Broadband in Norway 2016

21 December 2016
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 that Nexia has prepared on assignment from Nkom. At the end of the first half of 2016, more than 2.03 million households have access to high-speed broadband over fibre, cable TV networks or VDSL. On the same date, there were about 1.48 million residential subscriptions for high-speed broadband. This constitutes more than 73 per cent of those who have access. Nearly 1.09 million households have access to broadband over fibre at the end of the first half of 2016. This is nearly 136,000 more households than at the end of the first half of 2015. At the end of the first half of 2016, more than 691,000 residential subscriptions were based on fibre. This represents about 64 per cent of those who have access.

Chapter 3 describes the coverage estimates that Nkom has prepared for mobile networks based on 4G. The estimates use data for all base stations in Norway as at the end of the first half of 2016. The estimates include access to mobile data outdoors. The estimates do not include coverage for voice calls in the mobile networks. A distinction is drawn between population coverage and area coverage. At the end of the first half of 2016, the estimates are based on two alternative values for received signal strength: the so-called threshold values of -110 dBm and -114 dBm. The latter value is used to allow comparison with the corresponding calculations at the end of the first half in 2014 and 2015.

Population coverage for Norway as a whole is estimated to be 99.5 per cent at the end of the first half of 2016, using the received signal strength value of -110 dBm. Area coverage in the same period is estimated to 86.6 per cent.

Population coverage for mobile data based on 4G is consistently high in all counties. Only two counties (Sogn og Fjordane and Møre og Romsdal) have population coverage below 99 per cent. By contrast, there are major differences in 4G area coverage among the counties. Three counties (Sogn og Fjordane, Troms, and Møre og Romsdal) have lower area coverage than the other counties.

The individual mobile operators have overlapping coverage to a greater or lesser degree in different parts of the country. Population coverage for 4G for Norway as a whole was 99.5 per cent. Nearly 92 per cent of the population has coverage from all three mobile networks. Sogn og Fjordane and Troms are the counties with the lowest share of the population that has
coverage from three networks. Here 58 and 71 per cent respectively of the population have coverage from all three mobile networks.

Area coverage for Norway as a whole is almost 87 per cent when the calculations are based on received signal strength of -110 dBm. About 47 per cent of the total area is covered by all three mobile networks. Roughly 27 per cent is covered by two networks, while 13 per cent of the total area is covered by only one network. There is great variation between the counties.

Chapter 4 and appendix 1 describe the marketed speeds for each of the fixed access technologies. A distinction is drawn between marketed download speed and marketed upload speed. 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 2016, over 1.10 million residential broadband subscriptions have a marketed downstream speed of 30 Mbit/s or more. This is more than 57 per cent of all residential broadband subscriptions. The equivalent share at the end of the first half of 2015 was 39 per cent. Nearly 80 per cent of residential subscriptions based on fibre have a marketed downstream speed of 30 Mbit/s or more at the end of the first half of 2016. The corresponding figure for broadband over cable TV networks is nearly 73 per cent.

Nkom has analysed speed tests that broadband subscribers have performed on "Nettfart.no". This too is described in chapter 4. The analysis is based on speed tests from September 2011 to September 2016 inclusive.

There has been a significant increase in measured speeds based on fixed broadband over the past four years. In the last part of 2011, speed tests recorded an average downstream speed of just over 14 Mbit/s. In 2016, the test results are generally above 42 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 downstream speeds averaged just under 6 Mbit/s. In 2016, the corresponding average is about 15.5 Mbit/s.

Nkom has also analysed measured speeds against the marketed speed for each broadband product. Nearly 31 per cent of the speed tests 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 31 per cent and 34 per cent respectively.

"Nettfart.no" also measures response times (ping test). 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 13 ms and 14 ms respectively. The average response time for xDSL is 28 ms. Measured response times in
mobile networks are generally higher than for wired broadband. The average response time in mobile networks is 40 ms.
Contents

1 Introduction ........................................................................................................................................... 8

2 Access to and subscriptions for fixed broadband .............................................................................. 10
  2.1 Introduction ..................................................................................................................................... 10
  2.2 Access to and subscriptions for wired networks combined .............................................................. 10
  2.3 Access to and subscriptions for high-speed broadband ................................................................... 11
    2.3.1 Access to and subscriptions for high-speed broadband combined ............................................. 11
    2.3.2 Access to and subscriptions for broadband over fibre ............................................................... 13
    2.3.3 Access to and subscriptions for broadband over cable TV networks .................................... 14

3 Access to mobile data .......................................................................................................................... 16
  3.1 Introduction ..................................................................................................................................... 16
  3.2 Interpretation of the estimates ........................................................................................................ 17
  3.3 Assumptions in the estimates ........................................................................................................ 18
  3.4 Coverage map for 4G ..................................................................................................................... 20
  3.5 Population coverage ...................................................................................................................... 21
  3.6 Area coverage .................................................................................................................................. 26
  3.7 Coverage based on one or more mobile networks ......................................................................... 31

4 Broadband speeds ............................................................................................................................... 34
  4.1 Introduction ..................................................................................................................................... 34
  4.2 Marketed speed for fixed broadband overall ..................................................................................... 34
    4.2.1 Residential subscriptions ........................................................................................................... 34
    4.2.2 Business subscriptions ............................................................................................................ 36
    4.2.3 Residential and business subscriptions combined .................................................................... 37
  4.3 Marketed speed for high-speed broadband ....................................................................................... 38
  4.4 Measured speed .............................................................................................................................. 39
    4.4.1 About Nettfart.no ...................................................................................................................... 39
    4.4.2 Speed tests on Nettfart.no ....................................................................................................... 40
    4.4.3 Method and data ........................................................................................................................ 41
    4.4.4 Measured speed vs marketed speed .......................................................................................... 42
    4.4.5 Measured speed for wired broadband ....................................................................................... 45
    4.4.6 Measured speed for mobile broadband ..................................................................................... 48
  4.5 Measurement of response times ..................................................................................................... 50

APPENDIX 1 Marketed speed for different types of wired broadband ..................................................... 54
  1 Marketed speed for broadband over xDSL ....................................................................................... 54
1.1 Marketed speed for broadband over VDSL .............................................................. 54
2 Marketed speed for broadband over cable TV networks ........................................... 55
3 Marketed speed for broadband over fibre .................................................................. 56
APPENDIX 2 Measured speed by county ..................................................................... 58

