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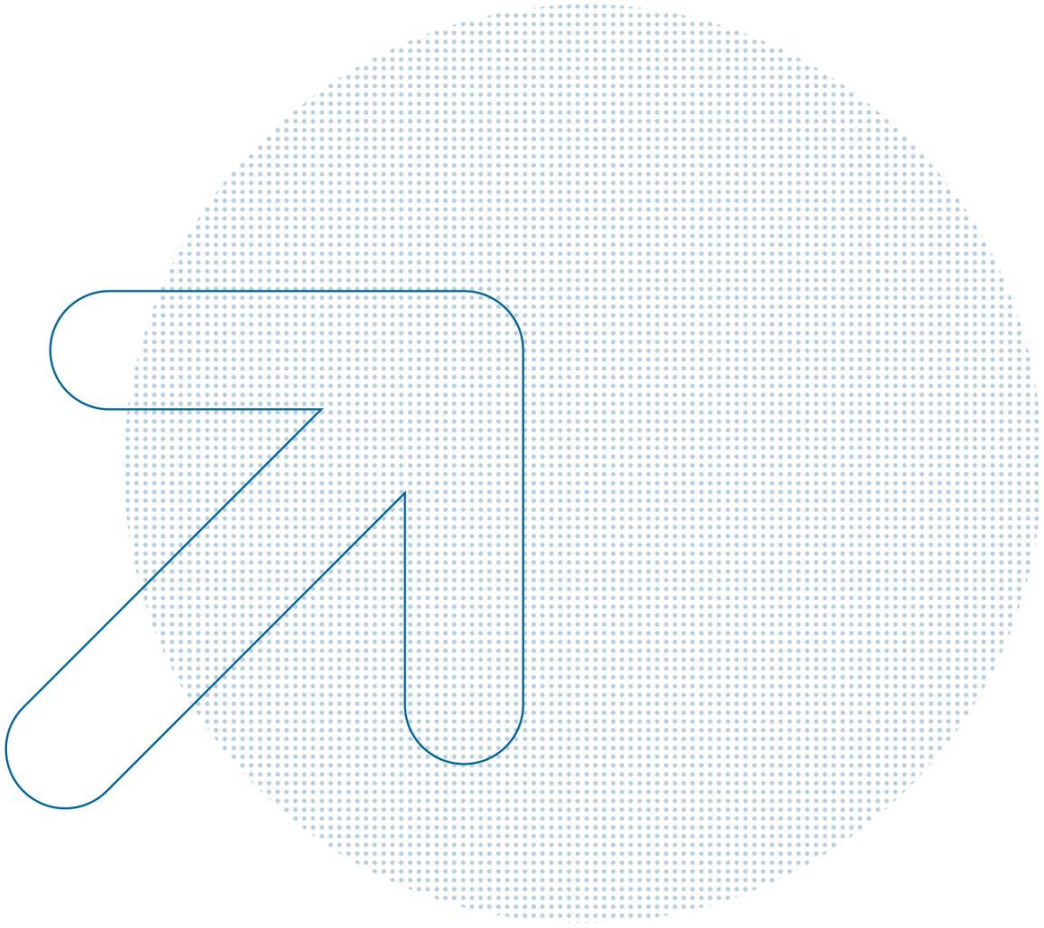
Study prepared for the Norwegian Communications Authority (Nkom)



Market study on the Norwegian Internet ecosystem

Case number 2306688

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1 Scope of the study and introduction

WIK Consult has been assigned by the Norwegian Communications Authority (Nkom) to provide an overview of the Norwegian internet ecosystem and in particular with respect to IP Interconnection (IC). The content of this study does not reflect the official opinion of the Norwegian Communications Authority. The information and views expressed therein lies entirely with the authors.

This report describes the main actors in the market, the interconnection structure and related agreements, cost developments and lastly competitive dynamics. Furthermore, the study will compare the observed trends in the Norwegian internet market with trends we observed in our earlier report on the IP Interconnection market in Europe.[1]

Historically, the large network operators have interconnected their networks bi-laterally to exchange internet traffic without payments, the so called bill & keep approach via settlement-free peering arrangements. In this manner, these large network operators, also called Tier-1 operators, have managed to establish connections to all networks worldwide. Smaller network operators historically have been exchanging their internet traffic by connecting to the Tier-1 operators which forwarded the traffic to all of their connected networks worldwide. This service is called transit and is paid for.

Interconnections between networks are done via high capacity fibre connections, which are either owned by the operators or rented. The different networks ‘meet one another’ in so called Points of Presence (POPs) or in data centers, where the physical connection between the networks in made. Exchange of internet traffic can also be done via so called Internet Exchange Points (IXPs), aggregating multiple networks to simplify this process.

The existing peering and transit arrangements in the Norwegian market will be discussed including the related traffic development, which are driving these. One of these trends is the ever increasing use by end-users of bandwidth demanding services on top of their internet connection, so called over-the-top (OTT) services like audio and video streaming services but also cloud services and home office work. This trend is also related to the current debate on possibly compensating Internet Service Providers (ISPs) for the increased traffic they have to transport to end-users connected to their networks, which is also dubbed by ISPs as ‘the fair share’ debate.

1.1 Structure of the report

Chapter two describes the relevant market actors in the Norwegian internet ecosystem, their role and eventual trends and lastly the comparison with the rest of Europe.

