Broadband in Norway 2015

October 22th 2015
Summary

This report describes the development in access to and use of fixed and mobile broadband in Norway.

Chapter 2 provides a comparison of the development in access to fixed broadband and the development in the number of subscriptions. Access to broadband is estimated based on annual coverage reports Nexia has prepared on assignment from Nkom or the Ministry responsible for broadband policy. At the end of the first half of 2015, more than 1.96 million households have access to high-speed broadband over fibre, cable TV networks or VDSL. At the same point, there were about 1.34 million residential subscriptions for high-speed broadband. This constitutes more than 68 per cent of those who have access. Nearly 974,000 households have access to broadband over fibre as at the end of the first half of 2015. This is nearly 109,000 more households than at the end of the first half of 2014. At the end of the first half of 2015, more than 587,000 residential subscriptions were based on fibre. This represents about 60 per cent of those who have access.

Chapter 3 describes the coverage estimates that Nkom have prepared for mobile networks based on 3G and 4G. The estimates are based on data for all base stations in Norway as at the end of the first half of 2015. The estimates include access to mobile data outdoors. The estimates do not include coverage for voice calls in the mobile networks. A distinction is made between population coverage and area coverage. At the end of the first half of 2015, estimates for the country as a whole shows a population coverage of 95 per cent for 4G and 99 per cent for 3G and 4G combined. At the same point in time, area coverage is 49 per cent for 4G and 61 per cent for 3G and 4G combined.

The highest population coverage for mobile data based on 4G is in Oslo and the counties surrounding the Oslo fjord. Sogn og Fjordane and the three northernmost counties have the lowest population coverage for 4G. The area coverage based on 4G shows considerable range from the highest to the lowest coverage. In Oslo, Akershus, Vestfold and Østfold, the area coverage is between 99 and 94 per cent. The three northernmost counties and Sogn og Fjordane have the lowest coverage, with 42 per cent coverage in Nordland, 38 per cent in Sogn og Fjordane, 37 per cent in Troms and 9 per cent in Finnmark.

The individual mobile operators have overlapping coverage to a greater or lesser degree in different parts of the country. When looking at 3G and 4G coverage combined, population coverage for the country as a whole is 98 per cent, while area coverage is 61 per cent. Seventy-six per cent of the population has simultaneous coverage from three network operators, while only four per cent has coverage from only one operator. For the country as a
whole, 14 per cent of the area is covered by three mobile networks, while 25 per cent of the area is covered by only one network. There are great variations from county to county.

Chapter 4 and appendix 1 describe the marketed speeds for each of the fixed access technologies. A distinction is drawn between the marketed speed for downloads and for uploads. There is a large increase in the number of fixed broadband subscriptions with speeds of 30 Mbit/s or above. At the end of the first half of 2015, there are about 722,000 residential broadband subscriptions that have a marketed downstream speed of 30 Mbit/s or more. This is nearly 39 per cent of all residential broadband subscriptions. The corresponding figure at the end of 2014 was 34 per cent. Nearly 69 per cent of residential subscriptions based on fibre have a marketed downstream speed of 30 Mbit/s or more as at the end of the first half of 2015. The corresponding figure for broadband over cable TV networks is nearly 40 per cent.

Nkom has analysed speed measurements that broadband subscribers have made in the Nettfart.no portal. This too is described in chapter 4. The analysis is based on measurements from September 2011 and up to and including September 2015.

There has been a significant increase in measured speeds based on fixed broadband over the past four years. In the last part of 2011, the measurements for download speeds averaged just over 12 Mbit/s. In 2015, the measurements are generally above 22 Mbit/s when we look at broadband based on xDSL, cable TV networks and fibre combined. Appendix 2 describes average measured speeds in each county. Average measured speeds in the mobile networks are also increasing significantly. In the last part of 2011, measured download speeds averaged just over 6 Mbit/s. In 2015, the corresponding average is about 14 Mbit/s.

Nkom has also analysed measured speeds against the marketed speed for each broadband product. Nearly 19 per cent of the measurements based on xDSL provide at least 100 per cent of the marketed speed. The corresponding figures for broadband based on fibre and cable TV networks are 25 per cent and 37 per cent, respectively.

Nettfart.no also measures response times. There is a considerable range in the average response time between the different access technologies. Broadband based on fibre and cable TV networks have the lowest response times, with averages of 17 ms and 18 ms, respectively. The average response time for xDSL is 47 ms. Measured response times in mobile networks are generally higher than for cable-based broadband. The average response time in mobile networks is 48 ms.
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1 Introduction

This report describes access to and the use of broadband in Norway with a main emphasis on households and individuals. Access to fixed broadband covers the access technologies that households can connect to. Further, it covers access to mobile data, or in other words the option of sending and receiving data over mobile networks. Mobile networks have different characteristics than fixed broadband and are therefore discussed separately. The report presents estimates of the number of people who have access to mobile data where they live and the range of geographic areas where such access is possible. These are referred to as population coverage and area coverage, respectively.

Broadband use includes the access technologies that the households actually subscribe to, and the speed included in the subscription. A distinction is made between the speeds providers list in their product descriptions for fixed broadband and the speed that broadband subscribers can measure on the "Nettfart.no" portal. Measurements of the speeds the customers experience are also presented for mobile data.

The business market is more complex and complicated, and in many areas very different from the residential market. The business market is only included in this report to a limited extent.

The use of digital information and communication technology has a great impact on all parts of society. The technology and the associated digital services affect sectors as well as processes and structures in society. Digitalisation is significant to the productivity of the Norwegian economy, the competitiveness of the business sector, the quality of services in public administration, and the welfare and everyday life of individuals. The use of digital services therefore require a basic infrastructure that is open, stable and robust. The Internet is the global carrier of digital services, while in its turn broadband connects the business sector, public administration and individuals to the Internet. The business sector, public administration and individuals must therefore have access to a well-functioning broadband and secure communication services.

Broadband providers mainly build their offerings based on market and business conditions. The electronic communication report for 2014\(^1\) shows that the operators invested a combined total of more than NOK 7.8 billion in tangible fixed assets in 2014. The corresponding figure for the previous year was nearly NOK 7.6 billion. The investments include fixed networks and mobile networks.

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\(^1\) Norwegian Communications Authority: "The Norwegian Electronic Communications Services Market 2014"
The Government places great emphasis on the development of effective infrastructure as a basis for the competitiveness of the business sector. This also applies to infrastructure for electronic communication. Nkom administers a grant programme for the construction of broadband networks. The scheme is financed over the national budget, and is an instrument to help ensure that all households are offered broadband where no broadband provision is expected to be offered in the next few years. In 2015, NOK 110 million was allocated to the scheme. The corresponding figure for 2014 was NOK 160 million.

Nkom shall generally contribute to society being as well informed as possible about the developments in the electronic communications markets, including the broadband market. This report collates information to this end.

Twice a year, Nkom presents statistics that show key developments in the markets for electronic communication services. The reports are based on figures obtained from all providers of electronic communications services. One report covers statistics for the past full year, while the other report covers the the first half of the year. The statistics in both the full year and half year reports include fixed telephony (including broadband telephony), mobile telephony, broadband and transmission of TV signals. The full-year report also includes data transmission services and transmission capacity (leased lines). The statistics mainly cover subscriptions and revenues, and traffic where relevant, in addition to the market shares for the largest providers.

