile data traffic in all years at 76%. However, mobile data traffic generated by 5G handsets has been increasing since the launch of 5G in 2020.

2.6 Summary appraisal of outcomes compared to previous forecasts

Figure 18 summarises the appraisal of outcomes and previous forecasts from the previous sections.

Figure 18 Mobile data usage actual vs forecast



Source: Frontier Economics

Total mobile data usage was 215m GB higher than the central forecast. This reflects the following:

- total mobile handset mobile data usage was lower than the forecast by 106m GB;
- MBB total mobile data usage was higher than the forecast by 320m GB; and
- M2M total mobile data usage was higher than the forecast by 1m GB.

Key reasons for difference between outcomes and forecasts.

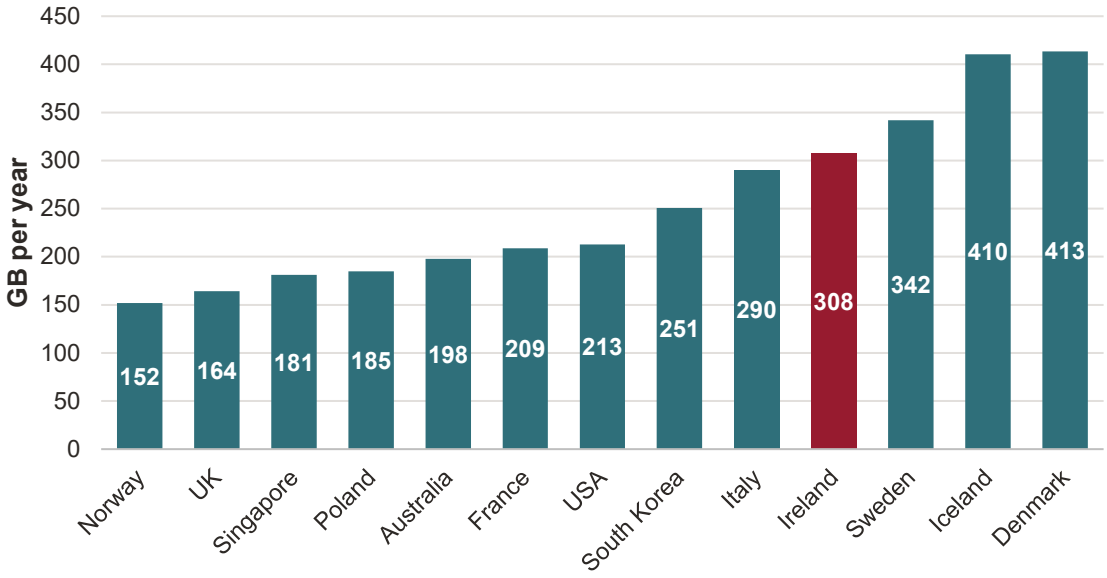
- Population growth was faster than forecasts of population used for informing the mobile data traffic forecasts. This accounts from a quarter of variation of outturn from forecast.
- Mobile handset penetration for 3G, 4G and 5G subscriptions was higher than forecast due to individuals upgrading from 2G to higher generation subscriptions.
- Mobile handset mobile data usage was lower than central forecast due to slower than expected growth in emerging use cases.
- MBB device connections were higher than projected (the forecast projected a decline in MBB connections whereas subscriptions grew). Data use per MBB device increased

significantly higher than forecast, likely due to the use of MBB at a fixed location to support multiple devices.

2.7 Data usage in Ireland compared to other countries

Mobile data consumption in Ireland is relatively high compared to many other countries.

Figure 19 Average annual mobile data consumption per capita, 2023



Source: *TeleGeography*
Note: *Data available for select countries.*

Figure 19 demonstrates that Ireland ranks above many advanced countries in terms of data use per capita.

3 Factors driving future data demand to 2028

This section describes the various factors that will affect the volume of mobile data traffic in the period to 2028. These include factors that will directly affect demand for data traffic, as well as supply related factors that will influence the volume of data traffic. This informs the assumptions used to forecast mobile data traffic in section 4.

3.1 Demand side factors

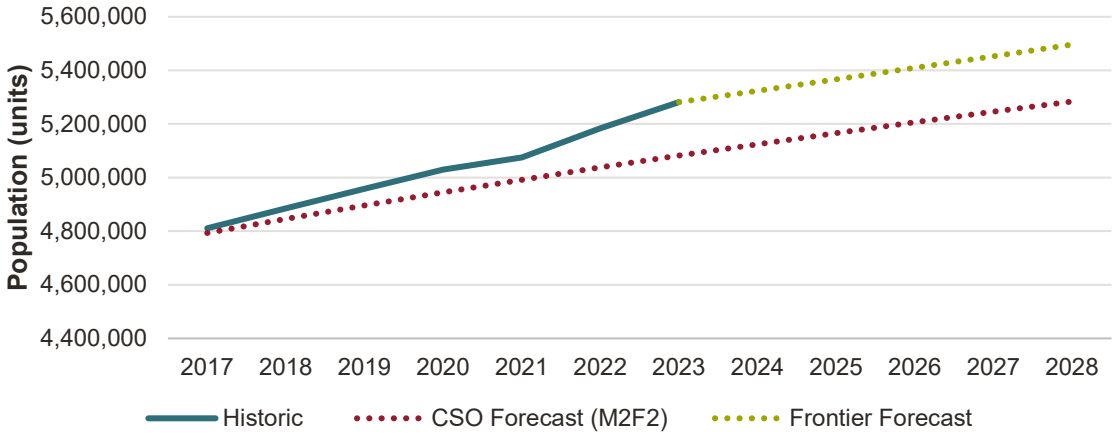
3.1.1 Population and demographics

Ireland's population stood at 5.3m at the end of 2023 and has increased by almost 0.5m since 2017, equivalent to a 10% increase. One driver of this increase in population has been positive net migration, which has increased from 2012 until 2023 (with exception of Covid years when net migration was negative).[29] Annual net migration went from -25,700 in 2012 (i.e. net emigration), to 39,200 in 2016 and 77,200 in 2023 (i.e. net immigration).

Ireland's growing population will drive total mobile data traffic. This is because, as population increases, the number of devices and mobile connections will increase, contributing to total mobile data usage.

The CSO last published population forecasts in 2017. In order to derive population forecasts for the purpose of this report, we have applied the population growth rate as forecast by CSO in 2017 (3.8% per annum) to the estimated population at the end of 2023.

Figure 20 Forecast population



Source: CSO Population Estimates

[29] Data from CSO Population and Migration estimates shows growth in net migration.

Note: Note that population has remained higher than CSO central M2F2 forecasts made in 2017. In order to update CSO forecast to these higher population figures, growth rates from the M2F2 forecast have been applied to the current population to obtain the Frontier forecast of population. This forecast has been used in the model. Note that axis begins at 4,400,000.

In addition to the population growth, it is possible that the changing demographic composition of the Irish population could affect demand for mobile data. Most notably, the population in Ireland has been aging: the share of population in the age group 45 and above is expected to increase from 37% in 2016 to 42% in 2026 with a corresponding decline in the ages 44 and below. Patterns of device penetration and mobile data usage can vary between age groups with younger age groups having higher device penetration and usage.[30] But as current cohorts of population age it is also likely that usage amongst older cohorts will increase.

Implication for modelling

The CSO population forecasts have not been updated since 2017; therefore the forecast model applies CSO population forecast growth rates to latest population figures. The model does not make any further adjustments for demographics such as aging population as behavioural patterns are hard to measure and can change over time.

3.1.2 Increasing penetration of mobile handsets

Mobile handset penetration in Ireland is quite mature – 107% in 2023. Despite high penetration levels, penetration has continued to increase, albeit more slowly in the recent years (see section 2.3.1). The growing penetration could reflect a number of factors. First, users increasingly have different subscriptions for personal and business use. Business subscriptions in Ireland have risen by 35% since 2017, from approximately 750,000 in 2017 to 1,010,000 in 2023.[31] Second, an increasing number of connections among young children may also be contributing to the rising mobile handset penetration. In Ireland, about 36% of all ten-year-olds had a mobile handset in 2022 and this increased to about 45% in 2023.[32] Third, there may be increased propensity for users to purchase subscriptions for wearable devices (e.g. smart watches – section 3.1.3).

These factors can continue driving mobile penetration and further drive up mobile data traffic.

30 100% of 18-24 year olds owned a smartphone whereas, 66% of 65+ olds owned a smartphone in 2022. See Mobile Consumer Experience 2022 – Survey results (slide 11).

31 ComReg QKDR data

32 CyberSafeKids, Trends and usage report, 2022-2023, CyberSafeKids, Trends and usage report, 2021-2022

Implication for modelling

The forecast model accounts for increasing handset penetration (driven by additional business subscriptions, increased subscription amongst children and wearable devices) by using a range of scenarios of future growth. If mobile handset penetration continues to rise (due to having more business subscriptions or increased coverage among the population), total mobile data usage will also rise.

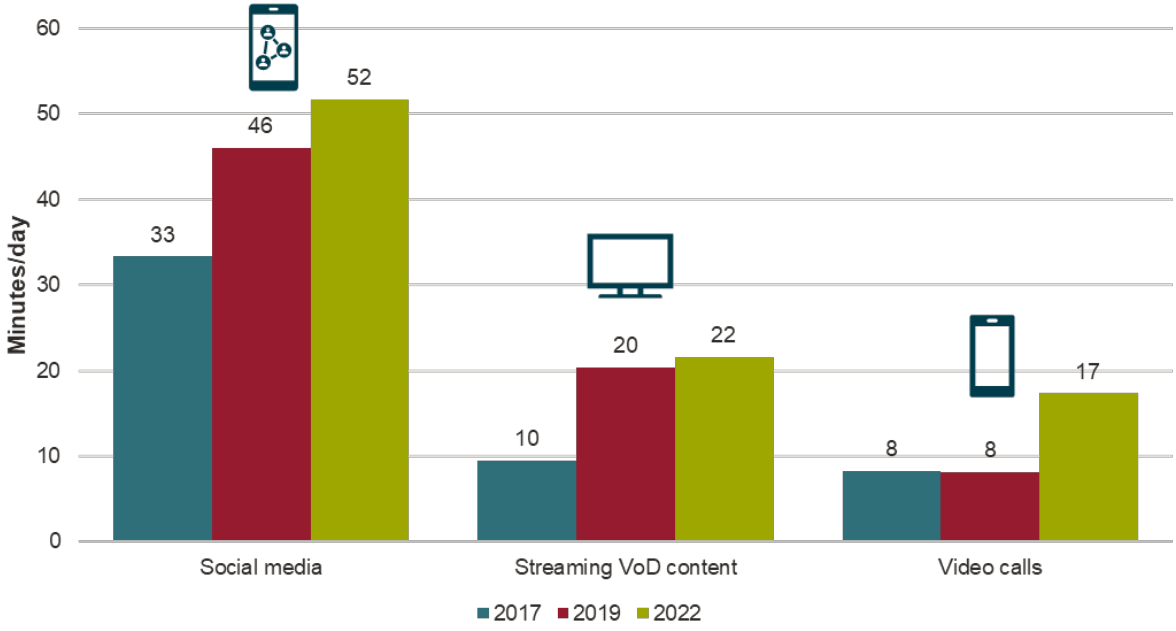
3.1.3 Consumer apps and services

Consumers' use of apps and services that rely on connectivity will drive continued growth in mobile data traffic.

Increasing use of data intensive activities

Use of data intensive activities on mobile devices is on the rise.

Figure 21 Minutes spent per day on data-intensive handset use cases



Source: ComReg 22/83, Mobile Consumer Experience survey
Note: This is the mean daily usage.

VoD streaming (250MB/ hour), video calling (250MB/ hour), and social media use (250MB/ hour – assuming video content is consumed) are all very data intensive activities (see Figure 8). Figure 21 shows that since 2017 social media use on mobile devices has grown 58% to reach 52 minutes a day; VoD streaming has grown by 137% to reach 22 minutes a day; and

video calling has grown 112% to reach 17 minutes per day. If this trend continues, then data traffic on mobile handset devices will increase.

Gaming

Gaming is a very popular activity. 36% of Irish adults play games which rely on an internet connection. An average gamer spends 70 minutes each day playing games online.[33] Historically, limitations on device capabilities and mobile network capabilities meant that gaming was undertaken on dedicated gaming consoles or PCs with fixed connectivity. However, in recent years advances in mobile device technology and mobile networks have meant that gaming increasingly occurs on mobile devices using wireless connectivity. Many games which were traditionally developed only for consoles have now been adapted for mobile. For example, PlayerUnknown's Battlegrounds (PUBG)[34] and Call of Duty[35] allow players to compete with each other in real time multiplayer games using mobile specific versions of their games.

Gaming can, depending upon the nature of the game, consume significant amounts of data. An average game consumes 100 MB of data per hour.[36] Mobile handsets are the most commonly used device for playing games globally.[37] It is likely that improvements in device and network technology will increase the prevalence of mobile gaming as well as the data consumption required. The introduction of 5G has led to improved internet connection speeds - which can provide higher download speeds - and low latency connectivity which can improve the gaming experience. The higher quality performance will increase time spent gaming on mobile devices.