Chapter three focuses on the internet traffic developments in Norway, the underlying drivers and the related interconnection agreements of market players for handling the traffic. Furthermore, the position of Norway in respect to its international interconnectivity

1 Neumann et al (2022)

is reviewed and lastly we compare these trends to trends we observed for the rest of Europe. Chapter four zooms in further on the interconnection arrangements in Norway, the underlying cost and price structure, policy aspects and the relevant trends.

The competitive dynamics between the different market actors is subsequently reviewed in chapter five followed by the closing chapter focussing on the policy dimensions of interconnection including possible bottlenecks, related regulatory intervention and the 'fair share' debate between ISPs and OTT providers.

1.2 Methodological approach

Methods used are desk research, online market survey among selected Norwegian stakeholder and selected interviews with Norwegian stakeholder. Due to the short time-frame of the project, the desk research has been done parallel to the market survey. Thereafter interviews with selected stakeholders in Norway have taken place.

Online market survey

WIK-Consult (from here on WIK) conducted an online survey with the online survey tool Lamapoll[2], which was open for responses from Sep 28th 2023 - Oct. 25th 2023. Almost 100 relevant stakeholders, active in the Norwegian market, were selected for participation in conjunction with Nkom. The invitation to participate was sent out via email by Nkom to motivate stakeholder to respond within a short timeframe.

The survey consisted of a total of 79 questions, which were divided in sections applicable for certain categories of respondents (Internet Service Provider (ISP), Content and Application Provider (CAP), Internet Exchange Point (IXP), data center (DC), Content Delivery Network (CDN) and cloud provider). The relevant sections, were only presented to the specific group reducing the amount of questions and thus increasing the chance of response. The overall response rate of the survey was around 32%, which can be considered good for an online business-to-business survey as literature suggests that for smaller sample sizes (<500), a response rate between 20-25% is required to provide confident estimates.[3] However, the response rate to specific questions may be lower because the question was only shown to a specific group of stakeholders, such as CDN providers. These responses are only used as an indication for the specific category and not for general conclusions. For more details on the respondents in our online market survey on Norway, see the Annex.

Stakeholder interviews

Finally, five, in-depth, interviews have been conducted with representatives from one ISP, one CAP, one IXP, one data centre and one CDN, which are active in Norway. These interviews were used to triangulate the findings from desk research and our market survey and thereby ensure that the different viewpoints of different categories of market players are well understood.

2 See www.LamaPoll.de
3 Fosnacht et al. (2017)

2 Overview of the main actors in the Norwegian Internet ecosystem

2.1 General overview of the Internet ecosystem in Norway

As of 2022, fixed internet connectivity in Norway is widely availability with 94 % (97 % in 2023) of Norwegian households and 92 % (96 % in 2023) of all active businesses being covered with download speeds of at least 100 Mbit/s and 93 % (95 % in 2023) even with 1000 Mbit/s by end of 2022.[4] These internet connections are being provided mostly over fibre (82%) (87 % in 2023) and cable (41%) (41% in 2023).[5]

High mobile and fixed broadband coverage consequently contributed to Norway being among the world's top countries in terms of available average download speeds. It ranked 4th globally and 1st in Europe for mobile and 31st globally and 11th in Europe for fixed broadband according data from Ookla in 2022. The data further reveal that the median mobile measured internet connection speed in Norway increased in 2022 by 52.83 Mbps (+82.8 percent) and fixed internet connection speed increased by 11.24 Mbps (+12.2 percent) over the course of twelve months to the start of 2022.[6]

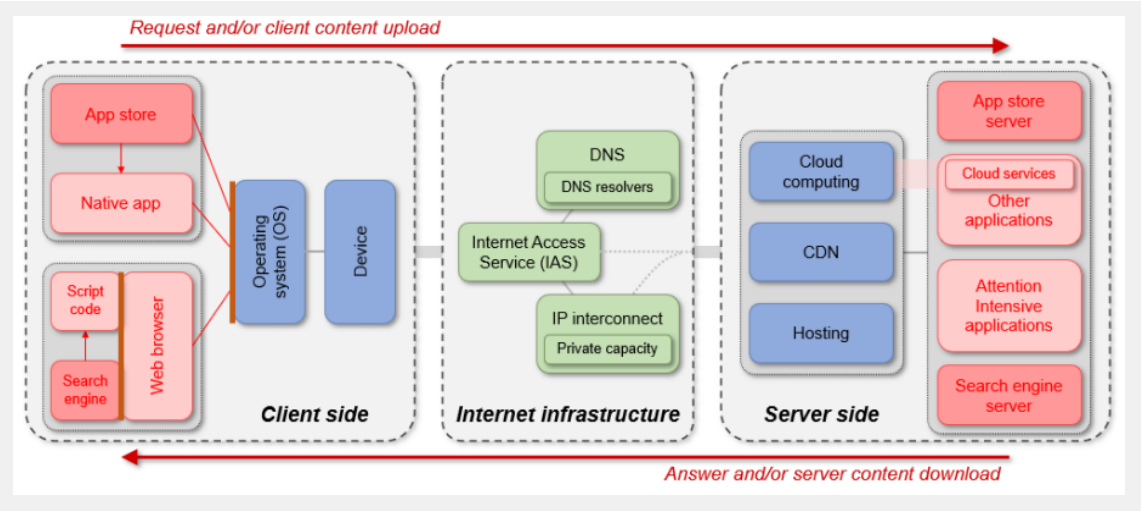
Data from Nkom annual internet report[7] shows that the growth of the average speed for fixed internet access appears to be continuing and stands at around 10-20 Mbit/s per year, the average download and upload speed for fixed internet access in Norway in 2023 are respectively 139 Mbit/s and 127 Mbit/s. In regards to mobile internet access services, Nkom data for 2022 shows that the average download speed, upload speed and latency for 5G networks in Norway in 2022 were 313 Mbit/s, 44 Mbit/s and 28 milliseconds (ms), respectively.