Rapid changes are taking place in electronic communication technology and the access households have to this technology. This also applies to the households' usage of new technological solutions, services and functions. Important developments in recent years include:

- Broadband based on cable TV networks and fibre are each as prevalent as broadband based on xDSL. At the same time, every year the available broadband speeds increase.
- Broadband lines are increasingly used for TV distribution and streaming services for sound and video.
- Apple launched its iPhone in 2007, and this mobile phone was introduced in Norway in 2008. It had an operating system, a web browser and a user interface that represented a new and easier way to connect a mobile phone to the Internet. Shortly thereafter, other providers\(^2\) introduced smartphones with equivalent functionalities.
- Mobile operators change their price plans and let the volume of included data govern subscription prices.

\(^2\) Today, Apple and Samsung have the largest market shares worldwide for smartphones.
• Mobile customers use smartphones and tablets seamlessly between mobile networks on the one hand and wifi zones connected to fixed broadband on the other hand. Data traffic over mobile networks grows significantly each year.
• Virtual interaction becomes more widespread. In many areas, digital processes and digital services reign more or less supreme.
• Electronic communication services and digital processes and services become an integrated part of our everyday lives.

On assignment from Nkom, the consultancy firm Nexia has collected and published figures for access to broadband in 2015. In previous years too, Nexia has carried out this task on behalf of the ministry responsible for the Government's broadband policy\(^3\). In Chapter 2, we use these coverage reports as a starting point and look at them in the context of the number of subscriptions by access technology and thereby measure the development in the take-up rate for broadband. Significant investments form the basis for the broadband roll-out, and a high take-up rate may mean that the investments become more profitable. Chapter 3 describes access to mobile data, while Chapter 4 describes broadband speeds. The report distinguishes between marketed broadband speeds and measured speeds as measured by broadband subscribers on the "Nettfart.no" portal.

\(^3\) Up until 2013, this was the Ministry of Government Administration and Reform (FAD). As of 2014, the Ministry of Transport and Communications (SD) has this task.
2 Access to and subscriptions for fixed broadband

2.1 Introduction
Among other things, the annual coverage reports show access to fixed broadband in Norwegian households. Address data is obtained from the providers that offer broadband via their own infrastructure. This is data that shows the number of households that can use fixed broadband on a commercial basis. Further, the access technology that the household uses and the speeds that are achievable on the available broadband is also shown. The information from the providers is connected to corresponding address data from the land register. The information is coded in digital maps and thus provides detailed information about broadband coverage.

In this report, our starting point is the coverage data for broadband based on xDSL, cable TV networks and fibre for the period from the first half of 2012 to the first half of 2015. In this period, the coverage reports are based on figures collected as at the end of every half year. Nkom has estimated the figures at the end of every year of the period as the mean value of the figures for every half year.

Nkom collects figures for the number of broadband subscriptions from the same providers as at the end of the first half of the year and as at the end of each year. By looking at broadband access in the context of the number of subscriptions, we get a picture of the utilisation of each of the broadband technologies. In this report, we refer to this as the take-up rate for broadband.

Significant investments form the basis for the roll-out of broadband. The roll-out of broadband is mainly market-based and commercial. For broadband providers, it is important that the investments are profitable, including by connecting a subscription to as many broadband accesses as possible. In principle, each provider wants the highest possible take-up rate. However, in many cases households have access to more than one access technology, and these are often from different providers. This gives the household greater choice and can lead to more competition. On the other hand, accesses will remain unused in these cases.

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4 The coverage reports give coverage data as percentages. Nkom has recalculated this to absolute figures with a starting point in Statistics Norway’s overview of the number of households. Page 10 of the report “Broadband coverage 2015” describes how broadband access is measured.

5 The greatest source of errors is missing information about whether someone is actually living in the buildings registered in the land register. See pages 9 and 10 of the “Broadband coverage 2015” report for information about the relationship between residences and households.

6 The 2015 survey is based on data from 128 broadband providers.
2.2 Access to and subscriptions for cable-based networks combined

Figure 1 shows access to and subscriptions for fixed broadband for all cable-based access technologies combined. This includes broadband based on xDSL, cable TV networks and fibre. Some households will have access to multiple access technologies, while others will only have access to one of these. The figure shows the number of households that have access to at least one of the technologies. There are more than 2.280 million households that as at the end of the first half of 2015 have access to one or more cable-based access technologies. This amounts to 95.3 per cent of all households in Norway. At the same time, more than 1.832 million households have subscriptions for the above-mentioned cable-based access technologies. This gives a take-up rate of about 80.3 per cent of the households that have access to cable-based broadband networks. This rate has increased slightly over the years covered by figure 1. For example, at the end of the first half of 2012 the take-up rate was 77.3 per cent.

In practice, broadband based on xDSL constitutes the vast majority of the access in figure 1, while at the same time the number of subscriptions based on xDSL is declining. However, there are growing numbers of subscriptions based on fibre and cable TV networks.

Figure 1 Access to and subscriptions for fixed broadband. All cable-based broadband accesses. Residential customers

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7 This is discussed in depth in section 2.4.
Figure 2 Coverage map for Norwegian municipalities showing access to high-speed broadband as at the first half of 2015
2.3 Access to and subscriptions for high-speed broadband

2.3.1 Access to and subscriptions for high-speed broadband combined
High-speed broadband\(^8\) is used in this report as an umbrella term for broadband based on VDSL, cable TV networks and fibre. For cable TV networks, it is a requirement that the accesses have been upgraded to the DOCSIS 3.0 standard or higher\(^9\). In other words, high-speed broadband is accesses where the customers can be offered downloading speeds that at minimum correspond to 30 Mbit/s.

Figure 3 shows that there is strong growth in the number of subscriptions for high-speed broadband. By the end of the first half of 2015, there were over 1.3 million such subscriptions in the residential market. This constitutes more than 71 per cent of the total number of subscriptions for fixed broadband. By comparison, at the end of 2011 this share was about 53 per cent.

Broadband based on VDSL represents a relatively small share of the total number of subscriptions for high-speed broadband. At the end of the first half of 2015, nearly 132,000 residential subscriptions were based on VDSL. This is 28,000 more than at the end of 2014. Broadband based on cable TV networks constitute the largest share. At the end of the first half of 2015, just over 620,000 subscriptions were based on cable TV networks. This is an increase of about 11,000 subscriptions since the end of 2014. Subscriptions based on cable TV networks constitute about 46 per cent of the number of subscriptions for high-speed broadband at the end of the first half of 2015. Broadband based on fibre is growing the most. At the end of the first half of 2015, nearly 587,000 subscriptions were based on fibre. This is an increase of more than 38,000 since the end of 2014. At the end of the first half of 2015, subscriptions based on fibre constitute nearly 44 per cent of the total number of subscriptions for high-speed broadband.

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\(^8\) High-speed broadband is often referred to as Next Generation Access (NGA).

\(^9\) In this report, we presume that all subscriptions for broadband based on cable TV networks are at this level.
Figure 3 Number of subscriptions for high-speed broadband. Residential subscriptions

Figure 4 shows access to and subscriptions for high-speed broadband$^{10}$. Some 1.96 million households have access to high-speed broadband at the end of the first half of 2015. This represents 82 per cent of all households. This is an increase of more than 66,000 compared with the end of 2014. Nearly 1.34 million households subscribed to high-speed broadband at the end of the first half of 2015. This is an increase of nearly 78,000 subscriptions compared with the end of 2014.

The number of subscriptions for high-speed broadband represented nearly 68 per cent of total access to high-speed broadband at the end of the first half of 2015. By comparison, this take-up rate was just over 66.5 at the end of 2014.