Consumer IoT such as smart wearables/devices

The use of consumer IoT devices such as smart wearables has been rising in recent years. In 2022, 54% of people in Ireland used wearable devices such as a smart watch, fitness band, connected goggles or headsets, safety-trackers, internet-connected accessories, internet-connected clothes or shoes, etc.[38] This was rapid growth from the level in 2022 (23%).[39]

Increased penetration and usage of these devices will increase total and per capita mobile data usage. Some smart watches connect by Bluetooth to a user's handset, others have a

33 Pure Telecom, Pure Telecom survey

34 https://www.theverge.com/2018/3/16/17128526/pubg-mobile-hands-on-review-vs-xbox-fortnite

35 https://www.callofduty.com/uk/en/mobile

36 Microsoft, "*How much data does gaming use?*", 2023

37 Deloitte, Digital Consumer Trends, 2022

38 CSO, Information Society Statistics - Households 2020

39 CSO, Smart Technology 2022.

dedicated mobile connection that can be used to independently make calls[40] or stream music[41]. As such, the increased penetration of these devices is likely to increase mobile data traffic overall (as it would be largely incremental use rather than substitution of usage on other devices). However, the data usage per wearable device is significantly lower than mobile devices (since video is not streamed onto a smart watch). As such, the growth in these devices is likely to have a less significant impact on overall data usage than would further growth in mobile handsets.

Implication for modelling

Use of data intensive activities on mobile devices is on the rise. This includes VoD streaming, video calling, and social media use. Similarly, gaming on mobile devices is also increasing. These trends are expected to continue and drive up mobile data traffic on mobile handset devices.

Additionally, penetration and use of wearables is also on the rise but data usage per wearable device is not significant.

The model uses current trends of increasing mobile data usage per device to forecast future scenarios.

3.1.4 Device technology

Devices evolve to become more advanced with higher resolution screens and cameras, faster chip processors and improved battery power (Figure 22). There have also been improvements in terms of spectrum bands that can operate on these devices which aligns with the release of additional spectrum (see section 3.2.1). This technological evolution will drive demand for mobile data as people use their handset more, with more data intensive activities, and app providers develop new and innovative improvements to their services which rely on the more advanced device technology.

40 The smart watch has a separate phone number which is linked and is "subordinate" to the user's main number, such that a call can be routed to either the watch or handset, and the smart watch can independently make and receive calls.

41 For example, all Apple's smart watches enable users to stream music direct to the smart watch which can be played on the watch's speaker or via a connected Bluetooth device. See: https://www.apple.com/uk/watch/compare/.

Figure 22 Evolution of mobile handset specifications

	iPhone 6	iPhone X	iPhone 12	iPhone 13 Pro Max	iPhone 15 Pro Max
Year of release	2013	2017	2020	2021	2023
Display	4.7	5.8	6.1	6.7	6.7
Pixel density	326 ppi	458 ppi	460 ppi	458 ppi	460 ppi
CPU	Apple A8 (1.4 GHz)	Apple A11 Bionic (2.39 GHz)	Apple A14 Bionic	Apple A15 Bionic	Apple A17 Pro @ 3.73GHz
Camera Resolution	8 megapixels	12 megapixels Dual	12 megapixels Dual (Ultra-Wide) ƒ/2.4 (Wide) ƒ/1.6	12 megapixels x3 (Ultra-Wide) ƒ/1.8 (Wide) ƒ/1.5 (Telephoto) ƒ/2.8	48 megapixels ƒ/1.78 (Wide) 12MP ƒ/2.2 (Ultra-Wide) 12MP ƒ/1.78 (Telephoto x2) 12MP ƒ/2.8 (Telephoto x5)

Source: https://socialcompare.com/en/comparison/apple-iphone-product-line-comparison

However, over the next forecast period, the rate of increase in mobile data demand that is driven by evolution of handset technology is likely to slow. This is because as the handset market matures, each new version provides a more limited iterative improvement on previous versions. For example Figure 22 shows how the specifications for high-end devices have evolved. While there are gradual improvement in these devices, the rate of change has slowed. Indeed, pixel density and display have remained broadly similar in the past few years as it reaches limits of what is perceptible to the human eye. Furthermore, high end devices now also cost over €1,000, making them an expensive purchase, so slowing product life cycles.

Implication for modelling

Devices have been evolving over time with higher resolution screens and cameras, faster processors, and improved battery power. However, as this market matures, each new upgrade provides limited improvement. Demand for mobile data traffic driven by device improvements is likely to slow over the forecast period and hence the model does not make specific adjustments.

3.1.5 Increasing M2M connections

M2M connections in Ireland have been rising over the past few years. As noted, the rollout of smart meters has been a major contributory factor to this increase. This roll out is expected to be completed by the end of 2024,[42] following which, it could be reasonable to expect a decline in the rate of growth of M2M connections. However, even after stripping out connections that are related to smart meters, there has still been growth in M2M connections. This is driven by increasing adoption of IoT technology by businesses and households. This growth is expected to continue.

One M2M use case that is gradually becoming more prevenient is connected cars. Many modern cars come equipped with connectivity to report data on vehicle safety and maintenance; and to enable "Over The Air" (OTA) updates of in-car software (managing environment, control and infotainment systems). These will use mobile networks to transmit data to and from the vehicle and the manufacturer. The volumes of data are relatively low, and OTA updates are usually undertaken at off peak times (or over Wi-Fi where possible) to efficiently use network capacity.

IoT in Ireland

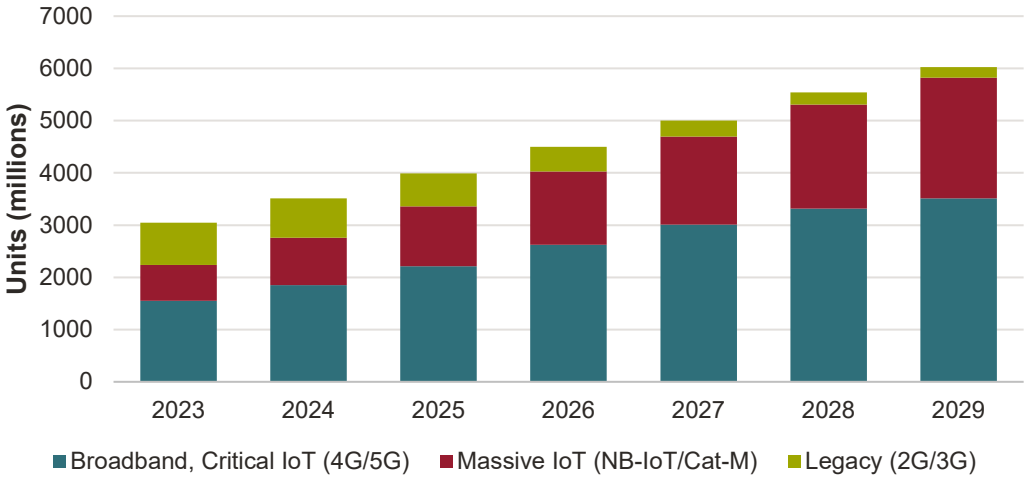
There are many established industrial and commercial uses for IoT in Ireland. For example, medical device manufacturer Medtronic has implemented IoT-enabled machines and devices in their manufacturing process to improve efficiency, reduce downtime, and improve the quality of their products.[43] Irish dairy giant Glanbia monitors temperature and quality of milk as it is processed using IoT sensors throughout their production process. This has resulted in cost savings and increased production output.[44]

42 Commission for Regulation of Utilities, Smart Meters

43 Confirm Smart Manufacturing, "*Revolutionizing Industry 4.0: The Role of IoT in Transforming Smart Factories in Ireland*"

44 Confirm Smart Manufacturing, "*Revolutionizing Industry 4.0: The Role of IoT in Transforming Smart Factories in Ireland*"

Figure 23 Number of IoT devices worldwide



Source: *Ericsson https://www.ericsson.com/en/reports-and-papers/mobility-report/mobility-visualizer?f=16&ft=2&r=1&t=21,22,23&s=14&u=1&y=2023,2029&c=1*

Note: *Cat-M1 and NB-IoT are types of Massive IoT devices. NarrowBand NB)-IoT supports ultra-low complexity devices with very narrow bandwidth, 200 kHz (such as smart meters). Cat-M1 operates at 1.4 MHz bandwidth with higher device complexity/cost than NB-IoT. The wider bandwidth allows Cat-M1 to achieve greater data rates (up to 1 Mbps), lower latency and more accurate device positioning capabilities. See: https://www.ericsson.com/en/blog/2019/2/difference-between-nb-iot-cat-m1*

New IoT use cases may arise due to the rollout of 5G and the enhanced capabilities that it can offer. These use cases include examples in industry, logistics, smart vehicles, smart-homes, smart-cities, medical devices and power grids. These new use cases are likely to cause a shift in the technology of IoT connections. That is, worldwide 2G and 3G IoT connections are expected to decline over time falling by 69% between 2024 and 2028. However, mobile IoT (i.e. M2M) will grow by 79%, more than offsetting the decline. Worldwide, Ericsson predicts a 12% p/a increase in total IoT devices 2025-2028 (see Figure 23).

Implication for modelling

M2M connections have been increasing in Ireland, with the rollout of smart metering contributing a large share to this increase. The modelling takes into account completion of smart metering in Ireland by forecasting no growth in connections of those devices beyond 2024. For other emerging IoT use cases, the model uses scenarios to forecast future growth. M2M connections are expected to continue to increase during the forecast period due to emerging IoT use cases such as industry, logistics, medical devices etc. These use cases may use 4G/5G instead of 2G/3G which most current M2M connections in Ireland use.

3.1.6 Emerging consumer use cases and wider trends

There are a number of emerging use cases which may be data intensive, though at this stage it is not known whether they will contribute to higher mobile data traffic as their use may not become widespread.

Virtual reality (VR) and augmented reality (AR)

VR and AR are particularly data intensive activities since they require very high-definition video across a very wide field of vision (to enable the device's display to instantly reflect any movement of the wearer). However, though the technology has been available for a number of years, with major tech players offering services based on this technology (Apple's Vision Pro will launch in 2024, and Meta's Quest launched in 2019), it has yet to achieve widespread usage, with a number of factors, such as the high cost of equipment, potentially limiting usage. It is possible, however, that usage might incrementally grow, driven by workplace applications such as training and healthcare.[45] Despite this, analysts do not expect there to be a sudden change in take up in Ireland.[46]

High adoption rates have not yet been seen, even in early adopter countries such as South Korea where sales of these devices are reported to have been sluggish. Though, some reports have noted that demand will increase in the near future,[47] there is uncertainty in the use of AR/VR given the slow take up to date, therefore the model does not make any specific assumption for the use of the technology.

Automated vehicles and autonomous drones

Autonomous vehicles may consume large amounts of mobile data. In Ireland, legislation to allow testing of autonomous vehicles was introduced in 2019.[48] However, technology alone will not determine the take-up of autonomous vehicles - the legal, regulatory and broader policy environment must also adapt to account for and facilitate this change.[49] Even in countries pioneering in autonomous vehicles, such as China, autonomous vehicles are still in development and trial phase. China has granted approval to a first group of nine automakers to carry out tests on vehicles with advanced autonomous driving technologies on public roads in 2024.[50] Given uncertainty of both technology and regulation, it is unlikely like that there will be significant take-up of such technology in Ireland during the forecast period.

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45 Eirmersive, The Irish Immersive Economy, 2022

46 Irish Times, "*The high costs and slow take-up of virtual reality for employee training*", 2023

47 Pulse, *"Korean telecom giants bet on metaverse in 2024 amid anticipated XR boom"*, 2023

48 Department of Transport, Cabinet approves legislation to test Autonomous vehicles on public roads, 2019

49 Government of Ireland, National Investment Framework for Transport in Ireland

50 Reuters, " China gives first approvals for public trials of advanced autonomous driving", 2024

Similarly, autonomous drones may have many industrial use cases both indoors (warehouse stock management) and outdoor (surveillance or delivery)[51]. For example, Irish drone delivery service provider Manna[52] provides food and beverage delivery services which it claims will become routine part of everyday life.[53] It has made 150k deliveries[54] and relies on mobile networks to connect the drone to its data portal. However, it is still uncertain whether there will be widespread adoption of such drones during the forecast period.

AI

The use of AI and machine learning data analytical techniques promise economy wide productivity gains. The Irish government's AI strategy quoted forecasts that AI will boost Ireland's GDP by 11.6% or €48B by 2030[55]. AI is likely to enable mobile operators to improve their services and lower costs (for example in customer services, optimising operations, supporting security, reducing energy usage and supporting sales)[56].

AI may not have direct effects on driving mobile data traffic, though there may be indirect impacts, as AI is used by content and app providers to boost the attractiveness of their content and advertising that is served to consumers.[57] For example, the rapid growth of usage of social media content on mobile handsets in Ireland in recent years (growing from 33 minutes per day in 2017 to 52 minutes per day in 2022) likely partly reflects refinements in the content that is served using AI technology to drive consumption.[58]

Implication for modelling

There are some emerging data intensive use cases such as AR/VR, autonomous vehicles/drones and AI. However, it is unlikely that these technologies will have widespread take-up during the forecast period. The forecast model does not make specific adjustments for these emerging use case and trends.