Norway is leading in terms of end customer connectivity speeds, but is also among Europe's leading countries in terms of digitization as measured by the European DESI index. In 2022, Norway ranked 5th among 28 European countries with only the Netherlands and the nordic countries of Finland, Denmark and Sweden ranking higher.[8]

The above described Internet access services are one part of the Internet ecosystem as shown in the reference model by BEREC (2022) in Figure 2-1.

4 Nkom statistics, see Broadband coverage - Nkom
5 WIK (2022a), p. 3
6 Ookla (2023) and https://datareportal.com/reports/digital-2022-norway
7 Nkom (2023a), p. 9
8 EC (2022)

Figure 2-1: BEREC reference model of the internet ecosystem



Source: BEREC (2022), page 16

This representation of the Internet ecosystem separates the client side devices, applications at the left from the Internet infrastructure in the middle and the supporting server side at the right. IP interconnection, which is in the focus of this study, is another part of the Internet infrastructure. The server side includes all elements used by CAPs and cloud providers to provide services to end-users.

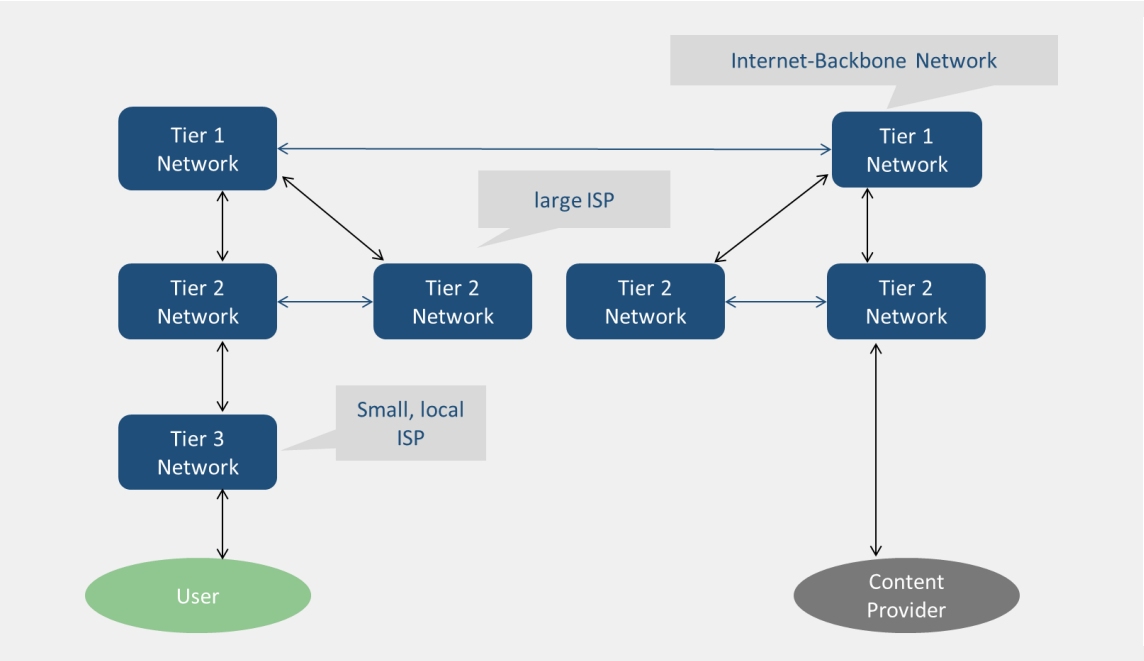
This chapter will describe the role and position of the various market players in this ecosystem starting with infrastructure providers, the ISPs and the IXPs. Thereafter the parties from the server side are discussed being the CAPs, cloud providers and data centers.

2.2 Internet service providers

ISPs provide transport of Internet traffic on behalf of other ISPs, companies, organisations, and individuals. Traditionally, they are classified into a 3-tier model based on the provided services.[9]

9 See also Internet Service Provider 3-Tier Model | ThousandEyes

Figure 2-2: Tier 1,2,3 ISPs



Source: WIK Consult

Tier-1 ISPs own extensive network infrastructure such as sea cables, which enable them to globally connect to most of the other Tier-1 ISP networks enabling them to exchange all internet traffic bi-laterally via peering. This provides the best quality and is mostly done settlement-free. These are long-established telecommunications companies that have built up international connectivity over the years while serving their end users in their home market(s). These are companies like Lumen, Liberty Global, Tata Communications, Verizon and AT&T.[10] These Tier-1 ISPs provide a, paid for, transit service to Tier 2 ISPs, which do not have the extensive global reach as Tier-1 networks and therefore have to rely on both peering- and transit arrangements to exchange their traffic.

Tier 2 ISPs still serve a significant number of end-customers and related traffic, which is exchanged where possible settlement free with other Tier-2 ISPs and in addition via transit arrangements with Tier-1 ISPs. Telenor and Telia are examples of Tier 2 ISPs.