$^{10}$ No figures have been collected for high-speed broadband overall in the period prior to the first half of 2013.
2.3.2 Access to and subscriptions for broadband over fibre

Figure 5 shows the access to and subscriptions for fixed broadband based on fibre. At the end of the first half of 2015, nearly 974,000 households had access to fibre. This amounts to nearly 41 per cent of all households in Norway. In the period from the end of the first half of 2014 to the end of the first half of 2015, there was an increase of nearly 108,000 in the number of households with access to fibre. At the end of the first half of 2015, some 587,000 households subscribed to fibre. This is a take-up rate of around 60 per cent. The take-up rate has increased over time. For example, at the end of the first half of 2012 the take-up rate was about 55 per cent.
Figure 5 Access to and subscriptions for broadband based on fibre Residential customers

2.3.3 Access to and subscriptions for broadband over cable TV networks

Figure 6 shows access to and subscriptions for fixed broadband based on cable TV networks\(^{11}\). There are more than 1.2 million households that as of the end of the first half of 2015 have access to broadband based on cable TV networks. This amounts to nearly 51 per cent of all households in Norway. At the same time, 620,000 households have broadband subscriptions based on cable TV networks. This represents a take-up rate of just over 51 per cent. This share has been relatively stable in the past three years.

\(^{11}\) It is assumed that cable TV networks have been upgraded to DOCSIS 3.0 or higher.
2.4 Access to and subscriptions for broadband over xDSL

Figure 7 shows access to and subscriptions for fixed broadband based on xDSL. As of the end of the first half of 2015, there are about 2.14 million households that have access to broadband based on xDSL. This amounts to 89.5 per cent of all households in Norway. In the past year, the number of households with access to xDSL has declined slightly. At the end of the first half of 2015, there are about 625,000 households with broadband subscriptions based on xDSL. The number of subscriptions based on xDSL is declining rapidly, and the take-up rate is falling.
3 Access to mobile data

3.1 Introduction

Nkom has collected information about base stations from mobile operators with their own mobile networks. Data was collected as at 30 June 2015. The network operators on this date were Telenor, TeliaSonera and ICE Norge. Other providers of mobile communication services enter agreements with one of these net operators regarding the use of the operator’s mobile network. Nkom also collected the same information as at 30 June 2014. At that time, the operators were Telenor, TeliaSonera, Mobile Norway\(^\text{12}\) and ICE Norge. The information is in regard to base stations in commercial use at the relevant date and covers 3G and 4G networks. The information includes all relevant frequencies, or in other words 450 MHz, 800\(^\text{13}\) MHz, 900 MHz, 1800 MHz, 2100 MHz and 2600 MHz.

The estimates are based on information that includes the geographic location of the base stations as well as technical data about the antenna systems for each base station. The information forms the basis for a theoretical calculation of access to mobile data in the operators' mobile networks at the relevant date.

The 2014 electronic communications report\(^\text{14}\) shows that in 2014, mobile operators invested more than NOK 2.5 billion in mobile networks. This comprises investments in tangible fixed assets. Investments in frequency resources are additional. The corresponding figures for 2012 and 2013 were NOK 2.4 and 2.6 billion, respectively. Mobile operators invest in networks and other infrastructure on a commercial basis. This applies to both the choice of technical solutions and the geographic placement of base stations, as well as the scope of and schedule for network roll-outs. The investments include upgrades of existing base stations, construction of new base stations and expansion of the capacity in networks that lead traffic to and from the base stations. Significant additional investments are also made in frequency resources. In connection with auctions of frequency resources in 2013\(^\text{15}\), payments of nearly NOK 1.8 billion were made for access to frequencies. In 2012 and 2014, only smaller amounts were paid in frequency auctions. Additionally, mobile operators must pay annual charges and fees for their frequencies.

Though as a starting point the building of mobile networks is carried out on a commercial basis, the electronic communications authority has in some instances imposed requirements.

\(^\text{12}\) Mobile Norway built a mobile network for Tele2 and Network Norway and operated the network. In the first half of 2015, parts of this network were taken over by ICE Norge.
\(^\text{13}\) 800 MHz is often referred to as the Digital Divide frequency because it became available after the digitalisation of the analogue ground network for transmission.
\(^\text{14}\) Nkom: "The Norwegian Electronic Communications Services Market 2014"
\(^\text{15}\) This covers the 800 MHz frequencies, among other things. See footnote 13.
when allocating frequency resources. The requirements normally mean that the mobile
operator in question must build the network in accordance with a plan that provides a specific
share of the population with mobile coverage at a specific date. Such a requirement was last
imposed in the allocation of frequencies in the 800 MHz band: for instance, as the winner of
the "coverage block", TeliaSonera was required to meet a coverage rate of 98 per cent of the
population by the end of 2018. The coverage requirement applies outdoors.

Table 1 shows the results of the estimates for the entire country. A distinction is made between
population coverage and area coverage, and the estimates are for outdoor coverage. Chapters
3.4 to 3.6 provide a more detailed description of coverage, including the distribution for each
county. The rollout of 4G networks has been the most in focus in recent years. This network
covered 95 per cent of the population and 49 per cent of the area as at the first half of 2015.
By comparison, at the same time in 2014, coverage was at 83 and 24 per cent, respectively. If
the 3G network is included, coverage is higher. Ninety-nine per cent of the population has
coverage based on the 3G or 4G network, both as at the first half of 2015, while area coverage
is 61 per cent.

Table 1 Population and area coverage for the entire country

<table>
<thead>
<tr>
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<th>1st half 2014</th>
<th>1st half 2015</th>
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<tbody>
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<td>Population coverage</td>
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<td>3G</td>
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<td>24 %</td>
<td>49 %</td>
</tr>
<tr>
<td>3G + 4G</td>
<td></td>
<td>61 %</td>
</tr>
</tbody>
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3.2 Interpretation of the estimates

This report includes all data communication in mobile networks, but not telephony. 2G
networks use GPRS and EDGE technology for data transmission, but these have low speeds
and cannot be considered broadband. We therefore do not include 2G networks in this report.

We distinguish between 3G and 4G technologies. The 3G networks (or UMTS\(^{16}\)) handle both
voice and data. The 4G networks (or LTE\(^{17}\)) have thus far been based on data traffic, but some
4G networks will now also include voice traffic. 4G networks handle data traffic at higher

\(^{16}\) UMTS = Universal Mobile Telecommunications System. HSPA (high-speed Packet Access) and HSPA+ are
versions of UMTS.
\(^{17}\) LTE = Long Term Evolution.
speeds than 3G. Telenor and TeliaSonera have both 3G and 4G technology in their networks. Mobile Norway only had 3G technology in its network, but after ICE Norge took over this network, it will be developed with 4G technology that allows both data traffic and voice to be offered. ICE Norge previously only used CDMA2000 technology\(^{18}\), which is normally defined as 3G technology. This network is fully operational as at the first half of 2015, but will in time be discontinued.

Access to mobile data is affected by many factors. The starting point is the electromagnetic field strength at a specific geographic location that enables the mobile customer's terminal to access a mobile network. Field strength depends on the distance from the base station and how electromagnetic waves are dampened on the way from the base station to the mobile customer's terminal. The damping depends on, among other things, the frequency band used, distance from the base station, the topography and structure of the terrain and the height and general design of buildings. These factors are included in the estimation model used.

Even though the field strength is sufficient to receive a signal, the customer is nevertheless not guaranteed to be able to send and receive data. Mobile communication is a shared resource, and the opportunity to send and receive data is therefore affected by the number of simultaneous users in the base station's area of coverage and the traffic volume the individual mobile customer is using. The capacity of the base station affects the number of simultaneous users that can send and receive data. An analysis that takes this into account will require more detailed information about the traffic in the mobile network being used. This is not analysed in this report.