3.2 Supply side factors

There are many supply side factors which will influence the volume of mobile data traffic. This is because the use of mobile networks not only reflects demand but also the availability of

51 GSMA, 5G Autonomous Drones

52 Manna, https://www.manna.aero/

53 Irish Independent, 'World's largest' drone delivery service Manna is the future for delivery services in Ireland, 2024

54 Bots and drones UK, Drone Delivery for Food & Beverage Takes Off in Ireland, 2023

55 Irish Government (2021) AI - Here for Good A National Artificial Intelligence Strategy for Ireland.

56 GSMA, The Mobile Industry and AI, 2023

57 See for example: https://aicontentfy.com/en/blog/impact-of-ai-on-website-traffic

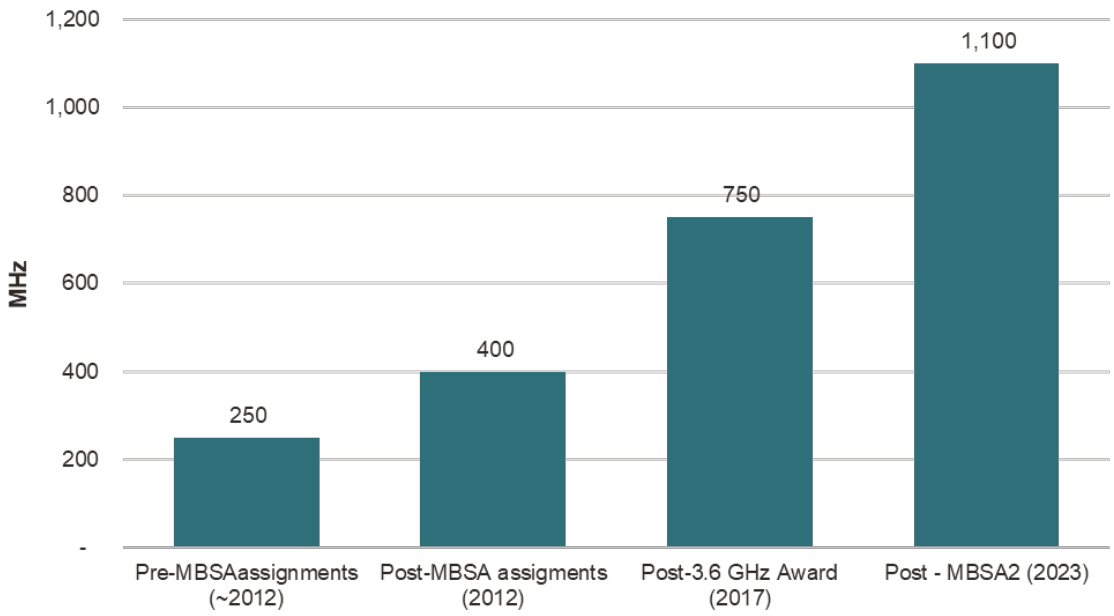
58 ComReg 22/83 Survey of Consumers Summer 2022

network capacity, with mobile network services being complementary to the apps and devices that users rely on. Thus, increases in the quality and performance of mobile network services will increase demand for the mobile apps and devices that generate mobile data traffic. The impact of a number of supply related factors is considered below.

3.2.1 Growing mobile network capacity and radio spectrum made available for mobile use

Spectrum is an essential input into the provision of mobile connectivity services. It enables mobile networks to communicate with end user devices (download data) and for devices to communicate with the network (upload data). ComReg manages the scarce radio spectrum resource in Ireland and has assigned increasing amounts of spectrum to mobile use. The volume of spectrum available for mobile use has increased both in sub 1GHz bands (used to provide wide geographic coverage and in building coverage), and above 1GHz bands (used to provide capacity in areas with high demand)

Figure 24 Total harmonised radio spectrum made available for mobile use



Source: ComReg Doc 21/136, ComReg Doc 22/105

Notes: post 2023 spectrum relates to the time slot 2 period of award (from 2027). The total spectrum available includes spectrum assigned to Imagine (55 MHz in MBSA2 and 60 MHz (rural) in 3.6 GHz band); and Dense Air (25 MHz (Rural) and 60 MHz (Urban) in 3.6 GHz band)

As can be seen from Figure 24, ComReg has been progressively increasing the volume of available spectrum reflecting a growing demand and need for mobile data connectivity.

- In 2017, ComReg assigned 350 MHz of spectrum in the 3.6 GHz band, an increase of 87% compared to the amount of spectrum previously assigned.

- In 2023, 470 MHz of spectrum was included in the second Multi-Band Spectrum Award (MBSA2 award). 60 MHz was in the sub 1GHz range, 405 MHz was in the above 1GHz range and 5 MHz was not sold. The award increased the amount of assigned and available spectrum by 350 MHz or 46%[59]. The MBSA2 also included conditions to roll out network services to defined minimum levels.

Together, the above spectrum assignments represent a 175% increase (700 MHz) over the available spectrum following the first MBSA (400 MHz).

The increased assignment and use of mobile spectrum has enabled mobile operators to upgrade and improve the capacity and performance of their networks and will enable further increases as MNOs continue their network rollout.

Table 1 shows how MNOs have gradually upgraded their networks to use new spectrum bands.

Table 1 Number of cell sites with each spectrum band in 2020 and 2024

Band	Number of sites listed in the licence schedules of the MNOs in 2020			Number of sites listed in the licence schedules of the MNOs as of Q1 2024		
	Eir	Three	Vodafone	Eir	Three[60]	Vodafone
700 MHz	n/a	n/a	n/a	2371	1409	1349
800 MHz	1060	1865	1555	2461	2393	2086
900 MHz	1932	2164	2032	2519	2776	2221
1800 MHz	643	1534	1019	1609	2195	1553
2.1 GHz	1414	1743	1441	1607	1660	1067
2.3 GHz	n/a	n/a	n/a	15	n/a	n/a
2.6 GHz	n/a	n/a	n/a	n/a	77	99
3.6 GHz	205	155	52	358	547	300
Overall Total	2055	2397	2340			

Source: ComReg Doc 20/122, ComReg licence schedules as per ComReg Website

59 Since the award included 120 MHz of reassigned spectrum in the 2.1 GHz range.

60 In the 800 MHz, 900 MHz and 1800 MHz bands, Three holds two licences (Three (no1) and Three (no2)). The number of sites presented for Three for these spectrum bands represents the greatest number of sites listed in either one of these licences.

The following conclusions can be drawn from Table 1.

First, over the last number of years the MNOs have deployed spectrum at more sites to expand their networks and provide more network coverage and capacity. For example:

- spectrum in the 700 MHz band has been deployed at a substantial number of sites (between 1349 and 2371 sites) while before 2020 this band was not in use; and
- spectrum in existing bands such as the 800 MHz, 900 MHz band and 1800 MHz band has been deployed at more sites.

Second, there remains scope to further increase the network capacity in the period up to 2028 (i.e. the end of this forecast period) by deploying spectrum at more sites. For example:

- spectrum in the 700 MHz bands has not been rolled out to the same extent as the 800 MHz and 900 MHz bands by two of the MNOs (Three and Vodafone);
- spectrum in the 2.3 GHz and 2.6 GHz bands in only beginning to be rolled out and is substantially less deployed than spectrum in the 1800 MHz and 2.1 GHz bands; and
- spectrum in the 3.6 GHz band is also considerably less deployed than spectrum in in the 1800 MHz and 2.1 GHz bands.

Increasing network capacity as outlined above would firstly be required to meet relevant coverage and base station rollout licence obligations and secondly to meet increasing network demand, noting also that network demand is generally heterogeneously distributed across different cells such that some cells are “heavily loaded” and require a greater amount of capacity, while other cells are more “lightly loaded” and require less capacity[61].

This increased network capacity, coupled with improvements in performance, in turn drives usage of mobile data traffic.

[61] Section 3.2.4 of ComReg Document 15/62a, “Frontier Economics - A cost benefit analysis of the change in use of the 700 MHz radio frequency band in Ireland”, published 30 June 2015

Implication for modelling

Both availability and deployment of spectrum has increased in recent years. The increased availability and use of mobile spectrum has enabled mobile operators to upgrade and improve the capacity and performance of their networks. Many spectrum bands, such as the 2.3 GHz, 2.6 GHz and 3.6 GHz bands, are currently under-utilised when compared to the more-established bands of 1800 MHz and 2.1 GHz. This provides scope for further network capacity increases as MNOs continue their network rollout.

The model takes this into account by forecasting mobile data traffic for all devices in line with recent trends and the upgrade from lower generation subscriptions (2G/3G) to higher generations (4G/5G).

3.2.2 Continued roll out of 5G networks

5G services – the latest generation of mobile technology - were introduced in 2019 and now account for 15% of all mobile connections (including M2M). All three MNOs in Ireland have upgraded their networks to offer 5G services, with 5G population coverage exceeding 75% (Vodafone)[62], 70% (Eir)[63] and 90% (Three)[64].

For many users, 5G offers enhancements (in download and upload speed) compared to 4G technology (i.e. “enhanced Mobile Broadband (eMBB)”). It provides incremental improvement for general mobile use offering faster services, delivered on more efficient networks.

Enhanced network capabilities mean that users are more likely to consume more mobile data as apps and services are displayed and provided in higher quality. This is for a number of reasons. Content providers will dynamically manage the video streams provided to end users and will download them at higher quality if bandwidth allows. Thus, 5G users will spend more time watching high definition (HD) quality content rather than standard definition (SD). Similarly, music will stream at higher quality (called “Hi-Res Audio” which is intended to replicate the quality of a studio recording (i.e. “lossless” quality)). Apple, for example, offers lossless quality streaming which it notes *“streaming lossless audio using mobile data or a Wi-Fi network consumes significantly more data.”*[65]. Furthermore, the availability of high-quality

62 As of Mid-2023. Source TeleGeography.

63 Eir, https://www.eir.ie/helpandsupport/mobile/eir-mobile-services/5G/#:~:text=eir%20has%20Ireland's%20best%205G,of%20the%20Republic%20of%20Ireland. Accessed on 01/05/2024.

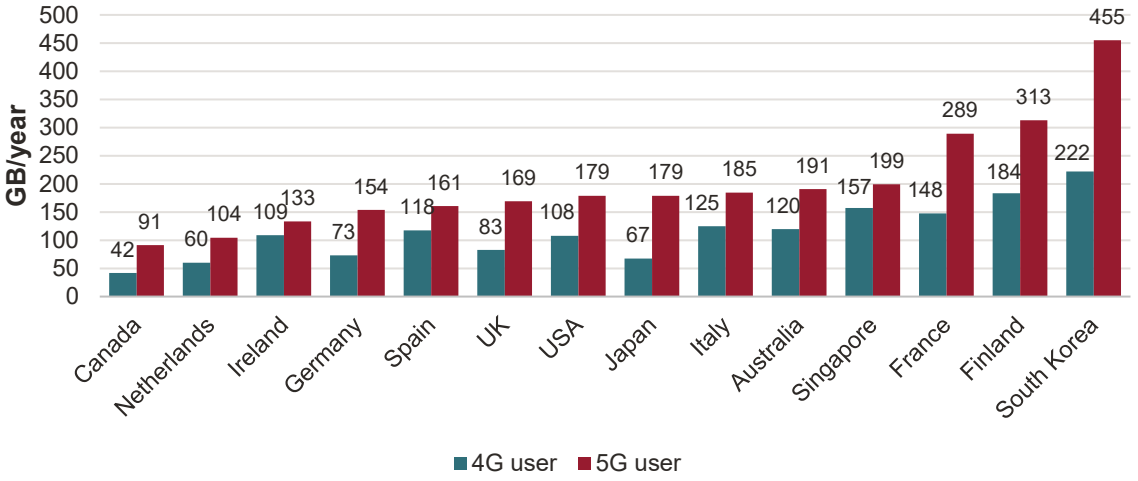
64 Three, https://www.three.ie/support/coverage-checker.html#:~:text=Frequently%20Asked%20Questions,over%2090%25%205G%20population%20coverage. Accessed on 01/05/2024

65 https://support.apple.com/en-gb/118295

networks will have behavioural impacts on end users such that they are likely to use more data since the quality of the apps and services that they use will increase.

A 2021 study found that 5G users in the leading 5G markets were found to consume up to 2.7x more mobile data than 4G users (see Figure 25).[66]

Figure 25 5G vs 4G data traffic per user , 2021



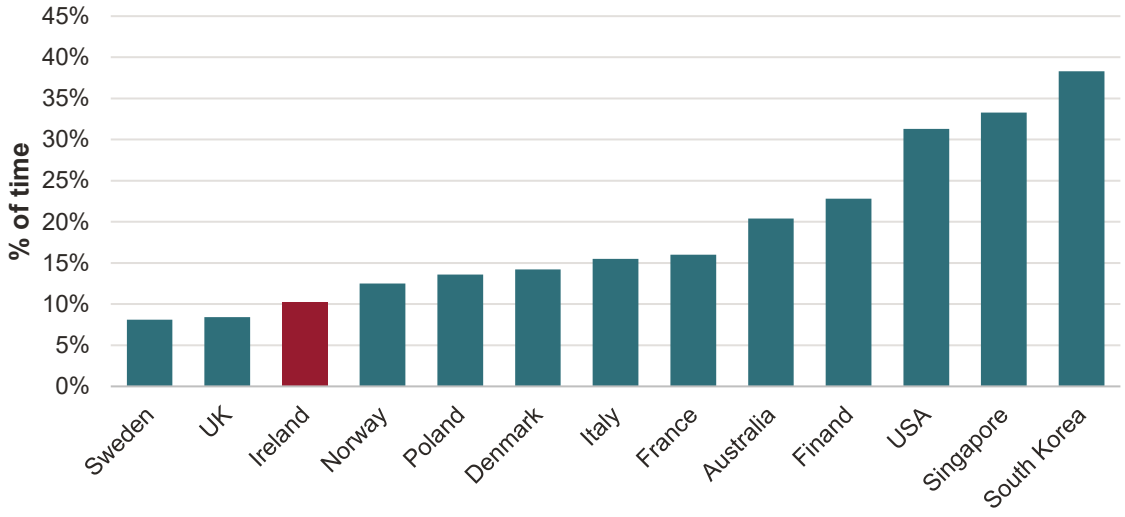
Source: OpenSignal, Impact of 5G and Covid 19 on mobile data consumption

As per this study, in Ireland, 4G data use was 109 GB per user in 2021 whereas 5G data use was 133 GB per user – though this was at a time when 5G networks were only starting to roll out. Consequently, the total volume of data consumed and the differential between 5G and 4G may have increased.