Tier-3 ISPs, also called ‘end user ISPs’ operate their local network offering Internet Access Services (IAS) to end customers and have to purchase transit for all their traffic coming and going to their end customers. This can be done by directly connecting to a Tier-2 ISP or via an IXP where multiple transit providers can be reached. In the following paragraphs, we discuss the different types of ISPs active in Norway.

10 See for complete list, https://en.wikipedia.org/wiki/Tier_1_network#List_of_Tier_1_networks

2.2.1 Backbone ISPs

In respect to the routing of Internet traffic, backbone ISPs provide the interconnection between networks. These can be Tier-1 ISPs but also Tier-2 ISPs. Backbone ISPs active in Norway are consisting of two groups, the traditional telecom incumbents in the Nordics, Telenor, Telia, Tele Danmark Communications (TDC), which have built their national and international connectivity over the years while still serving end-users in their home market as well end-user ISPs. The second group consists of specialized international companies like Lumen, Liberty Global, Arelion and Cogent, which focus on exchanging internet traffic and do not serve end-users directly.

Norway's international connectivity consists of a comprehensive system of undersea cables, connecting it to other parts of Europe and the world. This ensures that Norway has a high level of redundancy and resilience in its internet infrastructure, making it less susceptible to outages and disruptions.

Lumen and Arelion are the dominant transit providers for Norwegian's ISPs and NORDUnet, Cogent, Tata Communications and Liberty Global to a lesser extent. Only Telia Norway relies fully on Arelion, as Arelion has emerged from Telia's former carrier division and Uninett is part of NORDUnet, which is the international collaboration between the National research and education networks in the Nordic countries. NORDUnet, connects the local academic networks of the Nordic countries with the rest of the Internet and was founded in 1980 and implemented as network in 1988. It was able to provide an early connection to the Internet for the Nordic countries as it agreed early on the, at that time, much debated TCP/IP standard. [11]

2.2.2 Internet access providers

In Norway, Altibox, Telenor, and Telia are the major fixed Internet Access (broadband) providers while Telenor and Telia also dominate the mobile broadband market.

In 2022, Altibox, a partnership of 30 different providers[12], surpassed Telenor in Norway for being the largest fixed broadband provider. As of Q2 2023 Altibox has 31.5 % (revenue) market share, followed by Telenor (28.6%) and Telia (18%) of the fixed broadband market. On the mobile services market in Norway, as of Q2 2023 Telenor is still the largest provider by revenue market share of 42.1 %, followed by Telia (33.9 %) and Ice (13.4%).[13]

As discussed before, the traditional telecom incumbents Telenor and Telia are considered as Tier-2 ISPs having international backbone networks while also serving their end users in the national and adjacent markets in the Nordics. Parts of their access networks are

11 Nkom (2023), p. 25

12 a unified brand name for Broadband, IPTV and VoIP services distributed in Norway and Denmark with over 35 local Norwegian and 6 Danish FTTH networks. Altibox was set up by Southwestern Norwegian multi-utility firm Lyse Energi in 2002 under the name Lyse Tele. The company subsequently changed its name to Altibox in 2009.

13 See https://nkom.no/statistikk/

used in Norway as well by a significant number of smaller IAS providers, which focus on offering IAS to their end customers.[14] In addition, there are multiple local ISPs operating local fibre networks focusing solely on providing Internet access.
As WIK (2022a) analyzed, generally there is a good level of competition among the large ISPs in Norway, however competitive conditions are , no longer homogeneous at the national level and have to be considered regionally, or even locally to get a clear view of this market.[15] According to Nkom's 2023 market analysis of market 1 for standardized broadband based on fibre, HFC and fixed wireless broadband, there are providers with a strong market position in 12 of the 22 identified geographic markets in Norway.[16]

2.3 Internet Exchange Points

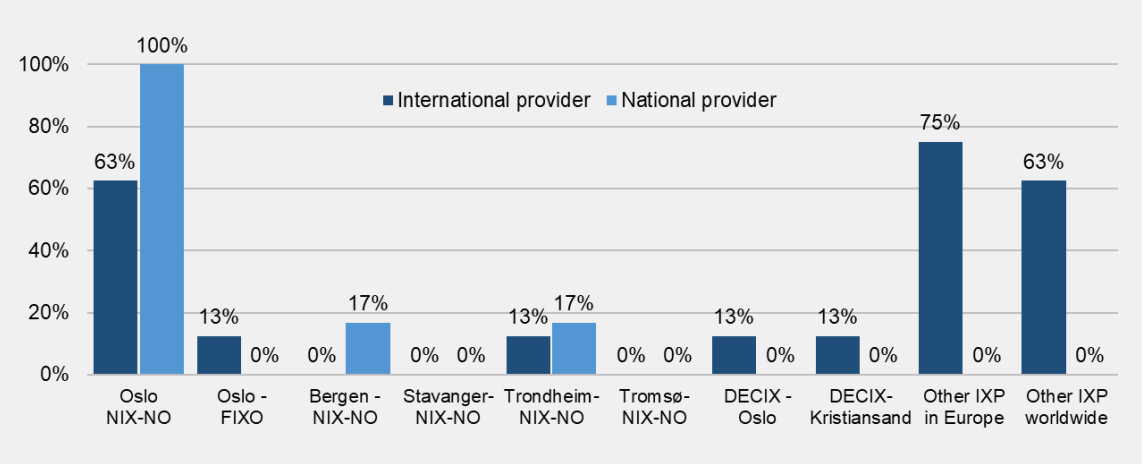
Most interconnection and hence traffic exchange between Norwegian market players in the internet ecosystem including ISPs is geographically centralised in Oslo, at private interconnection points.[17] In addition, public Norwegian Internet exchange points (IXPs) are used, which are located in Oslo, Stavanger, Bergen, Trondheim, Tromsø and lately Kristiansand.[18]

Figure 2-3 shows to which IXPs surveyed Norwegian market players are currently connected. All of the national operators are present at Oslo's NIX, international players are mostly present in Oslo and some in Trondheim, but also well represented in other IXPs around Europe and the world. None of the surveyed national and international operators are present in Tromso, although some operators are present as there is some traffic (about 5% of the total NIX traffic).