The estimations in this report are based on a number of assumptions and thus show a theoretical access to mobile data. In other words, it is difficult to predict how communication services based on mobile networks will work in any given place. The actual signal strength can differ from the estimated signal strength. The difference can go both ways. Furthermore, signal strength is from the outset stronger outdoor than indoor, unless equipment is used to strengthen the indoor signal. Signal attenuation in buildings varies significantly with the design and building materials used. The characteristics of the mobile phone antennae and the frequency used also impact the relationship between the outdoor and indoor signal strength. In this report, Nkom has chosen to estimate coverage that gives access to mobile data outdoor.

This report distinguishes between population coverage and area coverage. Population coverage shows the number of people who have access to mobile data based on 3G or 4G networks outdoors at the address. Area coverage is the geographic area where one has access to mobile data. The results from the estimation of the population and area coverages

are described in sections 3.4 and 3.5 and provide a snapshot of coverage at the end of the first half of 2015.

In the course of 2014 and 2015, there has been a rapid development of base stations using the 800 MHz band. This has led to significant changes in coverage and capacity. There are grounds to believe that this development will continue at a substantial scale. Therefore, new estimates of population and area coverage at later dates will show higher coverage compared to the first half of 2015.

The mobile operators estimate and publish information about the coverage for their respective mobile networks. Other companies\(^{19}\) can also estimate and publish this type of information. The estimates are based on assumptions that may vary. Further, the operators' networks will not completely overlap, which is significant when the coverage estimates include multiple mobile networks. This means that estimates other than those described in this report may show other percentages for coverage.

### 3.3 Assumptions for the estimates

In the estimates, all base stations and the associated sectors are grouped according to frequency band and technology. Sectors of base stations that use 2G technology have been filtered out. The results of the estimates in this report may therefore lead to lower outdoor coverages than the mobile operators may list. The coverage estimates are based on the sum of electromagnetic field strength from each base station and per frequency band.

The estimates use digital maps of Norway with a resolution of 100 m x 100 m. Each square of 100 x 100 metres specifies topography, buildings and population. The estimates of access to mobile data uses Norway's international border in the east and the baseline\(^{20}\) to the seas in the south, west and north. See figure 8. The sea areas inside the baseline are included, as these have mobile traffic from leisure boats, coastal fishing and transport of goods and persons.

\(^{19}\) See for example the report "Broadband coverage 2015" that Nexia has prepared on assignment from Nkom.

\(^{20}\) "Norwegian Baseline" is the concept the Norwegian Mapping Authority uses and it includes straight lines drawn between points on the outermost headlands and reefs that are above sea level at low tide. Norway has an area of nearly 413,000 km\(^2\) with the baseline as the starting point. By comparison, Norway's land area (mainland Norway) is nearly 324,000 km\(^2\), while what is designated as the Kingdom of Norway covers just over 385,000 km\(^2\).
Several frequencies are used for data transmission in mobile networks. There is a connection between frequency and range. Low frequencies have greater ranges and cover a larger area and are therefore referred to as "coverage frequencies". The typical coverage frequencies being used in current Norwegian mobile networks are 450 MHz, 800 MHz and 900 MHz. High frequencies cover a smaller area but provide better capacity and are therefore referred to as "capacity frequencies". 1800 MHz, 2100 MHz and 2600 MHz are typical capacity frequencies in Norwegian mobile networks.

The estimates assume an effect of $-104 \text{ dBm}^{21}$ for 3G networks and $-114 \text{ dBm}$ for 4G networks. This is the effect transmitted to the mobile customer's terminal as a minimum needed to send and receive data. The effect of $-104 \text{ dBm} -114 \text{ dBm}$ is recalculated as field strength for each frequency band.

21 dBm is a dimensionless measuring unit that describes the logarithmic relationship between the measured effect and 1 milliwatt.
3.4 Population coverage

Figure 9 shows the estimate of the share of the population with access to mobile data based on 3G at the end of the first half of 2015. Ninety-eight per cent of the entire population have access to mobile data based on 3G. Seven counties have coverage of 99-100 per cent. Four counties have coverage of 93-94 per cent.

ICE Norge uses CDMA technology based on frequencies in the 450 MHz band. Special modems are used to send and receive data in this network. Smartphones therefore cannot be used. It is therefore appropriate to estimate mobile coverage for 3G without this technology. This is shown in figure 9. For the entire country combined, this results in only a small reduction in population coverage. However, for the counties from Nord-Trøndelag and northwards, there is a slight difference, though not a significant one.

Figure 10 shows the estimate of the share of the population that has access to mobile data based on 4G at the end of the first half of 2015. The estimates have been compared to the corresponding estimate based on data from the first half of 2014. At the end of the first half of 2015, 95 per cent of the national population had access to mobile data based on 4G. At the end of the first half of 2014, this share was 83 per cent. In contrast to mobile data based on 3G, there are relatively large variations between the counties. Five counties had a coverage of 99-100 per cent at the end of the first half of 2015. On the other hand, the three northernmost counties and Sogn og Fjordane had population coverages for 4G of 92-93 per cent.

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22 Decimal points are not used in the presentation of the coverage estimates in the figures. In practice, 100 per cent coverage means that coverage is 99.5 per cent or higher.

23 With one decimal point, population coverage is at 97.9 per cent with CDMA technology included and 97.6 per cent without this technology.
Figure 9 Estimated share of the population with access to mobile data based on 3G, by county as at the end of the first half of 2015. Outdoor coverage
Figure 10 Estimated share of the population with access to mobile data based on 4G, by county. Outdoor coverage.
3.5 Area coverage

The trend among mobile customers is increasingly that they want access to mobile data where they are at any given time. Mobility is becoming a more important factor in the market, and mobile operators are therefore placing greater emphasis on being able to offer access wherever the mobile customers are. Estimates of area coverage have consequently become more important.

Area coverage is the geographic area where one has access to mobile data. Figure 11 shows the share of the area that has access to mobile data based on 3G at the end of the first half of 2015. For Norway as a whole, the area coverage is 53 per cent when all operators are included. Area coverage is highest in Oslo, Østfold and Vestfold, at 93-94 per cent. The three northernmost counties have the lowest area coverage. In Finnmark, area coverage is at 29 per cent.

Area coverage for the country as a whole is reduced from 53 per cent to 49 per cent when CDMA technology is not included in the area estimate. There is great variation from county to county. Area coverage is reduced the most in Finnmark when CDMA is not included. Here, area coverage is reduced from 29 to 21 per cent. Other counties also have significant reduction.

Figure 12 shows the estimated share of the area with access to mobile data based on 4G at the end of the first half of 2015. Area coverage at this point in time is compared with the equivalent at the end of the first half of 2014. For the country as a whole, area coverage increased from 24 per cent at the end of the first half of 2014 to 49 per cent at the end of the first half of 2015. However, there is great variation between the counties. The share is greatest in Oslo, Akershus, Vestfold and Østfold, which all had area coverages above 90 per cent. Area coverage is lowest in Sogn og Fjordane and the three northernmost counties. In Finnmark, area coverage was at 9 per cent at the end of the first half of 2015. Some counties have seen a significant increase in area coverage from the end of the first half of 2014 until the end of the first half of 2015. For example, area coverage in Nord-Trøndelag grew from 13 per cent to 62 per cent.