List of figures
Figure 1 Access to and subscriptions for fixed broadband. All wired broadband accesses. Residential customers .......................................................... 11
Figure 2 Number of subscriptions for high-speed broadband. Residential subscriptions...... 12
Figure 3 Access to and subscriptions for high-speed broadband. Residential customers ...... 13
Figure 4 Access to and subscriptions for broadband based on fibre. Residential customers .. 14
Figure 5 Access to and subscriptions for broadband based on cable TV networks. Residential customers .......................................................... 15
Figure 6 The map of Norway used to estimate area coverage........................................ 19
Figure 7 Coverage map showing the development in 4G coverage. Estimates as at the end of first half of 2014–2016 .............................................................................. 21
Figure 8 Estimated share of the population with access to mobile data based on 4G, by county. All mobile networks. Outdoor coverage. -114 dBm .................................................. 23
Figure 9 Estimated share of the population with access to mobile data based on 4G, by county at the end of the first half of 2016. Outdoor coverage ........................................... 25
Figure 10 Estimated area (%) with access to mobile data based on 4G, by county. Outdoor coverage. -114 dBm ....................................................................................... 27
Figure 11 Estimated share of the population with access to mobile data based on 4G, by county at the end of the first half of 2016. Outdoor coverage ................................................ 29
Figure 12 Estimated share of the area of each county with access to mobile data based on 4G at the end of the first half of 2016. Outdoor coverage -110 dBm.................................... 30
Figure 13 Population coverage for one, two or three mobile operators at the end of the first half of 2016. -110 dBm ....................................................................................... 32
Figure 14 Area coverage for one, two or three mobile operators at the end of the first half of 2016. -110 dBm ....................................................................................... 33
Figure 15 Marketed speed for fixed broadband. All forms of access. Residential subscriptions ................................................................................................................. 35
Figure 16 Marketed speed for fixed broadband. All forms of access. Business subscriptions . 37
Figure 17 Marketed speed for fixed broadband. All forms of access. Residential and business subscriptions combined ................................................................. 37
Figure 18 Marketed speed for high-speed broadband. Residential subscriptions .................. 39
Figure 19 The homepage of the online speed test portal "Nettfart.no" .................................. 40
Figure 20 The relationship between speed categories for all subscriptions and for subscriptions that have been measured in Nettfart.no ................................................................................. 42
Figure 21 Cumulative distribution of download speed as a percentage of marketed speed, broken down by technology .......................................................................................................................... 44
Figure 22 Cumulative distribution, around 100 per cent of marketed speed ............................ 44
Figure 23 Measured speed and marketed speed for Nettfart.no speed tests in 2016 .................. 45
Figure 24 Development in measured speed, broken down into average and median. All wired technologies ................................................................................................................................. 46
Figure 25 Development in average measured download speed. Broken down by technologies ................................................................................................................................. 47
Figure 26 Average measured upload speed. Broken down by technologies ............................ 47
Figure 27 Development in measured speed for mobile data, broken down into average and median. Downloads and uploads .......................................................................................................... 49
Figure 28 Measured download speed for mobile data ............................................................ 50
Figure 29 Measured upload speed for mobile data ............................................................... 50
Figure 30 Measured average ping response time over fibre, cable TV networks, xDSL and mobile networks ...................................................................................................................... 52
Figure 31 Distribution of measured ping response time over fibre, cable TV networks, xDSL and mobile networks .................................................................................................................. 53
Figure 32 Marketed speed for broadband over xDSL. Residential subscriptions .................. 54
Figure 33 Marketed speed for broadband over VDSL. Residential subscriptions ................. 55
Figure 34 Marketed speed for broadband over cable TV networks. Residential subscriptions 56
Figure 35 Marketed speed for broadband over fibre. Residential subscriptions ..................... 57
Figure 36 Average measured download speed by county. Wired broadband ......................... 58
Figure 37 Average measured upload speed by county. Wired broadband ............................. 59
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, i.e. the possibility 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 at their residential address 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 drawn between the speed the providers list in their product descriptions for fixed broadband and the actual speed that broadband subscribers can measure using the speed test portal "Nettfart.no". Measurements of the speed the subscribers experience are also presented for mobile data.

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. Digitisation affects the productivity of the Norwegian economy, the competitiveness of the business sector, the quality of services in public administration, and the general 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 broadband connects the business sector, public administration, households and individual people to the Internet. Users must therefore have access to well-functioning broadband and secure communication services throughout the whole country.

Broadband providers mainly build their offerings based on market and business conditions. The electronic communication report for 2015 shows that the operators invested a combined total of more than NOK 8.6 billion in tangible fixed assets in 2015. The corresponding figure for the previous year was nearly NOK 7.8 billion. The investments include fixed networks and mobile networks.

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 businesses and households are offered broadband where no broadband is available.

1 The Norwegian Communications Authority (Nkom): "The Norwegian Electronic Communications Services Market 2015"
provision is expected to be offered in the next few years. In 2016, NOK 126.5 million was allocated to the scheme. The corresponding figure for 2015 was NOK 110 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 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 sales revenues, and traffic where relevant. The market shares of the largest providers are also presented.

On assignment from Nkom, the consultancy firm Nexia has collected and published figures for access to broadband in 2015 and 2016. In previous years too, Nexia has carried out this task on behalf of the ministry responsible for the Government's broadband policy. In chapter 2, we look at the figures in these coverage reports in the context of the number of subscriptions, broken down by access technology. This allows us to calculate 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 fixed and mobile broadband speed. The report distinguishes between marketed broadband speed and measured speed as measured by broadband subscribers on the "Nettfart.no" speed testing portal.
2 Access to and subscriptions for fixed broadband

2.1 Introduction
Among other things, the annual coverage reports\(^2\) show access to fixed broadband in Norwegian households\(^3\). Address data are obtained from the providers\(^4\) that offer broadband via their own infrastructure. These data indicate the number of households that can connect to fixed broadband. Further, the access technology that the households can connect to and the speed that can be achieved on the available broadband are 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 2013 to the first half of 2016. In this period, the coverage reports are based on figures collected as at the end of 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.

2.2 Access to and subscriptions for wired networks combined
Figure 1 shows access to and subscriptions for fixed broadband for all wired access technologies combined. This includes broadband based on xDSL, cable TV networks and

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\(^2\) 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. Chapter 1 of the report "Broadband coverage 2016" describes how broadband access is measured.

\(^3\) The greatest source of errors is missing information about whether someone is actually living in the buildings registered in the land register.

\(^4\) The 2016 survey is based on data from 125 broadband providers.
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.