If we zoom in and split the responses between ISPs and CAPs (see Figure 2-4), ISPs are mainly present in NIX Oslo (91%) and Trondheim (36%), and to a lesser extent in FIX-Oslo (18%) and Stavanger (9%). International ISPs are also present in other IXPs in Europe and worldwide. CAPs are also mainly present in FIX-Oslo (67%) and, logically, in IXPs abroad (50%), but also in Bergen (17%) and Trondheim (7%). None of the surveyed ISPs and CAPs are present in the new DECIX IXPs, this seems to be preserved for the internationally operating CDN and cloud providers.

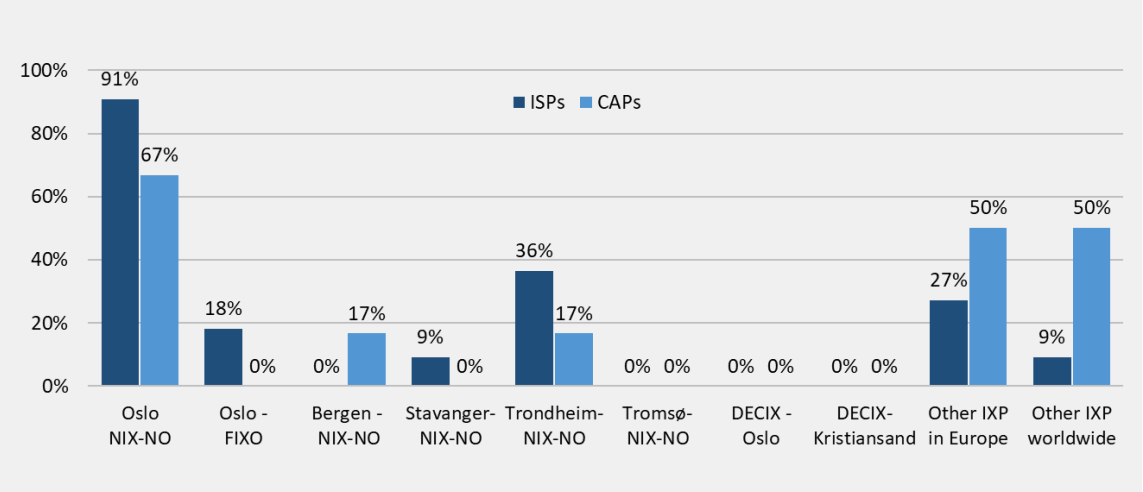
14 RIPE (2022)
15 WIK (2022a)
16 See https://nkom.no/ekom-markedet/nye-analyser-av-bredbandsmarkedene/horing-av-markedsanalyse
17 Nkom (2023), p. 21
18 Nkom (2022), p. 23

Figure 2-3: Connected IXPs in Norway by survey respondents (national/international)



Source: WIK survey via LamaPoll, n=14 (8 global, 6 national)

Figure 2-4: Connected IXPs in Norway by surveyed ISP/CAP



Source: WIK survey via LamaPoll, n=16 (10 ISPs, 6 CAPs)

The Norwegian Internet Exchange (NIX) in Oslo is the major public internet exchange in the country, which is owned and operated by the university of Oslo and interconnecting nearly 70 Norwegian and international networks.[19] Most major international CAPs and operators, such as Amazon, Microsoft, Akamai, Cloudflare, Dropbox, Huawei Cloud and NORDUnet, are also present at the NIX.[20] Particularly for smaller ISPs, public IXPs play a crucial role for interconnecting with the major players in the market. The larger ISPs use NIX to supplement their private interconnection. This is also in line with the findings for the European market.

19 Olsen (2021)
20 Nkom (2023), p. 23

Global exchange of traffic via IP transit at the NIX is provided by international transit providers Arelion and Lumen and the Norwegian ISPs Telenor, Telia, GlobalConnect and Altibox[21]. For connectivity across the Nordics, NIX cooperates with Netnod, the managing entity of IXPs in the Nordics, that allows customer to interconnect across Sweden, Denmark, Norway and Finland with just one contract[22].

NIX has been launched in March 1993 and today operates a total of six separate peering LANs across Norway to facilitate both redundancy in the Oslo area, and regional peering in the less densely populated areas of Norway. [23] Early 2019, peak traffic at NIX was just above 50 Gb/s. However, already by the end of 2021 peak traffic increased to over 200Gb/s. It operates sites in Oslo (NIX1 and NIX2) as well as in Bergen (BIX), Trondheim (TRDIX), Tromsø (TIX) and Stavanger (SIX).