Assumptions about the area are described in section 3.3.
Figure 11 Estimated share of the area of each county with access to mobile data based on 3G as at the end of the first half of 2015. Outdoor coverage.
Figure 12 Estimated area with access to mobile data based on 4G, by county. Outdoor coverage
3.6 Coverage based on one or more mobile networks

A geographic location can have access to mobile data from several technologies and one or more networks. There is significant overlap between the different operators' technologies and mobile networks. However, there may nevertheless be some places where only one technology (or only one mobile network) is available. The degree of overlap may be significant to the competition between the mobile operators. Whether an area is covered by one or more mobile networks can also be significant to vulnerability.

Figure 13 shows the share of the population in each county that has coverage from one, two or three mobile networks. It assumes that the population has coverage by 3G or 4G networks or both simultaneously. For the country as a whole, population coverage is 98 per cent for 3G and 4G combined as at the end of the first half of 2015. Seventy-six per cent of the population is covered by three mobile networks, while only 4 per cent of the population is covered by one mobile network. There is great variation between the counties. In Oslo, 98 per cent of the population is covered by three mobile networks. In contrast, in Sogn og Fjordane only 25 per cent is covered by three networks. Sogn og Fjordane is also the county with the largest share of the population that is only covered by one network. The three northernmost counties also have relatively many people who are only covered by one network.

Figure 14 shows the share of the area of each county that is covered by one, two or three mobile networks when we look at 3G and 4G combined. For the country as a whole, the combined area coverage was 61 per cent as at the end of the first half of 2015, and only 14 per cent of the area was covered by three operators. Twenty-five per cent was covered by one operator, while 22 per cent was covered by two operators. There is great variation between the counties. In Oslo, 69 per cent of the area is covered by three operators, while 14 per cent is covered by one operator. On the other hand, Troms and Finnmark have a combined area coverage of 48 and 31 per cent, respectively. In Troms, 26 per cent of the area is covered by only one operator. The corresponding share in Finnmark is 20 per cent. In some other counties too, large areas are only covered by one operator. In Sør-Trøndelag, 33 per cent of the area is covered by one operator. In Hedmark and Nordland, this share was 31 per cent and 30 per cent, respectively.
Figure 13 Population coverage for one, two or three mobile operators as at the first half of 2015. 3G and 4G combined.
Figure 14 Area coverage for one, two or three mobile operators as at the first half of 2015. 3G and 4G combined
4 Broadband speeds

4.1 Introduction

Nkom collects data on broadband speeds from providers of fixed broadband. It is the marketed speed that is reported. This is the speed the provider uses in its marketing or description of the products the provider has for fixed broadband. The listed speed is often part of the product name. Many providers specify in the product information and the terms of contract that subscribers cannot automatically expect a speed that is equivalent to the listed speed. Some providers emphasise that the listed speed is an "up to" speed. Other providers provide information about the speed one can normally expect, often by indicating an interval for speeds.

In the data Nkom collects from the providers, a differentiation is made between downstream and upstream speeds. Within each of these two categories, three intervals are used for marketed speed:

- Speeds up to 10 Mbit/s
- Speeds from 10 Mbit/s to 30 Mbit/s
- Speeds over 30 Mbit/s

Section 4.2 describes the distribution of marketed speeds for each of the speed categories for cable-based broadband generally and for high-speed broadband specifically. The marketed speeds for each of the access technologies are described in appendix 1.

The speed that the broadband subscriber will in fact experience will normally deviate from the marketed speed. Section 4.4.4 discusses issues that can help explain the discrepancy between the actual speed and the marketed speed. In the "Nettfart.no" portal, broadband customers who so wish can measure the speed of their broadband. Response times are also measured. The analysis of the measurements in "Nettfart.no" is discussed in more detail in section 4.4 and appendix 2.

4.2 Marketed speed for fixed broadband overall

4.2.1 Residential subscriptions

Figure 15 shows the development in the marketed speed for all residential subscriptions, regardless of the access technology. The figure shows that more broadband customers now use broadband with higher speeds than what was the case a few years ago. This applies to both downloading and uploading.
At the end of the first half 2015, there were about 498,000 broadband subscriptions that had a marketed speed of less than 10 Mbit/s downstream. This amounts to 27 per cent of the total number of broadband subscriptions. By comparison, at the end of 2012 about 875,000 subscriptions had less than 10 Mbit/s downstream. This amounted to more than half of all broadband subscriptions.

At the end of the first half of 2015, there were about 722,000 broadband subscriptions with a marketed speed above 30 Mbit/s downstream. This amounts to 39 per cent of the total number of broadband subscriptions. By comparison, at the end of 2012 there were about 219,000 subscriptions with more than 30 Mbit/s downstream. This amounted to 13 per cent of the total number of broadband subscriptions.

The distribution of broadband subscriptions by speed category is very different for downloads and uploads. This is related to many subscriptions being asymmetrical in the sense that download speeds are significantly higher than upload speeds. Only broadband based on fibre is generally symmetrical.

At the end of the first half of 2015, there were more than 1.15 million broadband subscriptions that had marketed speeds lower than 10 Mbit/s upstream. This amounts to 62 per cent of the total number of broadband subscriptions. By comparison, at the end of 2012 there were nearly 1.35 million subscriptions that had less than 10 Mbit/s downstream. This amounted to 78 per cent of the total number of broadband subscriptions.
At the end of the first half of 2015, there were about 390,000 broadband subscriptions that had marketed speeds above 30 Mbit/s for uploads. This amounts to 21 per cent of the total number of broadband subscriptions. By comparison, at the end of 2012 there were about 121,000 subscriptions that had more than 30 Mbit/s upstream. This amounted to 7 per cent of the total number of broadband subscriptions.

4.2.2 Business subscriptions
Figure 16 shows the development of the marketed speed for all business subscriptions, regardless of access technology. At the end of the first half of 2015, there were about 51,000 business subscriptions with a marketed speed lower than 10 Mbit/s downstream. This amounts to 40 per cent of all broadband subscriptions in the business market. By comparison, at the end of 2012 this share was 75 per cent.

At the end of the first half of 2015, there were about 24,000 business subscriptions with a marketed speed above 30 Mbit/s downstream. This amounts to 19 per cent of all broadband subscriptions in the business market. By comparison, at the end of 2012 this share was 6 per cent.

At the end of the first half of 2015, there were about 89,000 business subscriptions with a marketed speed lower than 10 Mbit/s upstream. This amounts to 69 per cent of the total number of business subscriptions. By comparison, at the end of 2012 this share was 89 per cent.

At the end of the first half of 2015, there were about 16,000 business subscriptions with a marketed speed lower than 30 Mbit/s for uploads. This amounts to 12 per cent of the total number of business subscriptions. By comparison, at the end of 2012 this share was 3 per cent.
Figure 16 Marketed speed for fixed broadband. All forms of access. Business subscriptions

4.2.3 Residential and business subscriptions combined

Figure 17 shows the development of marketed speeds for all broadband subscriptions combined, regardless of access technology. The figure shows that broadband customers now use broadband with higher speeds than what was the case a few years ago. This applies to both downloading and uploading.
At the end of the first half 2015, there were about 549,000 broadband subscriptions that had a marketed speed of less than 10 Mbit/s downstream. This amounts to 27 per cent of the total number of broadband subscriptions. By comparison, at the end of 2012 about 972,000 subscriptions had less than 10 Mbit/s downstream. This amounted to 52 per cent of the total number of broadband subscriptions.

At the end of the first half of 2015, there were about 746,000 broadband subscriptions with a marketed speed above 30 Mbit/s downstream. This amounts to 37 per cent of the total number of broadband subscriptions. By comparison, at the end of 2012 there were about 227,000 subscriptions with more than 30 Mbit/s downstream. This amounted to 12 per cent of the total number of broadband subscriptions.