At the end of the first half of 2016, more than 2.25 million households had access to one or more wired access technologies. This amounts to 95.3 per cent of all households in Norway at that time. At the same time, 1.90 million households have subscriptions for the above-mentioned wired access technologies. This gives a take-up rate of about 84 per cent of the households that have access to wired broadband networks. This rate has increased slightly over the years covered by figure 1. For example, at the end of the first half of 2013, the take-up rate was 79 per cent.

![Figure 1](image_url)

*Figure 1 Access to and subscriptions for fixed broadband. All wired broadband accesses. Residential customers*

### 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 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\(^5\). In other words, high-

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\(^5\) In this report, we presume that all subscriptions for broadband based on cable TV networks are at this level.
speed broadband is accesses where customers are offered download speeds of minimum 30 Mbit/s.

Figure 2 shows that there is strong growth in the number of subscriptions for high-speed broadband. By the end of the first half of 2016, there were nearly 1.48 million such subscriptions in the residential market. This constitutes more than 73 per cent of the total number of subscriptions for fixed broadband. By comparison, at the end of the first half of 2013 this share was roughly 53 per cent.

Broadband based on VDSL has increased slightly in recent years, but still constitutes a relatively small share of the total number of subscriptions for high-speed broadband. At the end of the first half of 2016, more than 156,000 residential subscriptions were based on VDSL. This is 24,000 more than at the end of the first half of 2015. Broadband based on fibre constitutes the largest share. At the end of the first half of 2016, just over 691,000 residential subscriptions were based on fibre. This is an increase of about 104,000 subscriptions from the end of the first half of 2015. Subscriptions based on fibre constitute about 47 per cent of the subscriptions for high-speed broadband at the end of the first half of 2016.

![Figure 2 Number of subscriptions for high-speed broadband. Residential subscriptions](image)

Figure 3 shows access to and subscriptions for high-speed broadband\(^6\). Some 2.02 million households have access to high-speed broadband at the end of the first half of 2016. This is more than 85 per cent of all households, and an increase of more than 100,000 compared with the end of the first half of 2015. Nearly 1.48 million households were subscribed to high-speed broadband at the end of the first half of 2016. This is an increase of 142,000 subscriptions compared with the end of the first half of 2015.

\(^6\) No figures have been collected for high-speed broadband as a whole in the years prior to the first half of 2013.
The number of subscriptions for high-speed broadband represented 73 per cent of the total access to high-speed broadband at the end of the first half of 2016. This take-up rate has been increasing for several years. By comparison, the take-up rate was 63 per cent at the end of the first half of 2013.

**Figure 3 Access to and subscriptions for high-speed broadband. Residential customers**

### 2.3.2 Access to and subscriptions for broadband over fibre

Figure 4 shows access to and subscriptions for fixed broadband based on fibre. At the end of the first half of 2016, 1.09 million households had access to fibre. This amounts to nearly 46 per cent of all households in Norway. In the period from the end of the first half of 2015 to the end of the first half of 2016, there was an increase of 136,000 in the number of households with access to fibre. At the end of the first half of 2016, some 691,000 were households subscribed to fibre. This is a take-up rate of roughly 64 per cent. The take-up rate has been increasing in recent years. For example, at the end of the first half of 2013 the take-up rate was about 59 per cent.
2.3.3 Access to and subscriptions for broadband over cable TV networks

Figure 5 shows access to and subscriptions for fixed broadband based on cable TV networks\(^7\). There are more than 1.24 million households that as of the end of the first half of 2016 have access to broadband based on cable TV networks. This amounts to more than 52 per cent of all households in Norway at that time. At the same time, 634,000 households have broadband subscriptions based on cable TV networks. This represents a take-up rate of just over 51 per cent.

\(^7\) It is assumed that cable TV networks have been upgraded to DOCSIS 3.0 or higher.
Figure 5 Access to and subscriptions for broadband based on cable TV networks. Residential customers
3 Access to mobile data

3.1 Introduction

Nkom has collected information about base stations from mobile operators with their own mobile networks. The data were collected at the end of the first half of 2016. The network operators on this date were Telenor, Telia and ICE. Other providers of mobile communication services enter into agreements with one of these net operators regarding the use of the operator’s mobile network. Nkom also collected corresponding figures on the same date in 2014 and 2015. The information applies to base stations in commercial operation on the relevant dates. The information includes all the relevant frequency bands, i.e. 450 MHz, 800 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\(^8\) of access to mobile data in the operators’ mobile networks on the relevant date.

The 2015 electronic communications report\(^9\) shows that in 2015, mobile operators invested NOK 2.43 billion in mobile networks. The corresponding figures for 2013 and 2014 were NOK 2.64 and 2.55 billion respectively. This comprises investments in tangible fixed assets. Investments in frequency resources are additional.

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, payments of nearly NOK 1.8 billion were made in auctions for access to frequencies. In 2014 only small amounts were paid in frequency auctions, while in 2015 NOK 878 million was paid for frequency auctions. In addition, mobile operators must pay annual charges and fees for their frequency licences.

Nkom has estimated the population coverage and area coverage for access to mobile data based on 4G using the collected data on the base stations at the end of the first half of 2016. The coverage figures pertain to outdoor coverage. The results of the calculations have been

\(^8\) The method and assumptions used in the calculations are described in section 3.3.

\(^9\) Nkom: “The Norwegian Electronic Communications Services Market 2015”
compared with corresponding figures for the same dates in 2014 and 2015. The results are shown in Table 1.

Together, the 4G networks covered 99.7 per cent of the population at the end of the first half of 2016. On the same date in 2014 and 2015, population coverage was 83.3 and 95.2 per cent respectively, based on the same signal strength assumption. The 4G networks covered 91.2 per cent of the area of Norway at the end of the first half of 2016. On the same date in 2014 and 2015, area coverage was 24.2 and 49.1 per cent respectively, based on the same signal strength assumption.

At the end of the first half of 2016, calculations were also carried out to determine population coverage and area coverage based on an alternative signal strength assumption in the 4G networks. This is shown in Table 1. This gives population coverage of 99.5 per cent and area coverage of 86.6 per cent.

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<td><strong>Population coverage</strong></td>
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<tr>
<td>-114 dBm</td>
<td>83.3%</td>
<td>95.2%</td>
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<td><strong>Area coverage</strong></td>
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<td>-114 dBm</td>
<td>24.2%</td>
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<tr>
<td>-110 dBm</td>
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<td>86.6%</td>
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*Table 1* Population coverage and area coverage for 4G. Norway as a whole

### 3.2 Interpretation of the estimates

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 damped on the way from the base station to the mobile customer's terminal. The damping depends on, among other things, the frequency band used, the 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 outdoors.