However, the use of 5G technology depends not just on geographic coverage, but on the capacity in different geographic areas. If 5G capacity is constrained in a certain area the device will instead use 4G or 3G network services.

66 Opensignal, Quantifying the impact of 5g and covid-19 on mobile data consumption, 2021

Figure 26 5G availability (% of time), Oct-Dec 2023



Source: OpenSignal, Mobile network speeds leaped ahead in 2023, but some markets lag behind

Using this metric and as shown in Figure 26 above, the availability of 5G in Ireland is relatively low compared to other countries. 5G availability will, however, likely increase over the forecast period as mobile operators continue to increase 5G capacity across their networks, so driving further growth in the use of mobile data services.

5G has also been designed to offer new capabilities. It can support "Massive Machine Type Communications (MMTC), and Ultra Reliable And Low Latency Communications (URLLC). MMTC will support certain business and industry use cases which will enable many densely located IoT devices to simultaneously connect. This will have particular importance in certain commercial use cases – where sensors can be deployed throughout industrial settings. URLLC can offer applications that require a very high degree of security or latency. This could be important in certain use cases such as autonomous vehicles or drone connectivity.

Importantly, 5G also enables operators to offer enhanced dedicated connectivity to certain users. It enables mobile operators to create a "network slice" which is a distinct logical (i.e. software defined) network, offered on top of a shared infrastructure. This will allow operators to offer services which can guarantee high levels of quality of service to certain end users, even where the network slice shares network infrastructure with many other users. Though stand alone 5G networks will be required to enable operators to "network slice" – this has only begun rollout recently.[67]

[67] Network slicing requires StandAlone 5G (5G SA) which include 5G upgrades in the core, transport and Radio Access Networks. Operators are only starting to roll out 5G SA. Three's standalone 5G network has only rolled out on a trial basis. See *"Three Ireland trials 5G standalone"*

While these technologies are being developed by mobile operators, app developers, device manufacturers and others, they are currently at an early stage of deployment. Predicting the impact on mobile traffic over the forecast period is therefore difficult. Though at this stage there is not expected to be significant incremental traffic generated as a result of these advanced use cases.

Implication for modelling

5G networks are being rolled out in Ireland with operators having high population coverage. 5G availability will likely increase over the forecast period as mobile operators continue to increase 5G capacity across their networks, so driving further growth in the use of mobile data services. Enhanced network capabilities mean that users are more likely to consume more mobile data as apps and services are displayed and provided in higher quality. The model accounts for this by forecasting for upgrade from lower generations to 5G along with the higher per device usage on a 5G subscription.

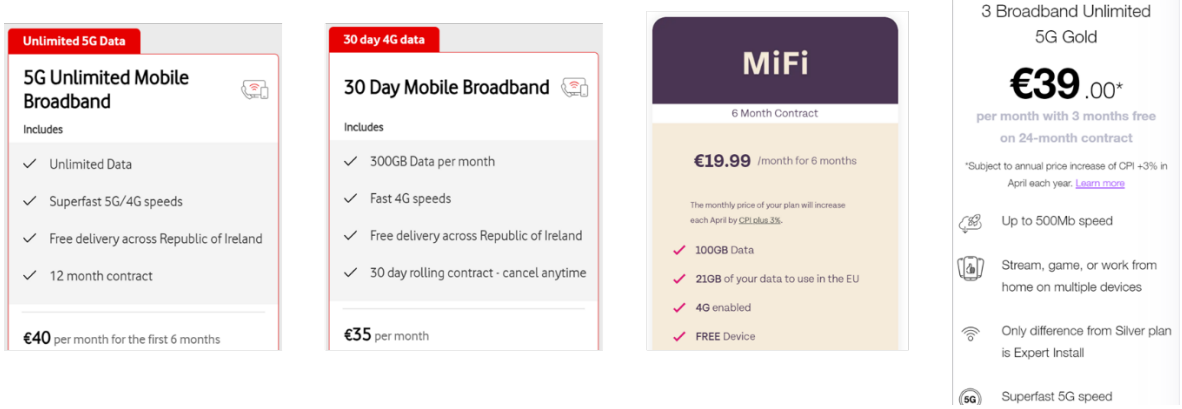
5G also enables operators to offer enhanced dedicated connectivity to certain users using network slicing but this technology is still at early stages of deployment. However, this uncertainty and potential for higher traffic is reflected in the high growth scenario we have included in the forecast.

3.2.3 5G to provide connectivity at a fixed location

The roll out and development of 5G networks will enable operators to offer a potential alternative for fixed networks (i.e. 5G broadband provided wirelessly to a fixed location). Given that 5G mobile networks can support high download and upload speeds, this will enable consumers to use mobile networks to access broadband from a fixed location[68]. For example, 3 Ireland offers packages offering up to 500Mb/s with options to have an engineer install an external transmitter to improve reception.

[68] When providing connectivity at a fixed location it is possible to attach an external transmitter / antenna that improves signal.

Figure 27 Home broadband in Ireland



Source: *Vodafone, eir, Three*

Rollout of 5G is improving internet speeds for mobile broadband, making it even more viable as an alternative for fixed broadband. Some commentators believe that 5G home broadband offers a significant opportunity for mobile operators to drive incremental revenues[69]. 5G home broadband has already been launched in a number of countries such as Spain[70] and Germany[71]. Some analysts predict that 5G home broadband will grow at 35% p/a 2023-29 worldwide.[72] In 2023, 86% of Irish households used fixed broadband and 31% used mobile broadband[73] (though this could relate to a mobile phone subscription or an MBB subscription).

Implication for modelling

The roll out and development of 5G networks will enable operators to offer a potential alternative for fixed broadband type service (i.e. broadband provided wirelessly to a fixed location). The model takes this into account as faster growth in connections and mobile data usage of MBB devices in the high scenario as rollout of National Broadband Plan (see section 3.2.4) will also play a role.

69 See for example: Ericsson (2024) Six actionable insights to capture the value of 5G FWA https://www.ericsson.com/en/reports-and-papers/further-insights/fwa-insights#insight2of6; Ookla (2023) he Rise of 5G FWA & The Battle for Fixed Broadband Customers https://www.ookla.com/articles/fixed-wireless-access-us-q3-2023 https://tbri.com/special-reports/the-telecom-industry-faces-a-reckoning/

70 See: https://5gobservatory.eu/vodafone-spain-launches-5g-home-broadband-service/

71 See: https://5gobservatory.eu/deutsche-telekom-launches-hybrid-5g/

72 ABI research, Fixed Wireless Access Market to Continue Its Strong Growth, Reaching Almost 265 Million Subscriptions by 2029, 2024

73 CSO, Internet Coverage and Usage in Ireland 2023

3.2.4 NBI will improve fixed broadband services in rural areas

Rollout of the National Broadband Plan[74] delivered by National Broadband Ireland (NBI) may likely *reduce* demand for MBB services at a fixed location. The roll out by NBI is expected to provide connectivity to over 560k premises (as well as 44k businesses and 65k farms) in rural areas that otherwise would not have access to high quality broadband connections. Households in the areas where NBI has not yet rolled out receive relatively slow broadband speeds (less than 30Mb/s download speeds, with some households located a long way from the exchange receiving even slower speeds).

Many residents located in an area with slow speed fixed connectivity would use mobile connectivity in order to access the internet. Therefore, as NBI rolls out it might reduce demand for mobile connectivity. Currently 233k premises have been passed and are available for order or pre-order NBI services, with such premises possibly being able to access broadband with speeds of 500Mb/s [75]

Implication for modelling

The roll out of National Broadband Plan is expected to provide connectivity to over 560k premises (as well as 44k businesses and 65k farms) in rural areas that otherwise would not have access to high quality broadband connections. Residents in these locations may be currently using mobile connectivity (through hotspot or MBB devices) – this roll out may reduce mobile data traffic.

In the model, this has been accounted for in the low growth scenario for MBB connections and data usage.

3.2.5 Public Wi-Fi offload[76]

Public Wi-Fi offload can reduce demand for mobile data. The use of Wi-Fi offload enables users to manage their use of mobile data, and potentially access networks with better performance than their mobile service. It is now common to be able to access public Wi-Fi where mobile users can roam onto a public network for short periods, such as at the office, when travelling, or in other public spaces such as cafes or bars.

74 National Broadband Plan aims to ensure that every home, farm and business in Ireland – regardless of how remote or rural – has access to high-speed broadband.

75 https://nbi.ie/ Accessed April 2024.

76 Wi-Fi is an important way to manage use of network services when in the home also. Devices are set to automatically roam onto Wi-Fi networks when in the home, and many devices can be set to route voice calls via Wi-Fi networks when in the home. Growing demand for data when at home has led the European Union (EU) to allocate the lower portion of the 6 Gigahertz (GHz) band (i.e., 5.945- 6.425 GHz) to Wi-Fi.

There is an increasing number of public Wi-Fi hotspots. For example, it is now common for public transport such as buses[77] and trains[78] to offer Wi-Fi and electricity charging points; and similarly, large transport hubs such as airports[79] and train stations offer Wi-Fi. In addition there are a number of wider public Wi-Fi services. Dublin recently launched a new free public Wi-Fi system available at over 150 locations across the city[80]. Furthermore, the NBI roll out plan includes the provision of a number of Broadband Connection Points (BCPs). BCPs are locations selected by local authorities to receive Wi-Fi in community and public facilities (such as community halls, libraries, sports facilities tourist locations and other public spaces).[81] There are currently 955 BCPs and schools which are connected to offer Wi-Fi with NBI. Each BCP will provide 150Mb high-speed broadband access to the local community.

While the availability of public Wi-Fi continues to increase, and a growing fibre network will improve quality of service at these points, there are a number of barriers to increased usage of Wi-Fi. The performance of shared public Wi-Fi can be lower (i.e. slower speeds) than available on mobile networks. The shared nature of public Wi-Fi, and difficulties of providing Wi-Fi on the move on transport networks, can lead to performance issues; and security concerns relating to use of public Wi-Fi[82] can limit use. Furthermore, as discussed below, the increased availability of high usage data plans from mobile operators reduces consumer need to move to public Wi-Fi at certain points of the day.

Implication for modelling

Public Wi-Fi offload can reduce demand for mobile data. There is an increasing number of public Wi-Fi hotspots such as public transport and airport. While the availability of public Wi-Fi continues to rise, there are barriers to increased usage – performance of shared public Wi-Fi can be lower, difficulty of usage on moving vehicles, and increased availability of high usage data plans from mobile operators reducing need to offload.

Given these barriers, the forecast model does not consider that the increased availability of public Wi-Fi will significantly affect ongoing trends in mobile data traffic.

77 Fleet connect, Case studies – Dublin bus

78 See for example: https://www.irishrail.ie/en-ie/travel-information/wifi-and-power

79 Dublin airport, Wi-Fi and printing services

80 BreakingNews.ie, "*Dublin city to have new free public Wi-Fi system*", 2022

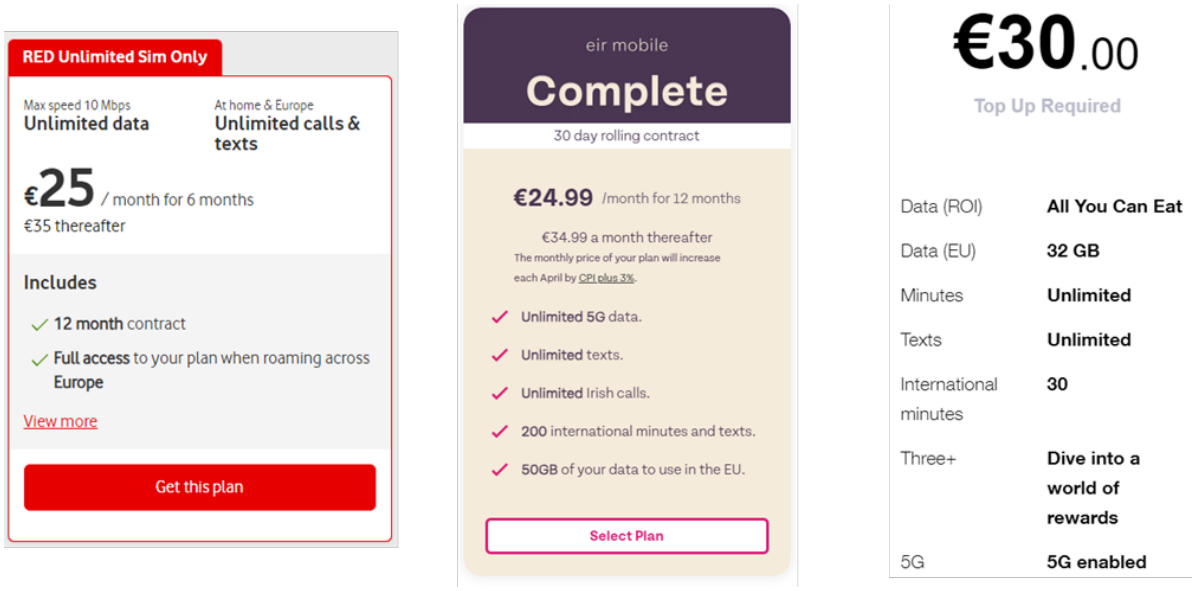
81 https://nbi.ie/broadband-connection-points/

82 See for example: Irish Times *Why you should be wary of connecting to public wifi, There are several scams to be aware of when deciding whether or not to use the wifi on offer*

3.2.6 Retail offers of "unlimited" data plans

Retailers offer a range of "unlimited" data plans[83]. Subscribers of unlimited data plans do not face incremental costs for using additional data and are hance incentivised to use more data. Additionally, users of large/unlimited data plans are less prone to switching to Wi-Fi.[84]

Figure 28 "Unlimited" use mobile data plans



Source: *Vodafone, eir, Three*

Note: *Note that unlimited use plans have limitations such as maximum speeds and "fair usage policy" which may reduce data speed after a limit of mobile data usage.*

Implication for modelling

Unlimited data plans offered by retailers make it such that subscribers do not face incremental cost for using additional data. We expect that such plans will continue to incentivise high mobile data usage over the forecast period.