Most of the traffic yet is centralized in Oslo with NIX1 and NIX2 accounting for 93 % of the traffic in the NIX infrastructure averaging 94 Gbit/s in 2022[24]. The second largest IXP is located in Stavanger (SIX) and accounts for only 5,4 % of the IXP's traffic. In its 2023 annual report on the state of the Internet in Norway, Nkom finds that all providers "emphasize the importance of regional peering at SIX and TIX in order to optimize data flows" and that content can be made available at these interconnection sites. However, apart from Stavanger and Tromsø, possibilities for regional peering are limited due to limited presence of possible peering partners. This implies that most providers have to bring their traffic to Oslo, which can be costly for smaller regional providers.[25]

For 2022, Nkom identified a 9% reduction of traffic at the Oslo NIX, which is most likely caused by providers shifting traffic to private interconnections (as is observed in the rest of Europe as well) and to a lesser extend to shifting traffic to regional IXPs (considering the low share of the traffic currently). However, it is clear that the regionalisation of traffic will lead to more regional IXPs in Norway as well.

The Norwegian market is also regarded as a relevant international data exchange node. In May 2023, the German IXP DE-CIX, one of the world's largest IXPs and interconnection operators with a global presence, put in place two interconnection points in Norway, namely in Oslo and Kristiansand.[26] This is part of the DE-CIX's internationalisation strategy.[27]

In the following paragraphs we discuss the 'server side' of the Internet ecosystem describing the main data center providers, CAPs and cloud providers in the Norwegian market.

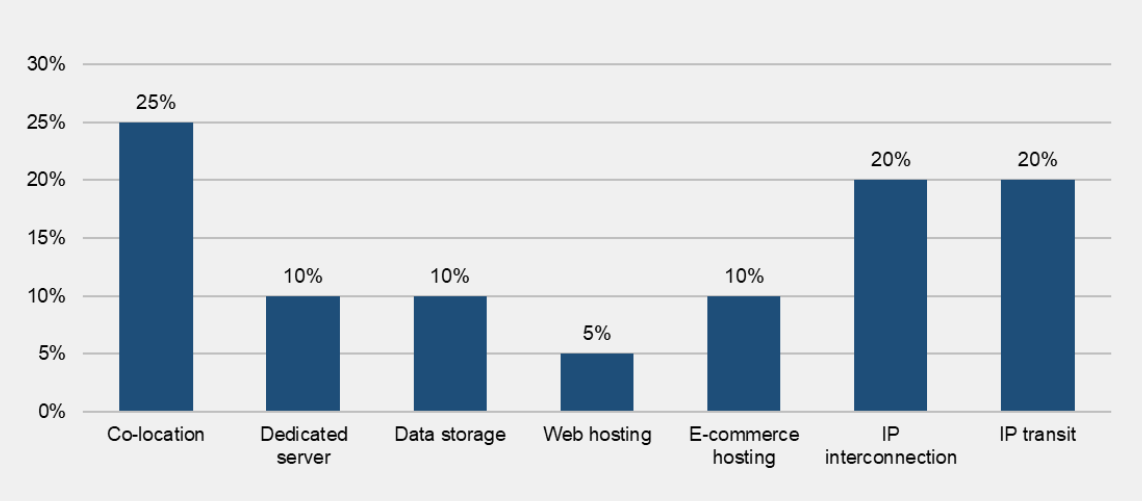
21 Nkom (2023), p. 21
22 https://www.netnod.se/ix/oslo, accessed on Sep 27th 2023
23 Kjetil Otter Olsen (2021)
24 Nkom (2023), p. 21
25 Nkom (2023), p. 22, Olsen (2021) and https://www.netnod.se/blog/peering-norway-traffic-growth-and-shifting-patterns
26 Nkom (2023), p. 23
27 WIK (2022c)

2.4 Data center providers

While IXPs and private connections serve as the hubs for exchanging internet traffic between different stakeholders, data centers can be considered as the 'hotels' where the data and applications reside, also called 'hosting'.

Figure 2-5 shows the services that respondents indicated that Norwegian data centres provide, ranging from infrastructure services such as IP interconnection, transit and collocation, which enable networks to be present and interconnected, to hardware outsourcing such as dedicated servers and storage, and application outsourcing such as web and e-commerce hosting.

Figure 2-5: Offered services by Norwegian data centers



Source: WIK Survey by Lamapoll, n=20

Data centers can be categorized into hyperscale, colocation and edge data centers. Hyperscale data centers are typically operated by large technology companies such as Meta, Microsoft, Apple, Amazon or Google to provide their own content and services. Co-location data centers in Norway are operated by data center operators such as Digiplex, Bulk and Green Mountain and offer data center services to third parties. Thirdly, edge data centers are typically operated by telecom or large IT operators for their own purposes and to sell data processing services.[28]

With the growth of the Internet, cloud services, but also other data-processing intensive activities like High Performance Computing (HPC) and Artificial Intelligence (AI), data centers have expanded significantly in the last 10 years. Consequently also data center capacities in Norway have increased by 17% per year since 2010. Average annual growth in sales revenue in Norway has increased to 19% since 2015 as well.[29]

28 Nkom (2021), p. 10
29 Norwegian Ministry of local Government and Modernisation (2021), p. 20

According market data from Statista, the annual growth of the Norwegian data center market from 2016-2022 (in revenue) has been 4,1%, which is below the benchmark of 5,5% for Europe in general. For the period 2023 until 2028 Statista foresees a slightly higher annual growth rate for Norway (4,7%) and 5,4% for Europe.[30]