At the end of the first half of 2015, there were nearly 1.24 million broadband subscriptions with a marketed speed lower than 10 Mbit/s upstream. This amounts to 62 per cent of the total number of broadband subscriptions. By comparison, at the end of 2012 there were nearly 1.47 million subscriptions that had less than 10 Mbit/s downstream. This amounted to 79 per cent of the total number of broadband subscriptions.
At the end of the first half of 2015, there were about 406,000 broadband subscriptions that had marketed speeds above 30 Mbit/s for uploads. This amounts to 20 per cent of the total number of broadband subscriptions. By comparison, at the end of 2012 there were about 125,000 subscriptions that had more than 30 Mbit/s upstream. This amounted to 7 per cent of the total number of broadband subscriptions.

### 4.3 Marketed speed for high-speed broadband

This report defines high-speed broadband\(^\text{25}\) as the sum of VDSL, broadband over cable TV networks and broadband over fibre. Figure 18 shows the number of subscriptions for high-speed broadband divided by speed. By the end of the first half of 2015, there were 1.34 million such subscriptions in the residential market. This is an increase of about 78,000 subscriptions compared with the end of the first half of 2014. At the end of the first half of 2015, 84 per cent of the subscriptions for high-speed broadband had a marketed speed for downloading of 10 Mbit/s or more. Fifty-four per cent of the subscriptions have a downstream speed of 30 Mbit/s or more. By comparison, these shares were 69 per cent and 22 per cent respectively at the end of 2012. Fifty-three per cent of subscriptions have a marketed upload speed of 10 Mbit/s or more as at the end of the first half of 2015.

\(^{25}\) High-speed broadband is discussed in depth in section 2.3.1.
4.4 Measured speed

4.4.1 About Nettfart.no
In this report we use data from Nettfart.no to analyse speeds and response times for broadband. Nettfart.no is owned by Nkom and is a public website where broadband customers can measure the speed of the broadband they use. Figure 19 shows the startpage of Nettfart.no. Broadband customers can also compare the results of their measurement with the average for other broadband customers with the same subscription. Speeds for all types of broadband are affected by a number of factors and several measurements of the same broadband access can give different results. Nettfart.no is therefore not meant as a recommendation of or advice against specific broadband technologies or providers.

Figure 19 The homepage of the internet portal "Nettfart.no"

4.4.2 Speed measurements on Nettfart.no
When a broadband customer runs a specific measurement, the achieved speed is measured for the broadband the customer is connected to at the moment the measurement is made.
Downstream and upstream speeds are given in megabits per second (Mbit/s) and response times are given in milliseconds (ms). Further, the broadband provider in question is registered along with an assumption about which county the broadband customer is located in. Nettfart.no identifies the county using the IP address\(^26\) the broadband customer is using. The customer receives suggestions about subscriptions available from the relevant broadband provider, and the customer can choose to link their subscription to the result of the measurement. In order to compare their own measurement with other measurements, the broadband customer must first register their own subscription. This means that there is possibility that a measurement is linked to the wrong subscription type. The likelihood of this error arising is assumed to be the same for all broadband providers.

All measurements are stored in a database. Over time, a number of measurement results are accumulated that provide a basis for an analysis of broadband speeds and response times. In this report we call these measurements "measured speed", in contrast to marketed speed, which is the speed the broadband provider lists for the individual subscriptions on offer. The difference between measured speed and marketed speed is discussed in more detail in section 4.4.4.

4.4.3 Method and data

As a starting point, 4.7 million measurements from Nettfart.no were registered from September 2011 to September 2015. Measurements from abroad are discounted. This is also true of measurements that are not linked to a specific broadband product as well as "invalid" products in the form of test products and products not offered to residential customers. This reduces the number of measurements to 758,000. Of the remaining measurements, the most extreme results\(^27\) have been removed. This leaves about 743,000 measurements that form the basis for the analysis in this report.

The data is based on self-selection, which normally could lead to a skewed distribution. In other words, the measurements are not based on a random or representative selection of all broadband subscriptions in Norway. Nkom does not collect information about the people using Nettfart.no. There is reason to believe that some groups are overrepresented compared to others, for example that younger people interested in technology have a greater representation than others.

Figure 20\(^28\) compares the marketed speed for broadband products that have been measured in Nettfart.no with marketed speeds for all cable-based broadband subscriptions. Of all

\(^{26}\) The IP address is deleted once the measurement has been completed and the result stored in the database.

\(^{27}\) The one per cent of measurements with the highest speeds and the one per cent of measurements with the lowest speeds are removed.

\(^{28}\) Data: Marketed speed for all measurements covers the period from January 2015 up to and including September 2015. Marketed speed for all subscriptions as at the end of the first half of 2015.
subscriptions for cable-based broadband, 39.4 per cent have a marketed downstream speed of 30 Mbit/s or more. By comparison, 41.5 per cent of the subscriptions that formed the basis for measurements had a marketed speed of 30 Mbit/s or more. Of all subscriptions for cable-based broadband, 75 per cent have a marketed downstream speed of 10 Mbit/s or more. By comparison, 81 per cent of the subscriptions that formed the basis for measurements had a marketed speed of 10 Mbit/s or more. The picture is more or less the same for each of the broadband technologies. Broadband subscriptions with relatively high speeds are overrepresented in the measurements compared to the distribution of speeds for all broadband subscriptions.

Figure 20 The relationship between speed categories for all subscriptions and for subscriptions that have been measured in Nettfart.no

4.4.4 Measured speed vs marketed speed

Each provider of fixed broadband presents their broadband products on their website. The customer can subscribe to a set of products with different speeds. The provider lists what the subscriber can expect in terms of speed when downloading from and uploading to the Internet. Speeds are given in Mbit/s. In this report we call this "marketed speed". Broadband based on xDSL and cable TV networks normally have lower speeds for uploading than for downloading. We refer to this as "asymmetrical broadband". In Norway, broadband based on fibre is generally set up with the same download and upload speeds. We refer to this as "symmetrical broadband".

The customer's experience is tied to the actual speed. The customer can measure this by using Nettfart.no. The measured speed may deviate from the marketed speed. The measured
speed may be higher or lower than the marketed speed. However, a larger percentage of the measurements will show a lower speed than the marketed speed than those that show a higher speed. We therefore often see that some broadband providers list the marketed speed as an "up to" speed, or in some cases as the theoretical speed.

There are many reasons that the measured speed can deviate from the marketed speed, and many of these relate to the situation of the individual broadband subscriber. Important issues that can affect speed relate to the equipment the subscriber uses and how the equipment is set up and used. Examples of issues that can reduce the measured speed include:

- The subscriber uses a number of different types of equipment in connection with their terminal, in the form of routers, modems and decoders. The equipment may be new or old, and is often a mixture of the two.
- Many subscribers use a wireless network in the form of a WiFi router. This is in turn connected to the subscriber's broadband access. In wireless networks, the signals weaken between the router and the terminal when compared to a situation where the terminal is connected directly to the external network.
- There are often multiple simultaneous users of the broadband in a household. Multiple terminals must therefore share the broadband. For instance, streaming video requires relatively high speeds.
- The actual terminal the customer is using can affect the speed the customer experiences. A computer with an old and therefore weak processor (CPU) will normally lead to reduced speed. Speeds will also be reduced if the terminal is infected by a virus or damaging software.

If the subscriber experiences a lower speed than that marketed by the broadband provider, it is not necessarily the fault of the provider. Broadband providers do of course not control all relevant factors all the way to the customer's computer. Each subscriber can normally do a number of things to improve performance.