This report distinguishes between population coverage and area coverage. Population coverage indicates the number of people who have access to mobile data based on 4G outdoors at their residential address. Area coverage is the geographic area in which people have access to mobile data.

The mobile operators estimate and publish information about the coverage for their respective mobile networks. Other companies\(^{10}\) 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 in 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 and 3G technology have been filtered out. The results of the estimates in this report may therefore lead to lower outdoor coverage 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 x 100 metres. 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\(^{11}\) to the seas in

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\(^{10}\) See for example the report "Broadband coverage 2016" that Nexia has prepared on assignment from Nkom.

\(^{11}\) "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
the south, west and north. See figure 6. The sea areas inside the baseline are included, as these have mobile traffic from leisure boats, coastal fishing and transport of goods and persons.

Figure 6 The map of Norway used to estimate area coverage

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 the areas included in the Kingdom of Norway amount to 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 of population coverage and area coverage based on 4G in 2014 and 2015 assume a signal strength of -114 dBm\textsuperscript{12}. This is the signal strength supplied to the mobile customer's terminal as a minimum needed to receive data. To compare the development in coverage from 2014, this value is also used as the basis for estimates of coverage at the end of the first half of 2016. For this date, calculations were also made based on signal strength of -110 dBm. This level means that a stronger signal is required to provide coverage, compared with -114 dBm. Estimates based on -110 dBm will therefore generally result in lower scores for population coverage and area coverage than estimates based on -114 dBm. In autumn 2016, Telenor, Telia and ICE entered into an agreement\textsuperscript{13} on harmonised coverage maps to make it easier for mobile users to compare the operators' coverage at different locations. The coverage maps are based on received signal strength of -110 dBm as the basic coverage for 4G.

Telenor and Telia had 4G technology in their mobile networks on all the dates in 2014, 2015 and 2016 for which Nkom has obtained information. In 2014 and 2015, ICE used CDMA technology, which was not defined as 4G. At the end of the first half of 2016, ICE had upgraded its network for 4G, and ICE is therefore included in the calculation results for this period. In addition, ICE uses frequencies in the 450 MHz band. Telenor and Telia do not use these frequencies. These frequencies provide good area coverage, but require a special modem to send and receive data. Ordinary smartphones cannot be used in networks with frequencies in the 450 MHz band. The estimates of area coverage\textsuperscript{14} in section 3.6 have therefore been done both including and excluding this frequency band.

3.4 Coverage map for 4G

Figure 7 shows the coverage map for 4G at the end of every half year for the years 2014 to 2016. It is clear from the maps that there has been intense expansion of 4G services in the

\textsuperscript{12} dBm is a dimensionless unit of measure that describes the logarithmic power ratio of measured power referenced to 1 milliwatt.

\textsuperscript{13} The agreement is available here.

\textsuperscript{14} Frequencies in the 450 MHz band can have a relatively large impact on area coverage, but less impact on population coverage.
period. In the first part of the period, the development was concentrated in areas with significant populations, meaning high population coverage was achieved relatively quickly. In the second part of the period, the roll-out of 4G has mainly been in other parts of the country, increasing the area coverage significantly.

Sections 3.5 to 3.7 provide a more detailed description of coverage, including the distribution for each county.

![Coverage map showing the development in 4G coverage. Estimates as at the end of first half of 2014–2016](image)

**3.5 Population coverage**

Figure 8 shows the share of the population that has access to mobile data at the end of the first half of 2016 for Norway as a whole and broken down by county. The results on this date have been compared with the corresponding calculations on the same dates in 2014 and 2015, based on the same signal strength assumption. For Norway as a whole, population coverage based on 4G increased from 83.3 per cent at the end of the first half of 2014, to 99.7 per cent on the same date in 2016. In 2014, there were major differences between the counties. In 2016, only Sogn og Fjordane and Møre og Romsdal have population coverage
below 99 per cent, while Nordland and Finnmark have mobile coverage of just over 99 per cent. At the end of 2016, several counties have population coverage of 100 per cent.
Figure 8 Estimated share of the population with access to mobile data based on 4G, by county. All mobile networks. Outdoor coverage. -114 dBm
The estimates shown in figure 8 for the years 2014–2016 are based on the assumption of signal strength of -114 dBm as the basis for coverage. If the signal strength is lower than this at a specific geographic point, there is no coverage. At the end of the first half of 2016, coverage based on signal strength of -110 dBm was also measured.

A Nordic report\textsuperscript{15} shows that there can be significant differences in experienced coverage depending on the types of mobile phone and how the phones are used. For example, calculations based on different signal strength values demonstrate the significance for signal reception of the antenna characteristics of different mobile phones.

Figure 9 shows population coverage calculated at the end of the first half of 2016 based on both values. Coverage was calculated for Norway as a whole and for each individual county. For Norway as a whole, population coverage declines from 99.7 to 99.5 per cent when we use -110 dBm instead of -114 dBm. Assumed signal strength is not significant in the counties with population coverage of almost 100 per cent. However, assumed signal strength does affect coverage in counties with relatively lower population coverage. Sogn og Fjordane is the county with the lowest population coverage. Here coverage is reduced from 94.7 to 93.4 per cent when we use -110 dBm instead of -114 dBm.

\textsuperscript{15} Report published by Nkom on 5 September 2016, which is available \url{here}. 
Figure 9 Estimated share of the population with access to mobile data based on 4G, by county at the end of the first half of 2016. Outdoor coverage
### 3.6 Area coverage

While the estimates of population coverage indicate the degree of coverage at residential addresses, area coverage indicates access to mobile data wherever the subscriber happens to be at any given time. Mobility is an important factor in the market, and mobile operators are therefore placing ever greater emphasis on being able to offer access wherever the mobile customers are. With population coverage at almost 100 per cent, there is growing focus on area coverage.

Area coverage is the geographic area\(^\text{16}\) in which people have access to mobile data. Figure 10 shows the change in area coverage from the end of the first half of 2015 to the same date in 2016 for Norway as a whole and broken down by county. At the end of the first half of 2014\(^\text{17}\), area coverage was very low. Area coverage has increased significantly in 2015 and 2016. For Norway as a whole, area coverage increased from 49.1 per cent at the end of the first half of 2015 to 91.2 per cent on the same date in 2016. However, there is great variation between the counties. The share is greatest in Oslo, Akershus, Vestfold, Østfold and Hedmark, which all had area coverage above 99 per cent at the end of the first half of 2016. Area coverage is lowest in Sogn og Fjordane, Troms and Møre og Romsdal. The counties with the lowest area coverage at the end of the first half of 2015 had the strongest growth to the same date in 2016. In Finnmark, area coverage has risen from 9 per cent at the end of the first half of 2015 to almost 97 per cent on the same date in 2016.