8383 Note that unlimited data plans have limitations on use. See for example: https://www.three.ie/legal/terms/all-you-can-eat-data.html

84 Ericsson, "Shifting mobile data consumption and data plans", 2017

3.3 Summary

Table 2 summarises the likely demand and supply drivers for growth in mobile data traffic in Ireland.

Table 2 Factors driving future data demand

Factors	Affect on future data demand
Demand side factors	
Population	Increase
Increasing penetration of mobile handsets	Increase
Consumer apps and services	Increase
Device technology	neutral to small increase
Increasing M2M connections	Increase
Emerging consumer use cases (AR/VR, autonomous vehicles/ drones, AI)	neutral to small increase
Supply side factors	
Growing mobile network capacity and spectrum allocated to mobile use	Increase
Continued roll out of 5G network	Increase
5G home broadband	Increase
NBI will improve fixed broadband services in rural areas	Decrease
Public Wi-Fi offload	Decrease
Retail offers	Increase

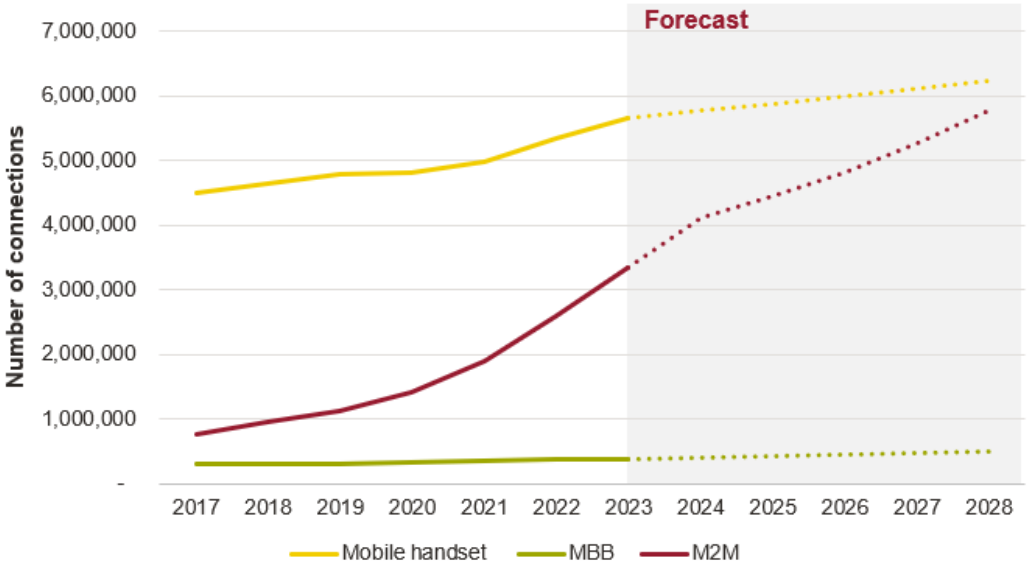
Source: Frontier Economics

4 Mobile data traffic forecasts

This section provides the central forecasts of mobile traffic in Ireland from 2024 to 2028. It shows forecast mobile connections, forecast data use per device, and forecast mobile data traffic. The assumptions that underpin the forecasts and the forecast for the high, central and low scenarios are set out in Annex A and Annex B

4.1 Total mobile connections

Figure 29 Total mobile connections, central forecast, 2024-2028

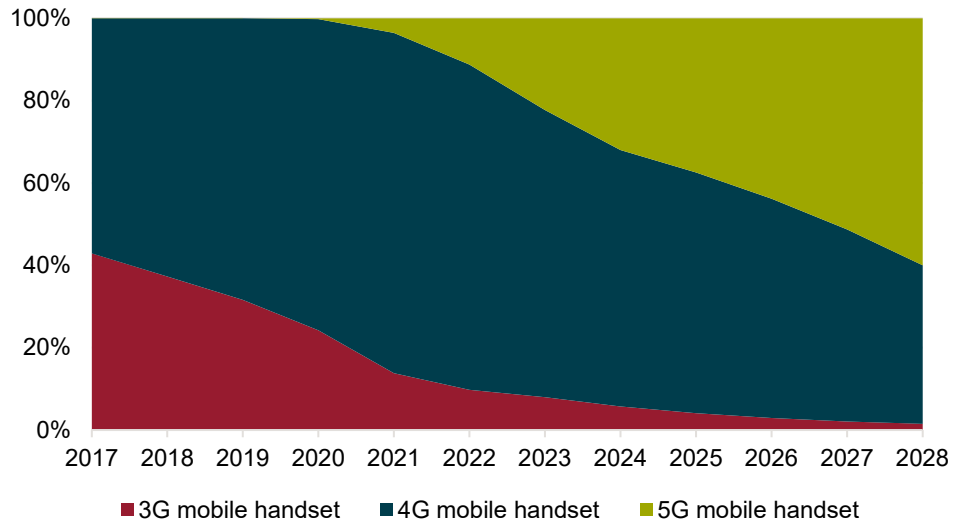


Source: Frontier Economics

Figure 29 shows forecast mobile connections by type of device.

- Mobile handset connections are forecast to rise by 2% each year to reach 6.2 million by 2028, driven by the increasing population (see Section 3.1.1) and increasing propensity for users to have more than one subscription (for example for work and personal, or additional subscriptions for peripheral devices).
- MBB connections are forecast to grow by 5% each year to 2028. This growth is expected to be driven by increasing population and consumers' increasing propensity to use mobile networks to support home broadband as 5G performance improves. This implies that MBB connections will reach almost 500,000 by 2028.
- M2M connections are forecast to grow by 9% between 2024 and 2028 with a faster growth in 2024 as the smart meter roll out programme completes, followed by a period of slower growth.

Figure 30 Forecast percentage distribution of mobile handsets



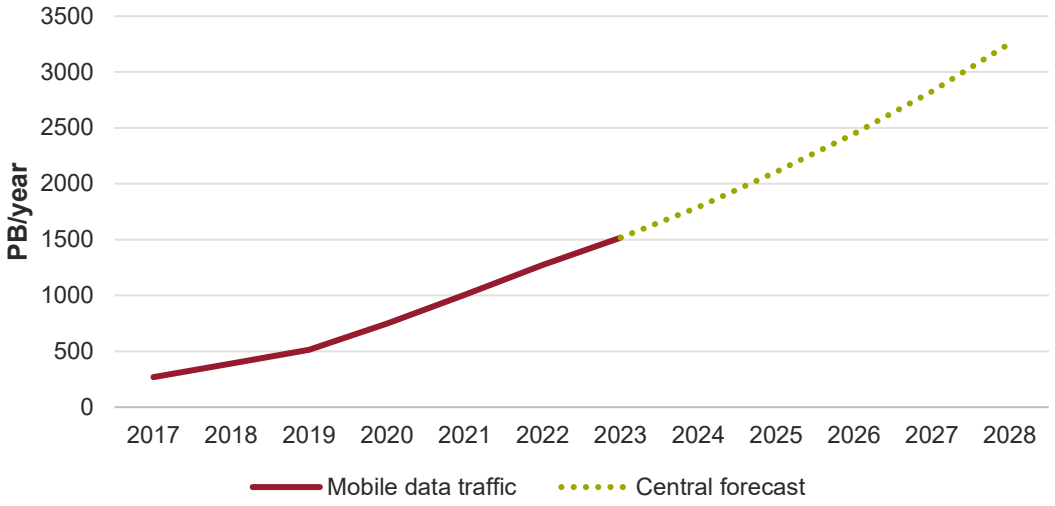
Source: Frontier Economics

Figure 30 shows forecast mobile handset by generation of technology. By 2028 3G mobile handsets are expected to decline to only be a 1% proportion of all mobile handset devices. 5G mobile handsets are forecast to increase and take a share of 60% by 2028. This implies that the penetration of 5G handsets will grow more slowly than the penetration of 4G handsets, given slower handset upgrade cycles and a slowing rate of technological enhancement of handsets (see section 3.1.4).

4.2 Total mobile data usage

The forecast growth for mobile data in Ireland is set out in Figure 31.

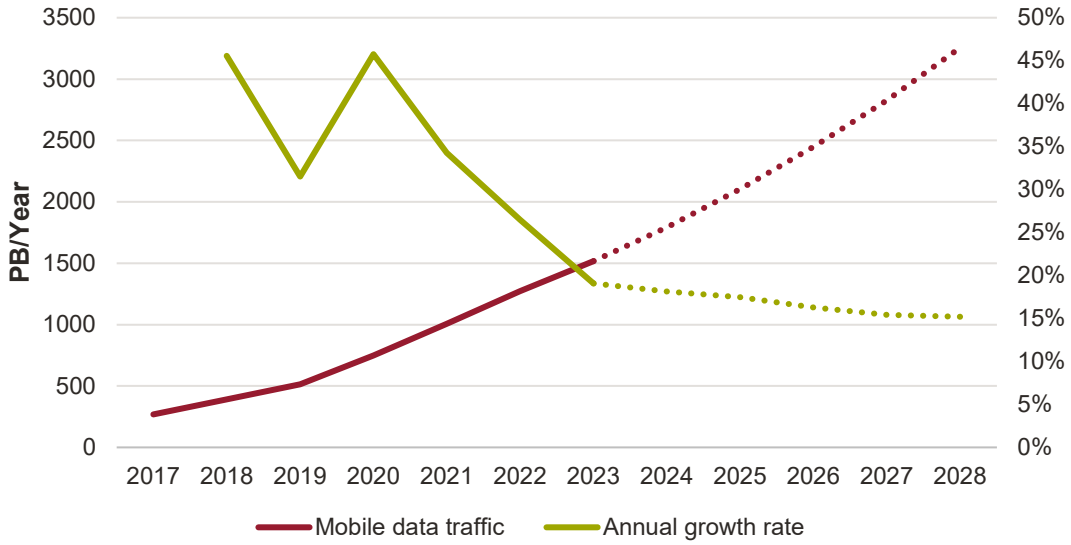
Figure 31 Total mobile data forecast 2024-2028



Source: Frontier Economics

Mobile data traffic is forecast to grow at an average of 16.5% per year up to 2028 to reach 3,200 PB in 2028. Alongside growth in connections, mobile data traffic growth is driven by increasing data use per device. Usage of data intensive activities (social media, HD streaming, video calling) will continue to grow, though at a slower pace than previously.

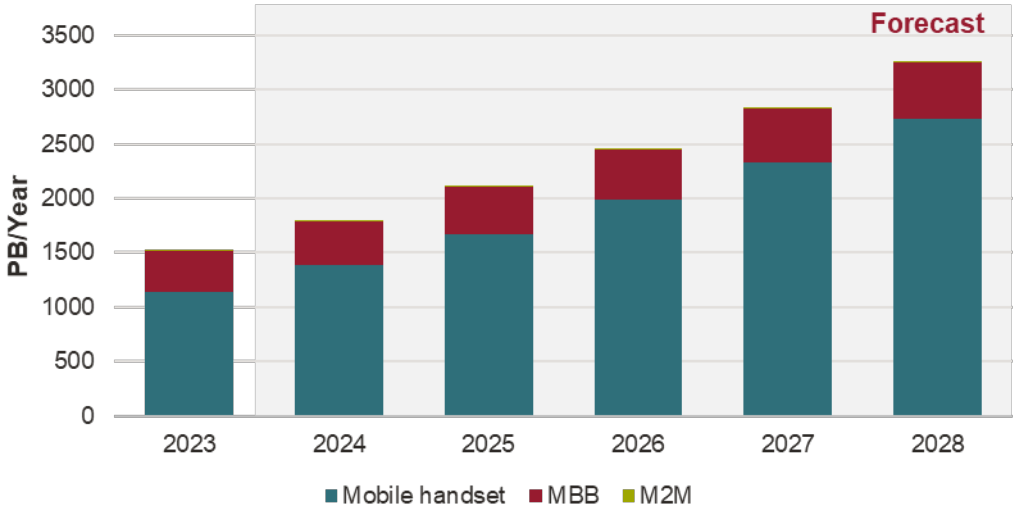
Figure 32 Growth rate of central forecast



Source: Frontier Economics

This means that the annual rate of traffic growth slows, within our model, from 18% in 2024-25 to 15% in 2027-28 (see Figure 32).