Norway's largest data centers are:

- Green Mountain facility at Rennesøy, a former Nato ammunition storage facility
- Digiplex, operating three sites near Oslo (Ulven, Fetsund and Rosenholm)
- The Lefdal facility, which opened in 2017 in an abandoned gemstone mine

Furthermore, there have been initiatives like US-Norwegian Kolos, which proposed a giant data center in Norway, 2018 plans to build a major data center with help of Norwegian energy companies Ringeriks-Kraft and Statkraft using their hydroelectricity. The latest announcement in March 2023 was the building of a dedicated data center for ByteDance, provider of the short video service "TikTok", outside Hamar by Green Mountain.[31]

The Norwegian data center strategy

In 2018, the Norwegian government launched its data center strategy[32], which objective was to foster and develop this industry further to create new jobs and boost value creation in Norway. At that time the Norwegian data center industry consisted of small to medium-sized players and large data centers were not yet established.

- The strategy proposed to exempt data center providers from tax on plants and machinery, better connectivity to the rest of the world as well as an alternative backbone within Norway. This would be enabled by new regulations making it easier to carry out excavation work on public highways to install network connections and additional infrastructure funding of NOK 100 million.
- Fibre capacity linking to abroad was expanded increasing redundancy of connections and capacity in general. As a result downtime was reduced and capacity and quality increased to the major European hubs. This is essential for data centers as they require reliable, high capacity and high quality connections both nationally and internationally.[33] This strategy was confirmed to be successful in an interview with a large Norwegian data center provider, which noted that as a result of the expanded fiber connectivity in and out of Norway, network latency[34] is really good, around 15 milli-seconds in addition to the marketing effect of 'putting Norway on the map'.

30 Statista Markets Insights. See https://www.statista.com/outlook/tmo/data-center/network-infrastructure/service-provider-network-infrastructure/norway?currency=USD, accessed 5 November 2023
31 See Green Mountain unterzeichnet Rechenzentrumsvertrag mit TikTok für neuen Standort in Norwegen – BusinessPortal Norwegen (businessportal-norwegen.com)
32 Norwegian Ministry of local Government and Modernisation (2021), p. 6
33 Norwegian Ministry of local Government and Modernisation (2021), p. 41
34 Latency is the total time or "round trip" needed for a packet of data to travel. The lower the time, the faster end user requests on websites or applications can be handled.

Since then investment in data centers increased with new centers from Digiplex, Green Mountain and Bulk built in 2019. Also foreign investment increased with Orange acquiring Base Farm in 2018, [35] Google buying land in Skien and Microsoft opening data centers in Oslo and Stavanger and Volkswagen moved its most intense data processing (related to crash tests of cars) to the Green Mountain data center in Rjukan.[36]. Furthermore, there is global interest from parties, with a focus on sustainability e.g. the Columbia Threadneedle European Sustainable Infrastructure Fund acquiring the majority of Lefdal Mine Data center in 2020.[37]

The Norwegian data center sector is quite concentrated with the six largest companies, including Orange, Google and Microsoft, accounting for around 70 % of all data center's capacity. Smaller data centers only account for 30% market share.

Overall, in 2019 and 2020 NOK 2.7 billion has been invested in data centers in Norway.[38] Moreover, also Norwegian companies contributed to the growing demand in data processing services as the majority of companies increased their use of cloud services significantly from 2018 onwards.[39]

In 2020, the Norwegian Ministry of Local Government and Modernisation commissioned an economic impact assessment of potential and completed data centers in Norway.[40] It estimated the economic impact of the existing data centre industry to be significant, with a conservative estimate of a NOK 3 billion contribution to the annual economy and the potential to employ more than 11,000 people in 2025 and almost 25,000 in 2030.

Overall, Norway seems well positioned to locate more datacenter capacity not only for use in the country but especially for use by market players from abroad, which appreciate the availability of green energy and which benefit from the excellent international connectivity. A Data center confirmed this by noting that a significant parts of their data center capacity is used by foreign market players. The further growth of the market is not only facilitated by a solid digital infrastructure, highly skilled labour and favorable overall economic conditions but especially by secure access to affordable[41] sustainable and green energy (the major cost component for data centers).

An internationally active CDN provider interviewed by WIK noted that it has only 1 data center in Norway from which it serves the entire country. However, it noted that generally in more developed countries one would see multiple data centers in order to localize traffic and ensure redundancy, but right now this is less likely for Norway due to geographical characteristics and size of the country.

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35 See https://tech.eu/2018/07/16/orange-acquires-norwegian-founded-cloud-infrastructure-company-basefarm-holding-for-e350-million/

36 Norwegian Ministry of local Government and Modernisation (2021), p. 23

37 See https://www.lefdalmine.com/columbia-threadneedle-european-sustainable-infrastructure-fund-has-acquired-a-majority-stake-in-lefdal-mine-datacenter/, accessed Sep 27th 2023 and Nkom (2021), p. 13