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\(^{16}\) Assumptions about the area are described in section 3.3.

\(^{17}\) Nkom calculated area coverage at the end of the first half of 2014 to 24 per cent for the country as a whole.
Figure 10 Estimated area (%) with access to mobile data based on 4G, by county. Outdoor coverage. -114 dBm
The calculation of area coverage in figure 10 includes all the mobile networks that had 4G technology on the relevant dates. At the end of the first half of 2015, this included Telenor and Telia. At this time ICE was using technology that was not defined as 4G. In the period prior to the end of the first half of 2016, ICE has upgraded its network to 4G. The large increase in area coverage from the end of the first half of 2015 to the same date in 2016 is therefore the result of a strong expansion of the 4G network in the period, but also reflects the fact that ICE’s network was based on 4G at the end of the first half of 2016.

The estimates shown in figure 10 are based on the assumption of received signal strength of -114 dBm as a basis for coverage. At the end of the first half year, coverage based on received signal strength of -110 dBm was also calculated. Figure 11 shows area coverage at the end of the first half of 2016 calculated on the basis of both values. Coverage was calculated for Norway as a whole and for each individual county. For Norway as a whole, area coverage is reduced from 91.2 to 86.6 per cent when we use -110 dBm instead of -114 dBm. Choice of assumed signal strength is not significant in those counties that have relatively high area coverage. However, assumed signal strength does affect coverage in counties with relatively low area coverage. Sogn og Fjordane is the county with the lowest area coverage. Here coverage is reduced from 78.6 to 70.5 per cent when we use -110 dBm instead of -114 dBm.
ICE uses frequencies in the 450 MHz band in its 4G network. These frequencies provide large area coverage, but require a special modem. Ordinary mobile phones cannot receive and send signals in this frequency band. It is therefore useful to calculate area coverage at the end of the first half of 2016 excluding this frequency band. This is illustrated in figure 12. Area
coverage for Norway as a whole with signal strength of -110 dBm is reduced from 86.6 to 82.3 per cent when we exclude the 450 MHz frequencies. There is great variation between the counties. In Nord-Trøndelag area coverage is reduced from 88.8 to 76.2 per cent, while area coverage in Sogn og Fjordane is reduced from 70.5 to 61.1 per cent. In the counties with the greatest area coverage, the reduction in coverage is small when the frequencies in the 450 MHz band are excluded.

Figure 12 Estimated share of the area of each county with access to mobile data based on 4G at the end of the first half of 2016. Outdoor coverage -110 dBm
3.7 Coverage based on one or more mobile networks

There is significant overlap between the different operators’ technologies and mobile networks. However, there may be some places where only one or two mobile networks are 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 4G mobile networks with signal strength of -110 dBm. For Norway as a whole, population coverage at the end of the first half of 2016 was 99.5 per cent. Some 91.7 per cent of the population is covered by three mobile networks, while 1.7 per cent of the population is covered by only one mobile network. There is great variation between the counties. In Oslo, the entire population is covered by three mobile networks. In Sogn og Fjordane, by contrast, only 57.7 per cent of the population 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 (9.6 per cent).

Figure 14 shows the share of the area in each county that has coverage from one, two or three 4G mobile networks. For Norway as a whole, total area coverage was 86.6 per cent at the end of the first half of 2016. Some 46.5 per cent of the total area was covered by three operators, 13.5 per cent was only covered by one operator, and 26.8 per cent was covered by two operators. The remaining 13.4 per cent of the total area had no 4G coverage at the end of the first half of 2016. There is great variation between the counties. In Oslo, 98.6 per cent of the area is covered by three operators. At the other end of the scale, only 28–29 per cent of the area of Sogn og Fjordane, Troms and Finnmark are covered by three operators. In Troms, 22.3 per cent of the area is covered by only one operator.
Figure 13 Population coverage for one, two or three mobile operators at the end of the first half of 2016. -110 dBm
Figure 14 Area coverage for one, two or three mobile operators at the end of the first half of 2016. -110 dBm
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 speeds customers can normally expect by indicating a speed interval.

The data Nkom collects from the providers differentiates between downstream and upstream speeds. Within each of these two categories, four intervals are used for marketed speed:

- Up to 10 Mbit/s
- From 10 Mbit/s to 30 Mbit/s
- From 30 Mbit/s to 100 Mbit/s
- 100 Mbit/s and higher.

Section 4.2 describes the distribution of marketed speeds for each of the speed categories for wired broadband generally and for high-speed broadband specifically.

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 actual speeds and marketed speeds. In the "Nettfart.no" speed test portal, broadband customers can measure the speed of their broadband. Response times are also measured (ping test). The analysis of the tests in "Nettfart.no" is discussed in more detail in section 4.4.

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 access technology. The figure shows that more broadband customers now use broadband with higher speeds than was the case a few years ago. This applies to both downloading and uploading.
At the end of the first half of 2016, there were close to 332,000 residential broadband subscriptions with a marketed speed of less than 10 Mbit/s downstream. This amounts to 17 per cent of all broadband subscriptions at that time. By comparison, at the end of 2014 more than 548,000 subscriptions had a marketed speed of less than 10 Mbit/s downstream. This is roughly 30 per cent of the total number of broadband subscriptions.

At the end of the first half of 2016, there were some 201,000 broadband subscriptions with a marketed speed of more than 100 Mbit/s downstream. This constitutes just over 10 per cent of all broadband subscriptions. By comparison, at the end of 2014 there were around 62,000 subscriptions with more than 100 Mbit/s downstream. This amounts to 3.4 per cent of all residential 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 speed is significantly higher than upload speed. Only broadband based on fibre is generally symmetrical.

At the end of the first half of 2016, there were about 727,000 broadband subscriptions that had a marketed speed of less than 10 Mbit/s upstream. This amounts to 38 per cent of the total number of broadband subscriptions. By comparison, at the end of 2014 there were nearly 1.17 million subscriptions that had less than 10 Mbit/s downstream. This constitutes just under 65 per cent of all broadband subscriptions.

Figure 15 Marketed speed for fixed broadband. All forms of access. Residential subscriptions
At the end of the first half of 2016, there were about 596,000 broadband subscriptions that had a marketed upload speed of 30 Mbit/s or more. This amounts to 31 per cent of the total number of broadband subscriptions. By comparison, at the end of 2014 there were some 365,000 subscriptions that had more than 30 Mbit/s upstream, which is 20 per cent of the total number of broadband subscriptions.