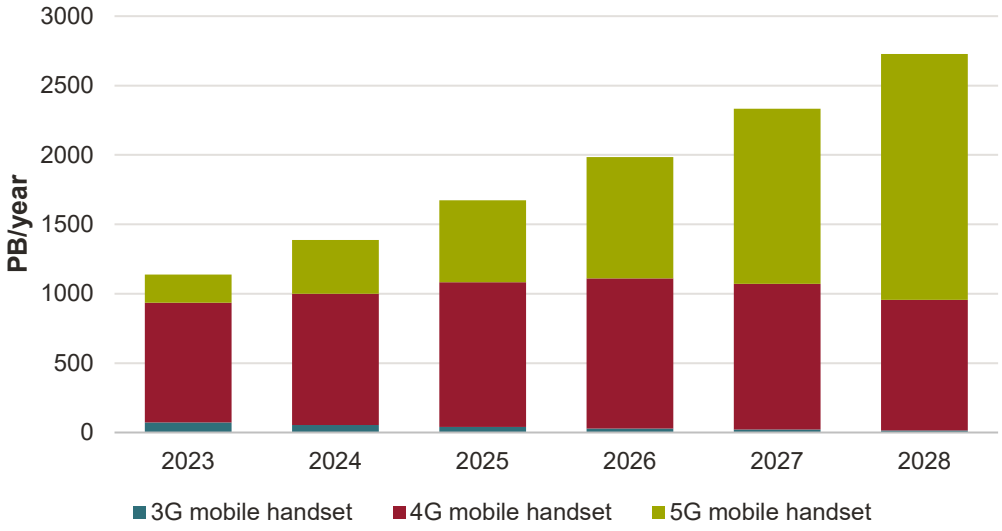
Figure 33 Total mobile data usage forecast split by device



Source: Frontier Economics

Figure 33 shows mobile data traffic forecast by type of devices – mobile handsets, MBB devices and, M2M connections. Traffic generated by mobile handsets will continue to take up the largest share during the forecast period and MBB devices will hold the second largest share. In 2023, mobile handsets contributed 76% to total mobile data traffic whereas MBB devices contributed 23%. By 2028 the model forecasts that mobile handsets' share of mobile traffic will be almost 84%, as growth in mobile data traffic on mobile handsets is likely to be faster than MBB devices. M2M devices will continue to contribute a very small share of less than 1% of total traffic. This is because of the low data use of these devices.

Figure 34 Total mobile data usage of mobile handsets

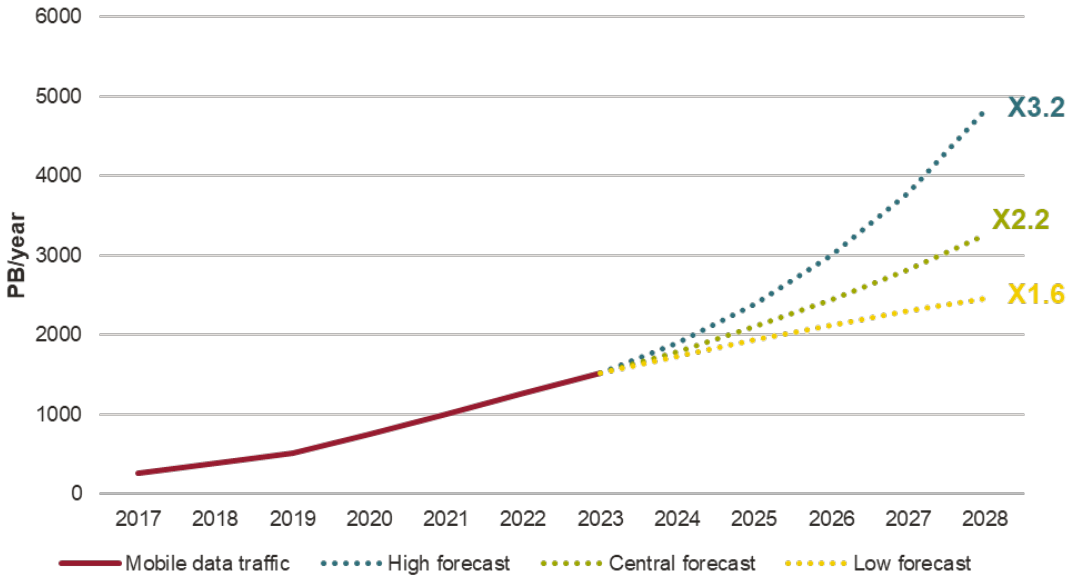


Source: Frontier Economics

Figure 34 shows mobile handset data traffic by generation. In 2023, 4G handsets contribute the largest share to the mobile data traffic (generated by mobile handsets). 5G data traffic could overtake 4G traffic in 2028 as penetration of 5G handsets increases over time and network quality improves. Mobile data traffic on 3G handsets is forecast to decline during the forecast period from 3.4% in 2023 to 0.3% in 2028 as 3G networks are phased out.

4.3 Total mobile data traffic in the high and low scenarios

Figure 35 Total mobile data traffic (low, central and high forecast)



Source: Frontier Economics

In our central scenario, total mobile data traffic is expected to grow by 2.2 times its 2023 level, from 1,500 PB[85] per year in 2023 to 3,200 PB in 2028. However, there is some uncertainty over these projections (see Figure 35). Reflecting this, potential growth (in terms of volume of data in 2028) ranges from 4,800 PB in the high scenario (four times current levels), and 2,400 PB in the low scenario (just under two times current levels).

4.4 Comparison with other mobile traffic forecasts

As a cross-check, the forecast in this report is compared with two other mobile data traffic forecasts. These are a forecast of UK mobile data traffic growth by Ofcom, and a forecast of western Europe traffic growth by Ericsson.

The central forecast presented in this report is broadly consistent with these other forecasts, noting that a direct comparison is not possible as the other forecasts are different time periods and the mobile data traffic characteristics of each country will naturally be somewhat different.

[85] 1 petabyte = 1,000,000 gigabytes

Ericsson forecasts a 20% growth rate per annum for Western Europe for the 2022-2028 period. This is similar to our central forecast of 16.5%, noting that Ericsson's forecast is for the slightly earlier period of 2022-2028, where growth rates in earlier years reflect higher levels.

Ofcom forecasts a faster growth rate of 36% per annum in the UK for the 2021-2025 time period, an earlier forecast period which reflect higher growth rates in mobile data traffic. Further the mobile data traffic characteristics of the UK and Irish markets are different. In Ireland, the actual mobile data traffic growth rate between 2021 and 2023 was 22% which is lower than the Ofcom forecast for UK for the same time period (36%) suggesting that Ireland's growth curve is at a different stage to that of the UK. A potential reason for this could be that Ireland is already notably ahead of the UK in terms of mobile data traffic as can be seen in Figure 19 – in 2023, average annual mobile data consumption per capita was 164 GB in the UK and 308 GB in Ireland.

Table 3 Average p/a data traffic growth projection

	Frontier (Ireland)	Ofcom (UK)	Ericsson (western Europe)
High	26%	51%	
Central	16.5%	36%	20%
Low	10%	17%	
Time period	2024 - 2028	2021-2025	2022-2028

Source: Frontier Economics, Ofcom , Ericsson
Note: Ericsson forecasts do not provide a scenario analysis.

Annex A Scenario forecasts

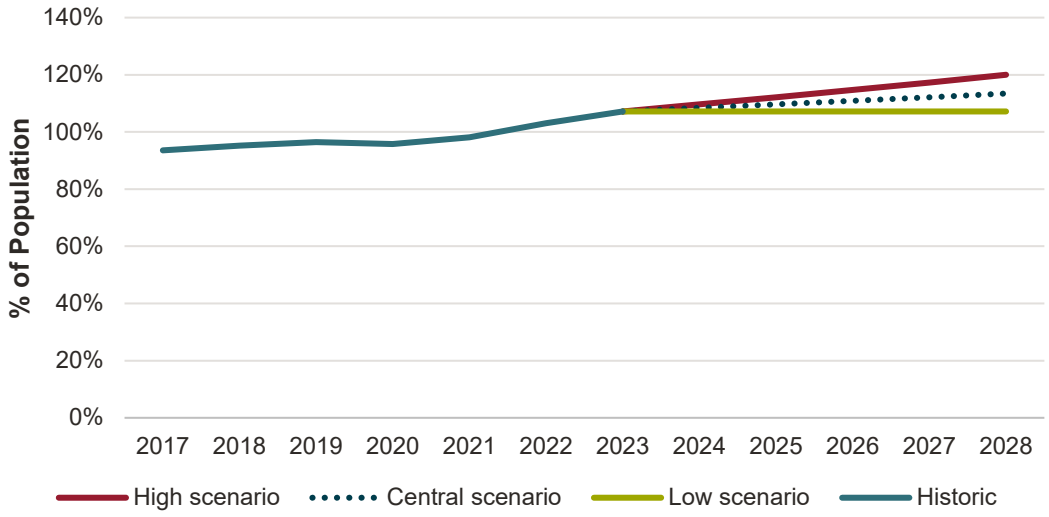
This section covers forecasts made for low, central and high scenarios for device penetration, device connection, mobile data use per device and total data traffic for each device.

A.1 Device penetration

Mobile handsets

Despite high penetration levels, mobile penetration continues to rise. The model therefore forecasts that penetration continue s to grow at 1% per year in the central forecast, consistent with recent growth rates. In the low forecast, the model assumes that a saturation point has been reached and there would be no further growth, whereas in the high scenario, model assumes faster than recent growth ~ 2% per year.

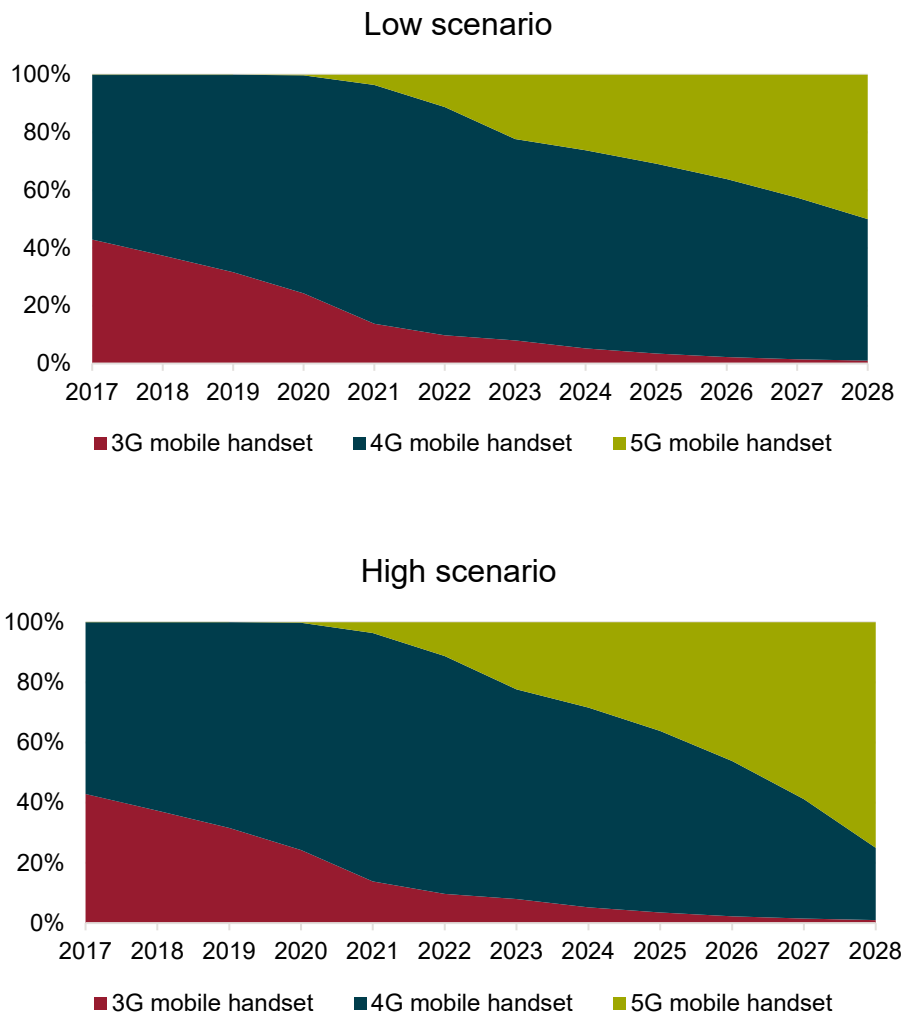
Figure 36 Mobile handset penetration forecast 2024-2028



Source: Frontier Economics

Figure 37 shows the split of mobile handset connections by technology for low and high scenarios. For the central scenario, refer to Figure 30.

Figure 37 Split of mobile handset connections by technology – Low and High scenario



Source: Frontier Economics

The rollout of 5G in Ireland began in 2020. Providers already have high 5G coverage – Three has 90% 5G population coverage[86], Eir has over 70% 5G coverage[87], and Vodafone provides 5G in areas of 26 counties[88]. As coverage of 5G increases the proportion of 5G mobile handset connections will increase (as users upgrade handsets). In the past, proportion of 4G connections rose rapidly as providers and users upgraded from 3G to 4G. 4G connections accounted for 67% of mobile handset connections eight years after launch. Upgrades may

86 Three, Coverage Checker, accessed on 11/04/2024

87 Eir, 5G, accessed on 11/04/2024

88 Vodafone, 5G, accessed on 11/04/2024

however be slower in the case of 5G because the change from 3G to 4G offered a larger upgrade to users in terms of speeds and expanded use cases as compared to that of 4G to 5G. 5G connections for mobile handsets are forecasted to follow a similar but slower trajectory than 4G and reach 60% in 2028, eight years after launch in the central scenario. In the low scenario, this growth is slower ~ 5G connections will account for 50%. In the high scenario, this is 75%.