Figure 21\textsuperscript{29} shows the cumulative distribution of download speeds as a share of marketed speeds. Some 65 per cent of all measurements based on xDSL measure at least 46 per cent of the marketed speed. For cable TV networks and fibre, this share is somewhat higher. About 65 per cent of all measurements based on fibre measure at least 52 per cent of the marketed speed. For cable TV networks, about 65 per cent of all measurements measure at least 59 per cent of the marketed speed.

\textsuperscript{29} Data: Measurements conducted in the period from January 2015 and up to and including September 2015.
Figure 21 Cumulative distribution of download speeds as a percentage of marketed speed, divided by technology

Figure 22 is an excerpt of figure 21 that shows the cumulated distribution around 100 per cent of marketed speeds. Sixteen per cent of the measurements based on xDSL provide at least 100 per cent of the marketed speed. Fifteen per cent of the measurements based on fibre provide at least 100 per cent of the marketed speed, while the corresponding figure for cable TV networks is 19.5 per cent.

Figure 22 Cumulative distribution, around 100 per cent of marketed speed
Figure 23 shows the distribution of marketed speed for the broadband subscriptions that form the basis for measurements in Nettfart.no. This is compared to the measured speed. Forty-one per cent of the cable-based broadband subscriptions that form the basis for measurement have a downstream marketed speed of 30 Mbit/s or more, while 27 per cent of the measurements achieve a speed of 30 Mbit/s or more. Nineteen per cent of cable-based broadband subscriptions that form the basis for measurement have a marketed speed under 10 Mbit/s, while as much as 41 per cent of the measurements achieve a speed under 10 Mbit/s.

Figure 23 Measured speed and marketed speed for Nettfart.no measurements in 2015

4.4.5 Measured speeds for cable-based broadband

In recent years, broadband subscribers have generally started using broadband with higher marketed speeds. Naturally, this also affects the speed that the subscribers experience. Figure 24 shows the development of average and median measured speeds shown over a four-year period from September 2011 to September 2015. Average measured speeds have increased significantly during the period. In the period from September 2011 to February 2012, the average measured downstream speed was 12.9 Mbit/s. In the period from April 2015 to September 2015, the average is 22.2 Mbit/s. The average upstream speed was 5.4 Mbit/s and

Data: Speeds measured in the period from January 2015 up to and including September 2015.
12.5 Mbit/s in the corresponding periods. Figure 24 shows that the median\textsuperscript{31} measured speed is significantly lower than average. This is because there is a skewed distribution between measurements with low and high speeds, as there is a greater amount of measurements with low speeds. In a frequency distribution where the measurements have a skewed distribution, there may be a considerable gap between the average and the median.

\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure24.png}
\caption{Development of average and median measured speeds. All technologies}
\end{figure}

Figures 25 and 26 present the average measured downstream and upstream speeds for each of the broadband technologies. Broadband based on cable TV networks and fibre generally have the same level and development for downstream speed. In contrast, for upstream speeds there are significant differences in the levels for fibre and broadband based on cable TV networks. For downloading, there are significant differences between the measured speeds for fibre and cable TV networks on the one hand and measured speeds for broadband over xDSL, radio and satellite on the other hand. Further, measured speeds for xDSL have not increased significantly over time.

\textsuperscript{31} In this case, the median is the measured speed that divides the total number of measurements in two equal parts.
There are large variations in measured speeds for the individual broadband technologies. Some of this relates to the fact that subscribers have different marketed speeds in their broadband products. However, there is some spread in the measured speeds even for broadband products with identical marketed speeds. Even the individual broadband subscriptions will normally experience some spread in measured speeds even though the same broadband product is used for all measurements.
Table 2\textsuperscript{32} shows the spread in measurements in 2015 for the individual broadband technologies. A differentiation is made between measured speeds for downloading and uploading. For broadband based on fibre and cable TV networks, nearly 75 per cent of all measurements cover speeds up to 49.4 Mbit/s and 49.8 Mbit/s respectively for downloads. For xDSL, 75 per cent of the measurements cover speeds up to 11.9 Mbit/s for downloads.

The share of 50 per cent of the measurements is referred to as the median. For broadband based on fibre and cable TV networks, the median is 30.1 Mbit/s and 26.0 Mbit/s respectively for downloads. In other words, the median for fibre is higher than the median for broadband over cable TV networks. For xDSL, the median is 7.0 Mbit/s when downloading.

For fibre, 75 per cent of all measurements cover speeds up to 49.8 Mbit/s for downloads. For broadband over cable TV networks, 75 per cent of the measurements cover up to 15.9 Mbit/s for uploads. For xDSL, 75 per cent of the measurements cover speeds up to 1.0 Mbit/s for uploads.

For broadband based on fibre and cable TV networks, the median is 28.2 Mbit/s and 10.5 Mbit/s respectively for uploads. For xDSL, the median is 0.7 Mbit/s when uploading.

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Fibre</th>
<th>Cable TV</th>
<th>xDSL</th>
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<tbody>
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<td>Uploading</td>
<td>Downloading</td>
</tr>
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\textit{Figure 2} Spread in measured speeds for cable-based broadband. Percentiles in Mbit/s

\textbf{4.4.6 Measured speeds for mobile broadband}

Figure 27 shows the development in average measured speeds for downloads and uploads in mobile networks\textsuperscript{33} in the past four years. The measurements are affected by the technology used in the mobile network in question, and the capacity available at the time the measurement is performed. Any speed limitations in the mobile customer's subscription can also affect the measurements.

\textsuperscript{32} Data: Speeds measured on Nettfart.no in the period from January 2015 and up to and including September 2015.
\textsuperscript{33} The measurements are presumed to mainly cover mobile broadband. Nettfart.no uses flash, and thus smartphones cannot normally be used for direct measurements in Nettfart.no.
There is a marked increase in average and median speeds in the period. The increase is especially marked for downloads. For uploads, there has been no corresponding increase in measured speeds. In this period there has been a significant roll-out of 4G networks, but the upgrades of parts of the mobile network to 3G has also had an impact. Average measured speeds were 6.4 Mbit/s for downloads and 2.7 Mbit/s for uploads in the first part of the period. In the latter part of the period, the average measured speeds had increased to 14.0 Mbit/s for downloads and 7.6 Mbit/s for uploads.

Figure 27 Development in measured speeds for mobile data. Downloads and uploads

While figure 27 shows the development in average and median measured speed over time, figures and 29 show the spread in the speed measurements for mobile networks. Each column shows the share of the measurements that are within a given speed interval. The columns total 100 per cent. The figures show that there is a very skewed distribution in measured speeds in mobile networks.

The skewed distribution is relatively larger for uploads than for downloads. More than 20 per cent of all downstream measurements have a speed below 2 Mbit/s. Some 33 per cent of the measurements have a speed that is below 4 Mbit/s. Upstream, 42 per cent of the

34 Average speeds in the first and last part of the period measured over a six-month period.
35 Data: Speeds measured on “Nettfor.tno” in the period from January 2015 and up to and including September 2015.
36 Each column is set up such that the first one shows 0-2 Mbit/s, the second shows 2-4 Mbit/s, etc.
measurements have speeds that are lower than 2 Mbit/s, while about 59 per cent of the measurements have speeds that are lower than 4 Mbit/s.

Figure 28 Measured download speeds for mobile data

It may be argued that a consideration of averages alone is misleading due to the skewed distribution shown in figures 28 and 29. There is a small number of measurements with relatively high speeds that increases the average, while the bulk of the measurements result in lower speeds than the average.