The marketed speed for each of the access technologies is shown in appendix 1.

### 4.2.2 Business subscriptions

Figure 16 shows the development in the marketed speed for all business subscriptions, regardless of access technology. At the end of the first half of 2016, there were about 39,000 business subscriptions with a marketed speed of less than 10 Mbit/s downstream. This amounts to 31 per cent of all broadband subscriptions in the business market. By comparison, at the end of 2014 this share was 45 per cent.

At the end of the first half of 2016, there were about 12,000 business subscriptions that had a marketed speed of 100 Mbit/s or more downstream. This amounts to over 9 per cent of all broadband subscriptions in the business market. By comparison, at the end of 2014 this share was just under 5 per cent.

At the end of the first half of 2016, there were about 78,000 business subscriptions with a marketed speed of less than 10 Mbit/s upstream. This amounts to 61 per cent of the total number of business subscriptions. By comparison, at the end of 2014 this share was 72 per cent.

At the end of the first half of 2016, there were about 22,000 business subscriptions with a marketed upload speed of more than 30 Mbit/s. This amounts to 17 per cent of the total number of business subscriptions. By comparison, at the end of 2014 this share was 10 per cent.
4.2.3 Residential and business subscriptions combined.

Figure 17 shows the development in marketed speed for all broadband subscriptions combined, regardless of access technology. The figure shows that broadband customers now use broadband with higher speeds than was the case a few years ago. This applies to both downloading and uploading.

**Figure 16** Marked speed for fixed broadband. All forms of access. Business subscriptions

**Figure 17** Marked speed for fixed broadband. All forms of access. Residential and business subscriptions combined.
At the end of the first half of 2016, there were close to 371,000 broadband subscriptions with a marketed speed lower than 10 Mbit/s downstream. This amounts to 18 per cent of the total number of broadband subscriptions. By comparison, at the end of 2014 about 675,000 subscriptions had less than 10 Mbit/s downstream, which is 31 per cent of the total number of broadband subscriptions.

At the end of the first half of 2016, there were about 213,000 broadband subscriptions with a marketed downstream speed of more than 100 Mbit/s. This is nearly 11 per cent of all broadband subscriptions. By comparison, at the end of 2014 there were about 68,000 subscriptions with more than 100 Mbit/s downstream, which is 3.5 per cent of the total number of broadband subscriptions.

At the end of the first half of 2016, there were nearly 805,000 broadband subscriptions with a marketed speed of less than 10 Mbit/s upstream. This is nearly 40 per cent of all broadband subscriptions. By comparison, at the end of 2014 there were nearly 1.26 million subscriptions that had less than 10 Mbit/s downstream, which is 65 per cent of the total number of broadband subscriptions.

At the end of the first half of 2016, there were about 618,000 broadband subscriptions that had a marketed upload speed of more than 30 Mbit/s. This amounts to 30 per cent of the total number of broadband subscriptions. By comparison, at the end of 2014 there were about 378,000 subscriptions that had more than 30 Mbit/s upstream, which is 20 per cent of the total number of broadband subscriptions.

4.3 Marketed speed for high-speed broadband

This report defines high-speed broadband 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 broken down by speed. By the end of the first half of 2016, there were 1.48 million such subscriptions in the residential market. This is an increase of about 142,000 subscriptions compared with the end of the first half of 2015. At the end of the first half of 2016, 75 per cent of subscriptions had high-speed broadband with a marketed download speed of 30 Mbit/s or more, and 14 per cent of the subscriptions had a downstream speed of 100 Mbit/s or more. By comparison, these shares were 50 per cent and 5 per cent respectively at the end of 2014. Some 40 per cent of subscriptions had a marketed upload speed of 30 Mbit/s or more at the end of the first half of 2016.
Figure 18 Marketed speed for high-speed broadband. Residential subscriptions

4.4 Measured speed

4.4.1 About Nettfart.no

In this report we use data from Nettfart.no to analyse broadband speeds and ping response times. Nettfart.no is owned by Nkom and is a public website where broadband customers can measure the speed of the broadband connection they use. Figure 19 shows Nettfart.no's homepage. Broadband customers can also compare the results of their measurement with the average for other broadband customers with the same subscription. The speed of all types of broadband will be affected by a number of factors, and repeated speed tests using 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.
4.4.2 Speed tests on Nettfart.no

When a broadband customer tests their broadband speed on Nettfart.no, current speed is measured using the broadband connection that the customer is connected to. Downstream and upstream speeds are given in megabits per second (Mbit/s), and response times (ping) 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 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 speed test results with other measurements, the broadband customer must first register their own subscription. This means that there is possibility that a concrete test result is linked to the wrong subscription type. The likelihood of this error arising is assumed to be the same for all broadband providers. To reduce the likelihood of the test results we

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The IP address is deleted once the test has been completed and the result stored in the database.
analyse having the wrong subscription type, the test results are filtered. This filtering is discussed in more detail in section 4.4.3.

All test results are stored in a database. Over time, a number of test results are accumulated, providing a basis for analysis of broadband speeds and response times. In this report we call these test results "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, almost 6.2 million speed tests on Nettfart.no were registered between September 2011 and September 2016. Tests from abroad are excluded. Tests that are not linked to a specific broadband product and "invalid" products in the form of trial products and products not offered to residential customers are also excluded. This reduces the number of tests to 935,000. To reduce the likelihood of the test results we analyse having the wrong subscription type, the test results are filtered a second time. We remove tests with a speed lower than 40 per cent of the marketed speed and tests with a speed higher than 150 per cent of the marketed speed. This leaves around 635,000 test results 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. However, there is reason to believe that some groups are overrepresented compared with others, for example that younger people interested in technology have a greater representation than others.

Figure 20 compares the marketed speed for broadband products that have been measured on Nettfart.no with the marketed speed for all wired broadband subscriptions. Of all subscriptions for wired broadband, 57 per cent have a marketed downstream speed of 30 Mbit/s or more. By comparison, 54.7 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 wired broadband, 82.5 per cent have a marketed downstream speed of 10 Mbit/s or more. By comparison, 87.9 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 test results compared with the distribution of speeds for all broadband subscriptions.

19 Underlying data: Marketed speed for all tests covers the period from January 2016 to 7 September 2016 inclusive. Marketed speed for all subscriptions is marketed speed as at the end of the first half of 2016.
4.4.4 Measured speed vs marketed speed

Each provider of fixed broadband presents their broadband products on their website. Customers 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 speed. 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. Measured speed may differ from marketed speed, and it may be higher or lower than the marketed speed. However, a larger percentage of the speed test results will show a lower speed than the marketed speed, compared with 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, compared with 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, video streaming requires relatively high speed.