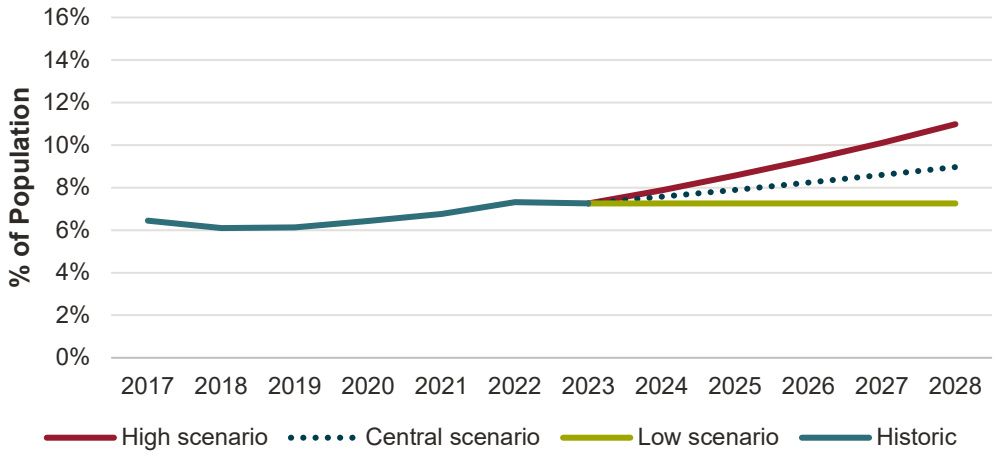
3G is forecast to decline to reach 1% in 2028 as users upgrade to 4G/5G connections in all scenarios and 4G is forecast to decline in each scenario to reach 24%, 39% and 29% in the low, central and high scenarios respectively.

MBB

During the forecast period, there will be positive and negative drivers of MBB penetration. Iterative increases in mobile network performance will increase demand for MBB (since it may be able to offer speed and reliability and act as an alternative to fixed broadband). However, the roll out of NBI will reduce demand for MBB in rural areas.

The central scenario forecasts that MBB will continue to grow in line with the trend in recent years - 2019-23 increasing from 383,000 in 2023 to 492,000 in 2028. The low scenario forecasts flat growth as NBI moderates demand with subscriptions increasing to 398,000 by 2028. The high scenario forecasts that MBB will continue to increase at a higher rate than recent trends to reach 600,000 subscriptions in 2028.

Figure 38 MBB penetration forecast



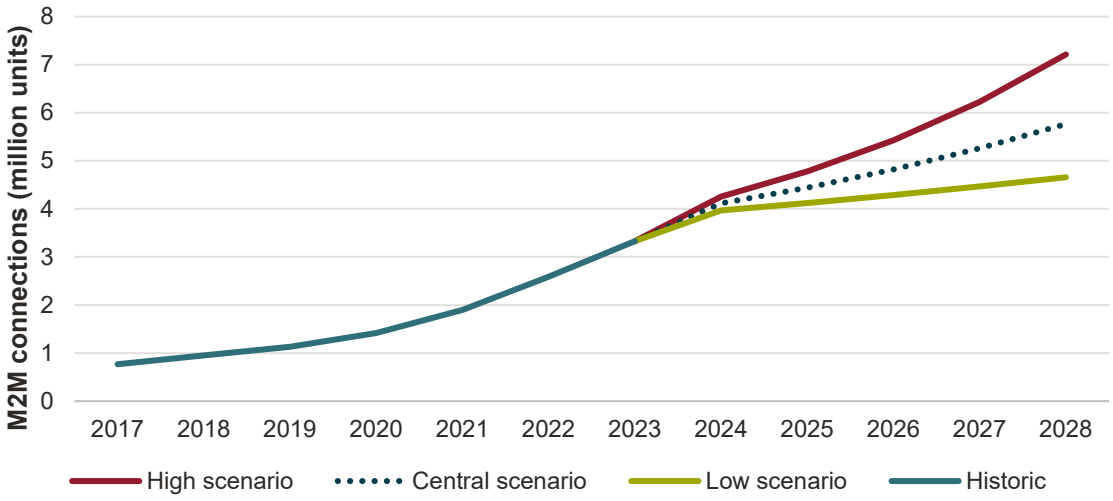
Source: Frontier Economics

M2M

M2M connections have grown rapidly from approximately 1M in 2017 to 3.3M in 2023. Much of this growth is due to the roll out of smart meters. The smart meter programme has rolled out to 1.5M dwellings, with plans to roll out to around another 0.5M in 2024. Therefore, the pace of growth in M2M is expected to fall as the smart meter roll out programme completes. Nonetheless, 5G may drive some further "organic" growth (i.e. growth not related to the smart meter roll out programme).

The central scenario assumes that once the smart meter roll out programme completes in 2024, growth will slow reflecting non-smart meter "organic" M2M growth with connections increasing to 5.7M by 2028. The low scenario assumes slower "organic" growth – half of the central scenario, bringing M2M connections to 4.6M in 2028. The high scenario assumes faster "organic" growth due to increasing M2M use cases such as medical devices, logistics tracking and vehicle monitoring – in this scenario, M2M connections are expected to reach 7.2M by 2028.

Figure 39 M2M connections forecast

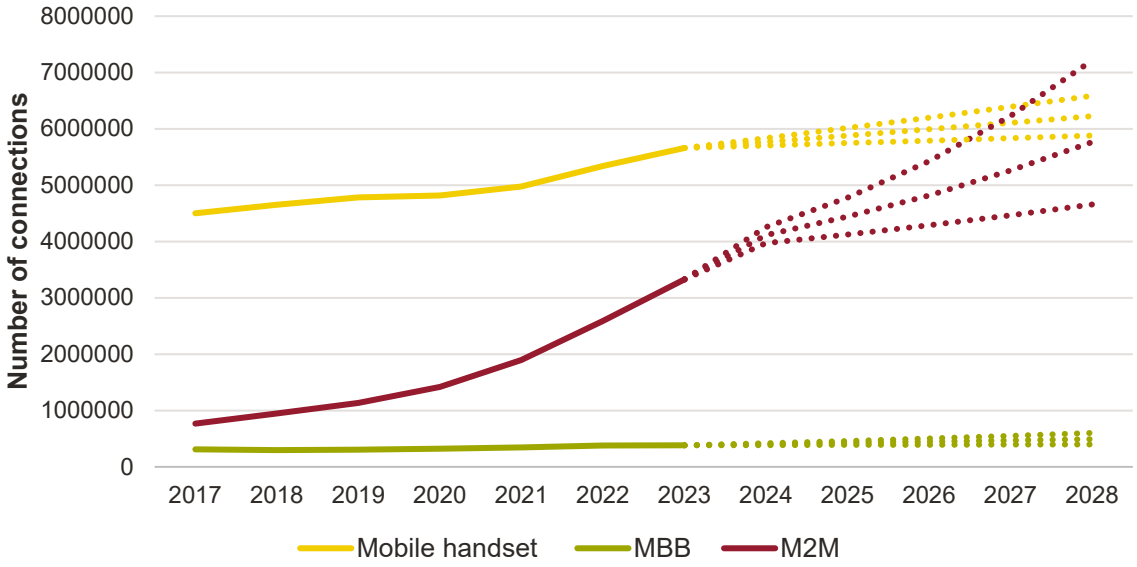


Source: Frontier Economics

A.2 Device connections

The forecasts for the total number of connections for mobile handsets and MBB devices are calculated by multiplying the forecasts for the respective device's penetration rate (see previous section) by the forecast for the population.

Figure 40 Number of connections forecast



Source: ComReg, CSO, Frontier Economics

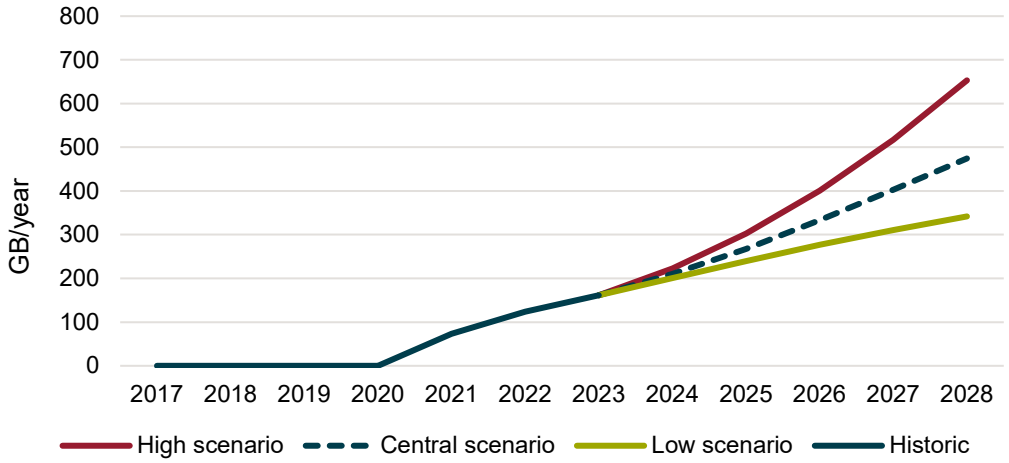
Figure 40 shows the forecast number of connections for all devices.

A.3 Mobile data usage per device

Mobile handsets

Figure 41 shows mobile data usage per connection for 5G mobile handsets.

Figure 41 Mobile data usage per connection – 5G mobile handsets

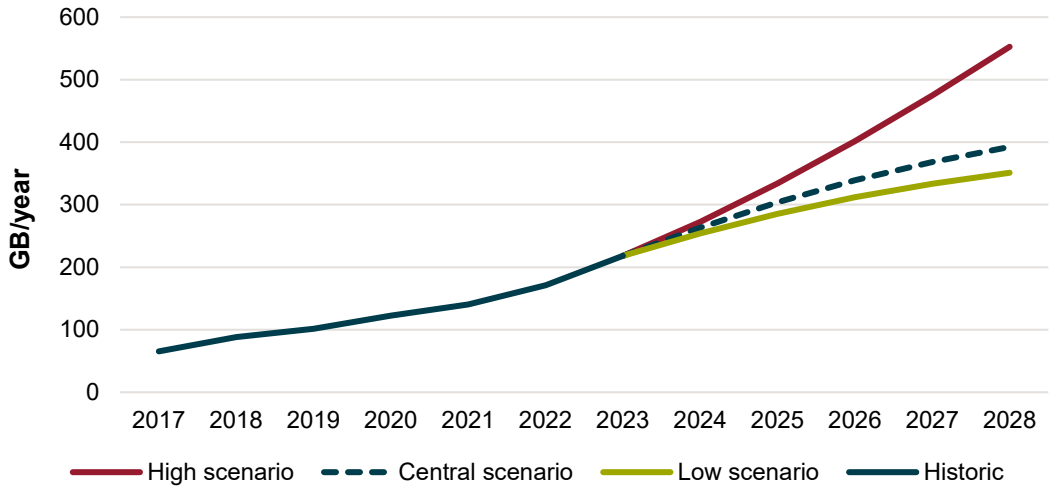


Source: Frontier Economics

Mobile data usage per 5G mobile handset connection is forecast to rise in all scenarios. In the high scenario, data usage increases at an increasing rate, assuming new use cases may emerge – it reaches over 650 GB per year by 2028. In the central scenario, mobile data usage increases at a declining growth rate from 30% to 18% reaching 470 GB per year. In the low scenario, data usage grows at a declining rate from 24% to 10% to reach almost 350 GB by 2028.

Figure 42 shows mobile data usage per connection for 4G mobile handsets.

Figure 42 Mobile data usage per connection – 4G mobile handsets

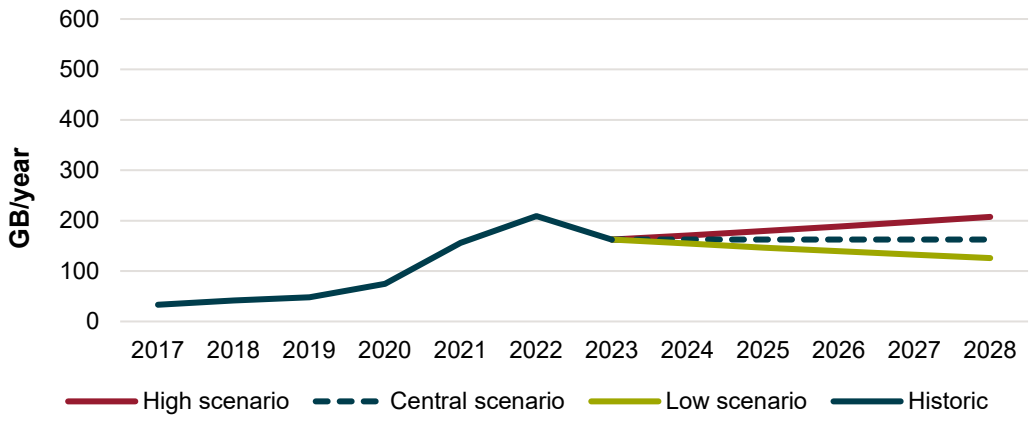


Source: Frontier Economics

Mobile data usage per 4G mobile handset connection is forecast to rise in all scenarios. Growth rates are declining over time in all scenarios. In the central scenario, 4G mobile data usage reaches approximately 400 GB per year per device with yearly growth rates declining from 21% to 7%. Similarly, in the high and low scenarios, mobile data usage is forecast to reach almost 560 GB and 350 GB respectively.

Figure 43 shows mobile data usage per connection for 3G mobile handsets.