Figure 29 Measured upload speeds for mobile data
4.5 Measurement of response times

Response times are measured by a computer programme that sends a signal to a nodal point on the Internet. The response time is measured in milliseconds (ms) and is the time it takes to send and receive the signal. The response time for broadband connections can be significant in connection with some types of functions, such as online gaming. Response times are normally different for broadband with different access technologies, but are independent of the marketed speed that the subscriber has for their broadband.

Figure 30\textsuperscript{37} shows the measurements for response times in Nettfart.no, divided by access technology. The response times vary a good deal. Measured response times for broadband based on fibre and cable TV networks are shorter than for broadband based on xDSL. Measured response times over mobile networks are generally longer than measured response times for cable-based broadband accesses. For broadband based on fibre, the average response time is 16.9 ms. The median here is 11 ms. Broadband based on cable TV networks has an average measured response time of 18.1 ms and a median of 12 ms. Broadband based on xDSL has an average response time of 46.9 ms. The median is 25 ms. For measurements of response times in mobile networks, the average is 48.3 ms and the median 33 ms.

\textsuperscript{37} Data: Speeds measured on "Nettfart.no" in the period from January 2015 and up to and including September 2015.
Figure 30 Measured response time over fibre, cable TV networks, xDSL and mobile networks
APPENDIX 1 Marketed speed for cable-based broadband

1 Marketed speeds for cable-based broadband in total

Combined, fixed broadband based on xDSL, cable TV networks or fibre constitute cable-based networks. Figure 31 shows the number of subscriptions for cable-based broadband by speed. The number of subscriptions increases every year. At the end of the first half of 2015, there were some 1.83 million such subscriptions in the residential market. This is an increase of more than 64,000 subscriptions compared with the end of the first half of 2014. At the end of the first half of 2015, 75 per cent of the subscribers for cable-based networks have marketed download speeds of 10 Mbit/s or more. By comparison, the corresponding share was 50 per cent at the end of 2012. Thirty-nine per cent of the cable-based broadband subscriptions have marketed upload speeds of 10 Mbit/s or more at the end of the first half of 2015.

![Figure 31 Marketed speed for fixed broadband. All cable-based networks. Residential subscriptions](image)

2 Marketed speeds for broadband over xDSL

Figure 32 shows the number of residential broadband subscriptions based on xDSL divided by marketed speed. The figure shows speeds for downloads as well as uploads. The total number of subscriptions based on xDSL is falling every year. At the end of the first half of 2015, there
were just under 625,000 subscriptions in the residential market. This is an increase of almost 43,000 subscriptions compared with the end of the first half of 2014.

At the end of the first half of 2015, 40 per cent of all residential subscriptions based on xDSL have a marketed speed lower than 10 Mbit/s for downloads. By comparison, the corresponding share was 71 per cent at the end of 2012. Eleven per cent of the subscriptions had a marketed speed of more than 30 Mbit/s at the end of the first half of 2015. In practice, this is broadband based on VDSL.

Figure 32 Marketed speed for broadband over xDSL. Residential subscriptions

2.1 Marketed speed for broadband over VDSL

VDSL is a term for high-speed broadband in the xDSL group. Figure 33 shows the number of residential subscriptions based on VDSL divided by speed. The number of subscriptions based on VDSL increases slightly every year, and constitutes a growing share of the total number of subscriptions based on xDSL. At the end of the first half of 2015, there were over 132,000 VDSL subscriptions in the residential market. This is an increase of nearly 45,500 compared with the end of the first half of 2014. The first half of 2015 saw a greater increase in the number of VDSL subscriptions than previously.

At the end of the first half of 2015, nearly all subscriptions based on VDSL have marketed speeds of 10 Mbit/s or more for downloads. Fifty-four per cent of the subscriptions have a marketed speed of 30 Mbit/s or more for downloads. By comparison, the corresponding share was 25 per cent at the end of 2012. VDSL has asymmetrical speeds, and 41 per cent of the
subscribers have marketed speeds for uploads of 10 Mbit/s or more at the end of the first half of 2015.

Figure 33 Marketed speed for broadband over VDSL. Residential subscriptions

3 Marketed speeds for broadband over cable TV networks

Figure 34 shows the number of subscriptions based on cable TV networks divided by speed. The number of subscriptions based on cable TV networks increases every year. At the end of the first half of 2015, there were nearly 620,000 such subscriptions in the residential market. This is an increase of about 25,000 subscriptions compared with the end of the first half of 2014. At the end of the first half of 2015, 75 per cent of subscriptions based on cable TV networks have marketed download speeds of 10 Mbit/s or more. By comparison, the corresponding share was 54 per cent at the end of 2012. Broadband based on cable TV networks normally have asymmetrical speeds also. Twenty-four per cent of subscriptions have a marketed upload speed of 10 Mbit/s or more as at the end of the first half of 2015. By comparison, at the end of 2012 this share was 6 per cent.
4 Marketed speed for broadband over fibre

Figure 35 shows the number of subscriptions based on fibre and divided by speed. The number of subscriptions based on fibre increases significantly every year. At the end of the first half of 2015, there were nearly 587,000 such subscriptions in the residential market. This is an increase of nearly 83,000 subscriptions compared with the end of the first half of 2014.

At the end of the first half of 2015, 89 per cent of the subscriptions based on fibre have marketed download speeds of 10 Mbit/s or more. By comparison, the corresponding share was 86 per cent at the end of 2012. Sixty-nine per cent of the broadband subscriptions have downstream speeds of 30 Mbit/s or more at the end of the first half of 2015. This share has increased significantly since the first half of 2014. An important reason for this may be that subscriptions with speeds below 30 Mbits/s have been upgraded to speeds above 30 Mbit/s.

Most subscriptions based on fibre have symmetrical speeds. Only a small number of providers deliver asymmetrical broadband based on fibre. Eighty-six per cent of subscriptions have a marketed upload speed of 10 Mbit/s or more as at the end of the first half of 2015.
Figure 35 Marketed speeds for broadband over fibre. Residential subscriptions
APPENDIX 2 Measured speeds by county

When broadband customers measure speeds in the Nettportal.no portal, the county that is the starting point for the measurement is registered. This is done on the basis of the customer's IP address\(^38\). Figure 36\(^39\) shows the average measured downstream speed in each county. The measurements are based on cable-based broadband in the form of xDSL, cable TV networks and fibre. Figure 50 shows the average upstream speeds.

![Average measured download speed by county. Cable-based broadband accesses](image)

The average download speed in 2015 varies from about 31 Mbit/s in Nord-Trøndelag to 11.8 Mbit/s in Sogn og Fjordane. Counties with a relatively high proportion of measurements based on cable TV networks and fibre have relatively high average speeds. This applies to counties such as Oslo, Rogaland, Telemark and Nord-Trøndelag. Counties with a relatively high

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\(^38\) The IP address is deleted once the measurement is registered.

\(^39\) Data: Measurements made in the period from January 2015 and up to and including September 2015. The number of measurements is highest in Oslo, Akershus and Hordaland. Finnmark is the county with the lowest number of measurements.
proportion of measurements based on xDSL are Sogn og Fjordane, Hordaland, Aust-Agder, Vestfold and Østfold. Most counties have a higher average in 2015 than in 2014.

Figure 37 shows average upload speeds. The average varies from over 27.7 Mbit/s in Nord-Trøndelag to 5.1 Mbit/s in Sogn og Fjordane. Rogaland, Nord-Trøndelag, Telemark and Buskerud counties have relatively large proportions of measurements based on fibre. This affects the average upload speed as fibre-based broadband normally has symmetrical speeds.

Figure 37 Average measured upload speed by county. Cable-based broadband accesses