• 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. Speed will also be reduced if the terminal is infected by a virus or malware.

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

Figure 21\(^{20}\) shows the cumulative distribution of download speed as a share of marketed speed. Some 43 per cent of all the tests based on xDSL measure at least 90 per cent of the marketed speed. For cable TV networks, this share is 52 per cent, and for fibre 56 per cent.

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\(^{20}\) Underlying data: Speed tests conducted in the period from January 2016 to 7 September 2016 inclusive.
Figure 21 Cumulative distribution of download speed as a percentage of marketed speed, broken down by technology.

Figure 22 is an excerpt of figure 21, in order to show the cumulated distribution around 100 per cent of the marketed speed. Some 31 per cent of the speed tests based on xDSL provide at least 100 per cent of the marketed speed. Similarly, 31 per cent of the speed tests based on fibre provide at least 100 per cent of the marketed speed, while the corresponding figure for cable TV networks is 34 per cent.

Figure 22 Cumulative distribution, around 100 per cent of marketed speed.
Figure 23\textsuperscript{21} shows the distribution of marketed speed for the broadband subscriptions that form the basis for speed tests in Nettfart.no, compared with the measured speed. Some 55 per cent of the wired broadband subscriptions that form the basis for tests have a marketed downstream speed of 30 Mbit/s or more, while 44 per cent of the speed tests achieve a speed of 30 Mbit/s or more. 12 per cent of the wired broadband subscriptions that form the basis for tests have a marketed speed of less than 10 Mbit/s, while 23 per cent of the speed tests achieve a speed of less than 10 Mbit/s.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure23.png}
\caption{Measured speed and marketed speed for Nettfart.no speed tests in 2016}
\end{figure}

### 4.4.5 Measured speed for wired broadband

In recent years, broadband subscribers have generally started using broadband with higher marketed speed. Naturally, this also affects the speed that the subscribers experience. Figure 24 shows the development in average and median measured speed shown over a five-year period from September 2011 to September 2016. Average measured speed has increased significantly during the period. In the last quarter of 2011, average measured downstream speed was 14.3 Mbit/s. The average for the period from July 2016 to September 2016 inclusive is 45.6 Mbit/s. Average upstream speed was 6.2 Mbit/s and 25.4 Mbit/s respectively in the corresponding periods. Figure 24 shows that median\textsuperscript{22} measured speed is significantly lower than average measured speed. This is because there is a skewed distribution between

\begin{itemize}
\item Underlying data: Speeds measured in the period from January 2016 to 7 September 2016 inclusive.
\item In this case, the median is the measured speed that divides the total number of tests into two equal parts.
\end{itemize}
tests with low and high speeds, as there is a greater number of speed tests with low speed connections. In a frequency distribution where the speed tests have a very skewed distribution, there may be a considerable gap between the average and the median.

![Graph showing development in measured speed](image)

**Figure 24 Development in measured speed, broken down into average and median. All wired technologies**

Figure 25 and figure 26 show the average measured downstream and upstream speed for each of the broadband technologies. Broadband based on cable TV networks and fibre generally have the same level and development for downstream speed. For downloading, there are significant differences in levels between the measured speed for fibre and cable TV networks on the one hand and the measured speed for broadband xDSL on the other. Further, measured speeds for xDSL have not increased significantly over time. For uploading, there are significant differences in the levels for fibre and broadband based on cable TV networks.
There are large variations in measured speed for the individual broadband technologies. Some of this relates to the fact that subscribers have different marketed speed in their broadband products. However, there is also some spread in the measured speed for broadband products with identical marketed speed. Individual broadband subscriptions will normally also experience some spread in measured speeds even though the same broadband product is used for all the speed tests.

Appendix 2 contains a county-by-county overview of average measured speed for wired broadband.
Table 2 shows the spread in measurements in 2016 for the individual broadband technologies. Table 2 distinguishes between measured speeds for downloads and uploads. For broadband based on fibre and cable TV networks, nearly 75 per cent of all the speed tests pertain to download speeds of up to 75.8 Mbit/s and 92.5 Mbit/s respectively. For xDSL, 75 per cent of the tests are for download speeds of up to 24.5 Mbit/s.

The share of 50 per cent of the speed tests is referred to as the median. For broadband based on fibre and cable TV networks, the median is 46.0 Mbit/s and 57.5 Mbit/s respectively for downloads. In other words, the median for cable TV networks is higher than the median for broadband over fibre. For xDSL, the median is 12.2 Mbit/s for downloads.

For fibre, 75 per cent of all the tests are for upload speeds of up to 70.1 Mbit/s. For broadband over cable TV networks, 75 per cent of the tests pertain to upload speeds of up to 20.7 Mbit/s. For xDSL, 75 per cent of the tests are for upload speeds of up to 5.1 Mbit/s.

For broadband based on fibre and cable TV networks, the median is 40.4 Mbit/s and 15.9 Mbit/s respectively for uploads. For xDSL, the median upload speed is 1.0 Mbit/s.

<table>
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<th>Fibre Uploads</th>
<th>Cable TV Downloads</th>
<th>Cable TV Uploads</th>
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</tr>
</tbody>
</table>

Table 2: Spread in measured speed for wired broadband. Percentiles in Mbit/s

4.4.6 Measured speed for mobile broadband

Figure 27 shows the development in average measured speed for downloads and uploads in mobile networks in the past five 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.

There is a marked increase in average and median speed in the period. The increase is especially marked for downloads. For uploads, there has been no corresponding increase in measured speed. 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

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23 Underlying data: Speed measured on Nettfart.no in the period from January 2016 to 7 September 2016 inclusive.
24 The speed tests are presumed to mainly cover mobile broadband. Nettfart.no uses flash, and thus smartphones cannot normally be used for direct speed tests in Nettfart.no.
speed was 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 speed had increased to 15.8 Mbit/s for downloads and 6.8 Mbit/s for uploads.

**Figure 27** Development in measured speed for mobile data, broken down into average and median. Downloads and uploads

While figure 27 shows the development in average and median measured speed over time, figure 28 and figure 29 show the spread in the speed test results for mobile networks. Each column shows the share of the tests 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 uploading than for downloading. More than 16 per cent of all downstream tests have a speed below 2 Mbit/s. Some 29 per cent of the tests have a speed below 4 Mbit/s. Upstream, almost 38 per cent of the tests have a speed of less than 2 Mbit/s, while about 55 per cent of the tests have a speed of less than 4 Mbit/s.