Figure 43 Mobile data usage per connection – 3G mobile handsets

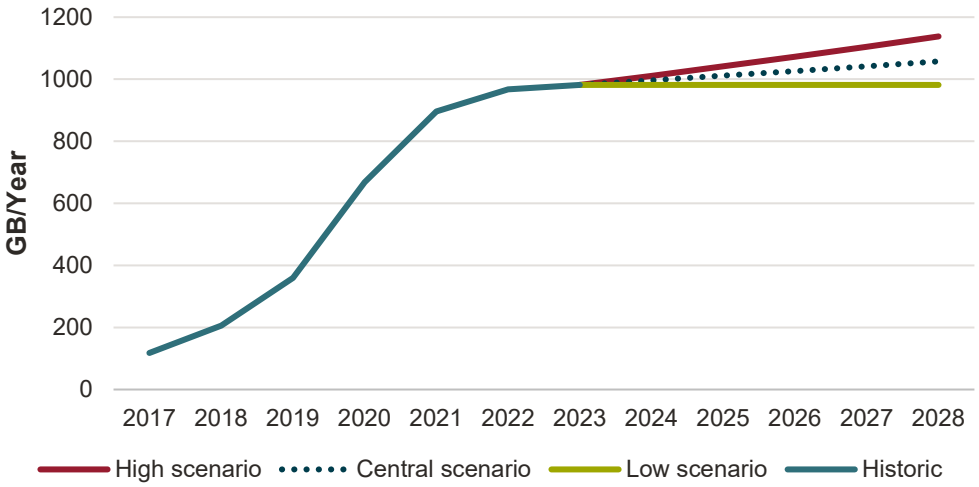


Source: Frontier Economics

Mobile data usage per 3G mobile handset is forecast to stay flat in the central scenario as a saturation point seems to have reached in 2022. In the low scenario, mobile data use per 3G mobile handset declines by 5% each year to reduce to 126 GB per connection by 2028 and in the high scenario, it increases by 5% each year to increase to 207 GB per connection in 2028.

MBB

Figure 44 Mobile data usage per connection - MBB

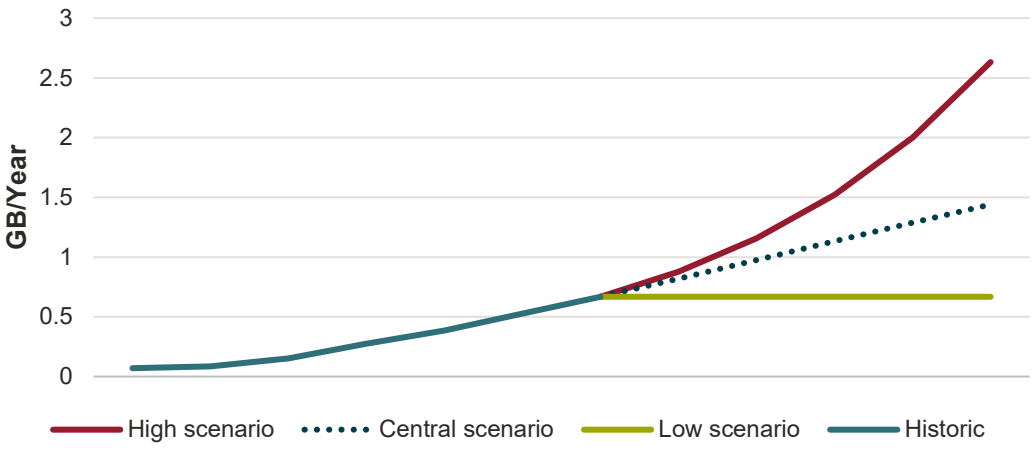


Source: Frontier Economics

Mobile data usage per MBB connection is forecast to rise slowly in the central scenario ~ 1% each year to reach 1,057 GB in 2028. As discussed in Sections 3.2.3 and 3.2.4, there are both upward and downward factors influencing MBB data usage. The high scenario assumes growth of 2% each year to reach 1,137 GB and the low scenario assumes no growth.

M2M

Figure 45 Mobile data usage per connection – M2M



Source: Frontier Economics

M2M devices currently use a very small amount of data. M2M data use per device is expected to increase at a declining rate in the central scenario to reach almost 1.5 GB per year – this scenario is assuming slow take-up of IoT use cases using 3G/4G/5G. The high scenario forecasts a fast growth rate of 32% each year (which is double the current growth rate) to reach 2.6 GB per connection and the low scenario forecasts M2M data usage to be flat.

A.4 Total mobile data traffic

Mobile handsets

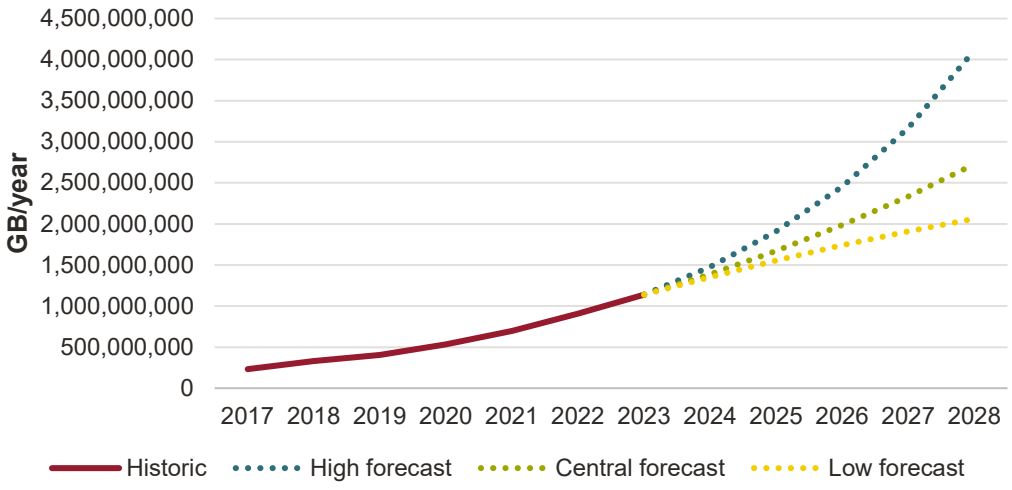
Mobile data traffic generated from mobile handsets is expected to reach 2.72B GB by 2028.

Table 4 Mobile handsets

Scenario	Total mobile data traffic 2023	Total mobile data traffic 2028
High		4.11B GB
Central	1.13B GB	**2.72B GB**
Low		2.06B GB

Source: Frontier Economics
Note: 2023 reflects the actual mobile data usage

Figure 46 Total mobile data traffic – mobile handsets



Source: Frontier Economics

MBB

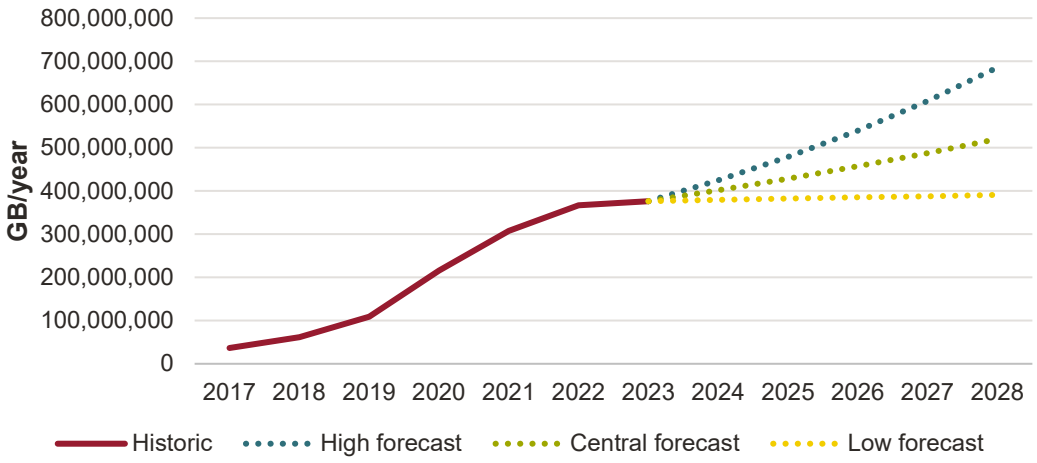
Mobile data traffic generated from MBB devices is expected to reach 477M GB by 2028.

Table 5 MBB

Scenario	Total mobile data traffic 2023	Total mobile data traffic 2028
High		685M GB
Central	350M GB	**520M GB**
Low		390M GB

Source: Frontier Economics
Note: 2023 reflects the actual mobile data usage

Figure 47 Total mobile data traffic – MBB



Source: Frontier Economics

M2M

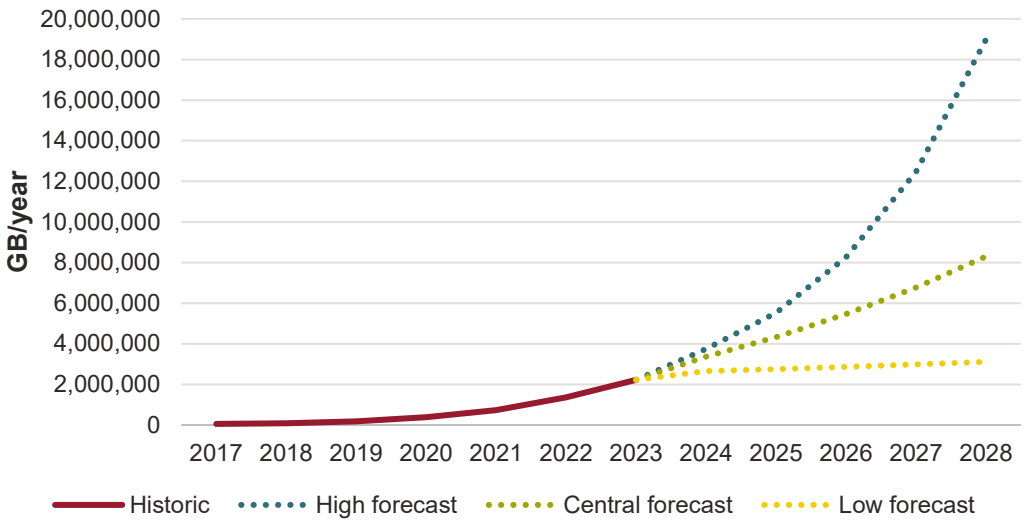
Mobile data traffic generated from M2M connections is expected to reach 8.2M GB by 2028.

Table 6 M2M

Scenario	Total mobile data traffic 2023	Total mobile data traffic 2028
High		18.9M GB
Central	2.2M GB	**8.2M GB**
Low		3.1M GB

Source: *Frontier Economics*
Note: *2023 reflects the actual mobile data usage*

Figure 48 Total mobile data traffic – M2M



Source: *Frontier Economics*

Annex B – Scenario assumptions used

This section sets out assumptions for scenario forecasting. The assumptions are informed by qualitative review of demand and supply drivers and past trends.

B.1 Scenario assumptions on device penetration

Table 7 sets out the assumptions on device penetration.

Table 7 Summary scenario assumptions

Input	Scenario	Assumption	Rationale
Mobile handset penetration	High	Grows at 2% each year	Mobile handset penetration grows at a faster rate that recent years.
	Central	Grows at 1% each year	Mobile handset penetration grows at the same rate as recent years (CAGR 2017 – 2023).
	Low	Stays flat	Penetration has reached a saturation level and does not grow further.
MBB device penetration	High	Grows at 8.6% each year	MBB penetration grows at a faster rate than recent years (CAGR 2019 – 2023).
	Central	Grows at 4.3% each year	MBB penetration grows at the same rate as recent years (CAGR 2019 – 2023).
	Low	Stays flat	Penetration has reached a saturation level and does not grow further.
M2M device connections	High	Grows at 23% each year after 2024	Connections grow at faster than (non-smart metering) “organic” growth with 500,000 additional connections due to smart metering in 2024.
	Central	Grows at 15% each year after 2024	Connections grow at the same rate as recent years for (non-smart metering) “organic” growth with 500,000 additional connections due to smart metering in 2024.
	Low	Grows at 8% each year after 2024	Connections grow at a slower rate as recent years for (non-smart metering) “organic” growth with 500,000 additional connections due to smart metering.

Source: Frontier Economics

B.2 Scenario assumptions on data use per device

Table 8 sets out the assumptions used on data use.

Table 8 Summary scenario assumptions

Input	Scenario	Assumption	Rationale
Mobile data use per mobile handset (5G)	High	Grows at a declining rate (38% to 26%)	Fast growth due to emerging use cases for 5G and supply side factors.
	Central	Grows at declining rate (30% to 18%)	Faster growth initially due to take-up of 5G and then slowing down towards the end of the forecast period.
	Low	Grows at a declining rate (24% to 10%)	Faster growth initially due to take-up of 5G and then slowing down towards the end of the forecast period (slower than central scenario)
Mobile data use per mobile handset (4G)	High	Grows at a declining rate (25% to 16%)	Growth at declining rate with staring point corresponding to current growth rate (previous year CAGR of 27%). Faster decline in low scenario and slower in high scenario.
	Central	Grows at a declining rate (21% to 7%)	
	Low	Grows at a declining rate (18% to 6%)	
Mobile data use per mobile handset (3G)	High	Grows at 5% each year	Slow growth due to additional time spent on mobile handsets.
	Central	Stays flat	No further growth in 3G due to limited use cases.
	Low	Declines by 5% each year	Remaining 3G handsets used by digital refuseniks with lower demand for data
Mobile data use per MBB device	High	Grows at 2% each year	Faster than recent growth (CAGR 2021-2023) due to increased at home and travel use.
	Central	Grows at 1% each year	Slow growth as per recent growth (CAGR 2021-2023).
	Low	Stays flat	No additional use cases.
	High	Grows at 32% each year	Fast growth due to emerging IoT use cases.

Input	Scenario	Assumption	Rationale
Mobile data use per M2M connection	Central	Grows at a declining rate (22% to 12%)	Declining growth due to slow take-up of IoT use cases.
	Low	Stays flat	No growth.

Source: Frontier Economics

frontier economics