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25 Average speeds in the first and last part of the period measured over a six-month period.

26 Underlying data: Speed tests on "Nettfart.no" in the period from January 2016 to 7 September 2016 inclusive.

27 Each column is divided up such that the first one shows 0–2 Mbit/s, the second shows 2–4 Mbit/s, etc.
It may be argued that a presentation of averages alone is misleading due to the skewed distribution shown in figure 28 and figure 29. A small number of tests have relatively high speed, pushing the average up, while the bulk of the tests have a speed below the average.

4.5 Measurement of response times

Response times are measured by a ping test whereby a computer programme sends a signal to a specified IP address. 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.

All the speed tests on "Nettfart.no" are made towards a server located in Oslo. The response time will depend on the distance to this server. This means that speed tests performed some distance from Oslo will generally have slightly longer response times. In figures 30 and 31, we look at speed tests performed throughout Norway. The differences by technology stand out clearly, since speed tests using different technologies are distributed fairly evenly across the country.

Figure 30\textsuperscript{28} shows the test results for ping response times on "Nettfart.no", broken down by access technology. The response times vary a good deal. Average 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 wired broadband accesses. For broadband based on fibre and cable TV networks, the average response time is 13.4 ms and 14.0 ms respectively. Broadband based on xDSL has an average response time of 27.9 ms. The average response time in mobile networks is 40.1 ms.

Figure 31 shows the distribution of the ping response times for the various technologies. While the average response times for fibre and cable TV networks are relatively similar, there are certain differences when we look at the distribution of the measured response times. Moreover, there are significant differences in the distribution of measured response times for fibre and cable TV networks on the one hand and the distribution of measured response times for xDSL and mobile data on the other.

\textsuperscript{28} Underlying data: Speed tests on "Nettfart.no" in the period from January 2016 to 7 September 2016 inclusive.
Figure 30 Measured average ping response time over fibre, cable TV networks, xDSL and mobile networks
Figure 31 Distribution of measured ping response time over fibre, cable TV networks, xDSL and mobile networks
APPENDIX 1 Marketed speed for different types of wired broadband

1 Marketed speed for broadband over xDSL

Figure 32 shows the number of residential broadband subscriptions based on xDSL, broken down by marketed speed. The figure shows the speed for downloads and uploads. The total number of subscriptions based on xDSL is falling every year. At the end of the first half of 2016, there were over 574,000 subscriptions in the residential market. This is a decrease of more than 47,000 subscriptions compared with the end of the first half of 2015.

At the end of the first half of 2016, 27 per cent of all residential subscriptions based on xDSL have a marketed download speed of less than 10 Mbit/s. By comparison, the corresponding share was 50 per cent at the end of 2014. Fifteen per cent of the subscriptions had a marketed speed of more than 30 Mbit/s at the end of the first half of 2016. In practice, this is broadband based on VDSL.

1.1 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, broken down 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 2016, there were over 156,000 VDSL subscriptions in the residential market. This is an increase of a little over 24,000 compared with the end of the first half of 2015.
At the end of the first half of 2016, nearly all subscriptions based on VDSL have a marketed download speed of 10 Mbit/s or more. 51 per cent of the subscriptions have a marketed download speed of 30 Mbit/s or more. This share has declined from 54 per cent at the end of the first half of 2015 and 52 per cent at the end of 2015. At the end of 2014 this share was only 38 per cent. VDSL has asymmetrical speeds, and 45 per cent of the subscriptions have a marketed upload speed of 10 Mbit/s or more at the end of the first half of 2016.

Figure 33 Marketed speed for broadband over VDSL. Residential subscriptions

2 Marketed speed for broadband over cable TV networks

Figure 34 shows the number of subscriptions based on cable TV networks, broken down by speed. The number of subscriptions based on cable TV networks increases every year. At the end of the first half of 2016, there were just over 634,000 such subscriptions in the residential market. This is an increase of about 14,000 subscriptions compared with the end of the first half of 2015. At the end of the first half of 2016, 73 per cent of subscriptions based on cable TV networks have a marketed download speed of 30 Mbit/s or more. By comparison, the corresponding share was 36 per cent at the end of 2014. Broadband based on cable TV networks also tends to have asymmetrical speeds. Some 75 per cent of subscriptions had a marketed upload speed of 10 Mbit/s or more at the end of the first half of 2016. By comparison, at the end of 2014 this share was 23 per cent.
3 Marketed speed for broadband over fibre

Figure 35 shows the number of subscriptions based on fibre, broken down by speed. The number of subscriptions based on fibre increases significantly every year. At the end of the first half of 2016, there were nearly 691,000 such subscriptions in the residential market. This is an increase of more than 104,000 subscriptions compared with the end of the first half of 2015 and the largest annual increase ever seen in fibre subscriptions.

At the end of the first half of 2016, 82 per cent of the subscriptions based on fibre have a marketed download speed of 30 Mbit/s or more. By comparison, the corresponding share was 67 per cent at the end of 2014. 14 per cent of the broadband subscriptions have a downstream speed of 100 Mbit/s or more at the end of the first half of 2016. By comparison, the corresponding share was 5 per cent at the end of 2014.

Most subscriptions based on fibre have symmetrical speeds. Only a small number of providers deliver asymmetrical broadband based on fibre. 79 per cent of subscriptions had a marketed upload speed of 30 Mbit/s or more at the end of the first half of 2016.
Figure 35 Marketed speed for broadband over fibre. Residential subscriptions
APPENDIX 2 Measured speed by county

When broadband customers test their connection speed in the Nettfart.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. Figure 36 shows the average measured downstream speed in the individual county for wired broadband in the form of xDSL, cable TV networks and fibre combined.

Figure 36 Average measured download speed by county. Wired broadband

29 The IP address is deleted once the measurement is registered.
30 Underlying data: Speed tests in the period from January 2016 to 7 September 2016 inclusive.
The average download speed in 2016 varies from about 64 Mbit/s in Oslo to 20.7 Mbit/s in Aust-Agder. Counties with a relatively high proportion of speed tests 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 proportion of speed tests based on xDSL are Sogn og Fjordane, Hordaland, Aust-Agder, Vestfold and Østfold. Most counties had a higher average in 2016 than in 2015 and 2014. The only exception is Aust-Agder, which had a lower average download speed in 2016 than in 2014.

Figure 37 shows the average measured upload speed for wired broadband in the form of xDSL, cable TV networks and fibre combined. The average varies from 34.6 Mbit/s in Telemark to 7.7 Mbit/s in Nord-Trøndelag. Telemark and Rogaland have relatively large proportions of speed tests 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. Wired broadband