38 Norwegian Ministry of local Government and Modernisation (2021), Chapter 3

39 Norwegian Ministry of local Government and Modernisation (2021), p. 11

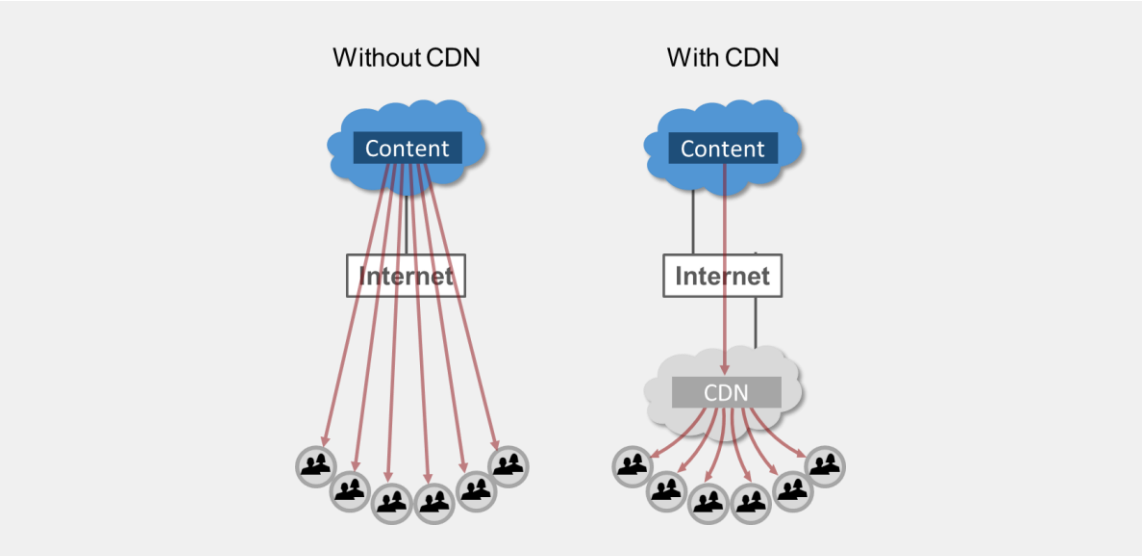
40 Implement Consulting Group (2020)

41 Since 2023, electricity prices in the south-west region of Norway have increased due to higher prices in the EU and limited transmission capacity between the other regions and the south-west.

2.5 Content distribution network providers

Content Delivery Networks (CDN) are bringing content as close as possible to end-users, which reduces traffic over long distance connections and reduces the latency to end-users and hence improves quality. To this end CDNs deploy cache servers at locations close to end-users, often even co-located in end-user ISP networks serving customers with most-requested content and/or applications. This is illustrated in the following figure.

Figure 2-6: How a Content Delivery Network (CDN) functions



Source: WIK Consult

Due to these benefits, there are different parties implementing CDN's: ISPs have developed and applied their own cache servers for internal network optimization and sometimes developed these into CDN services available to the market. At the same time CAPs have also developed their proprietary CDN solutions being optimized for their own content and applications and have started collaborations with ISP to co-locate their cache servers in ISPs networks to optimize performance. And thirdly there are third party CDN providers, like Akamai and Cloudflare, which provide their services to CAPs.

An interviewed ISP indicated that agreements with third party CDN providers are long-term tailormade agreements, which have been developed over the years together with their technical set-up all with the goal of providing the highest quality at the lowest costs.

2.6 Content and application providers

A further component on the server side of the internet ecosystem are CAPs providing their services to Norwegian end users. Apart from the large international CAPs like Netflix, Disney, HBO Max and Google, there are also CAPs which mainly operate in Norway like NRK, Schibsted, TV2, RIKSTV and Allente.

An interviewed CAP noted that Norway is an excellent example of growing embedded cache traffic instead of peering. The expectation is that the number of cache servers will remain stable as traffic is also stabilizing. Most of the large ISPs in Norway have co-located on-net CDNs from CAPs. Latency is no longer the driver of growth as applications have become less latency sensitive in last years due to technical progress, but it is about avoiding traffic congestion.

Furthermore, the interviewed CAP noted that Norway is 'very fertile ground' for CAPs due to a highly digitalised society and that many successful local content has been produced, which benefits the Norwegian audiovisual industry as well.

Many ISPs in Norway are also operating as a CAP, e.g. by cooperating under the Altibox label selling Altibox TV services or reselling Telia TV content (like Enivest, 3Net, Neas, Tussa and Tafjord) or offers from larger CAPs. These content services can be delivered in the traditional way as linear TV, but also over the IP infrastructure as over-the-top services.

2.7 Cloud computing providers

The Norwegian data center strategy of 2018 also intended to meet the interests of the big global CAPs, which are hosted in third party data centers or operate their own data center.[42] The government strategy seems to be successful in this respect, as Google and Microsoft are among the 6 largest data center providers In Norway.

Amazon Web Services (AWS) is also active in Norway but relies on Stockholm, Sweden as base to serve the Nordic region from 2018 onwards. According to Darren Mowry, the Head of AWS Nordics, Sweden was selected "due to its super fiber optics connectivity, thriving start-up community, great talent pool, and commitment to environmental sustainability".[43] There is a so called 'direct connect' in Oslo, which is a dedicated connection to AWS in Sweden reducing latency by 35% for content delivery within Norway. According the article, big names in the gaming industry like Rovio (Angry Bird), MovieStar Planet, and Supercell (Clash of Clans) are running their operations from Nordic countries by relying on AWS.

According market data from Statista, the annual growth of the Norwegian cloud market from 2016-2022 (in revenue) has been around 30% which is slightly above the 25% benchmark for the European cloud market in the same period.[44] Below figure shows that this steady growth is predicted to continue in the next three years. The European market is predicted to grow at a slightly lower pace of 22% CAGR in the same period.[45]

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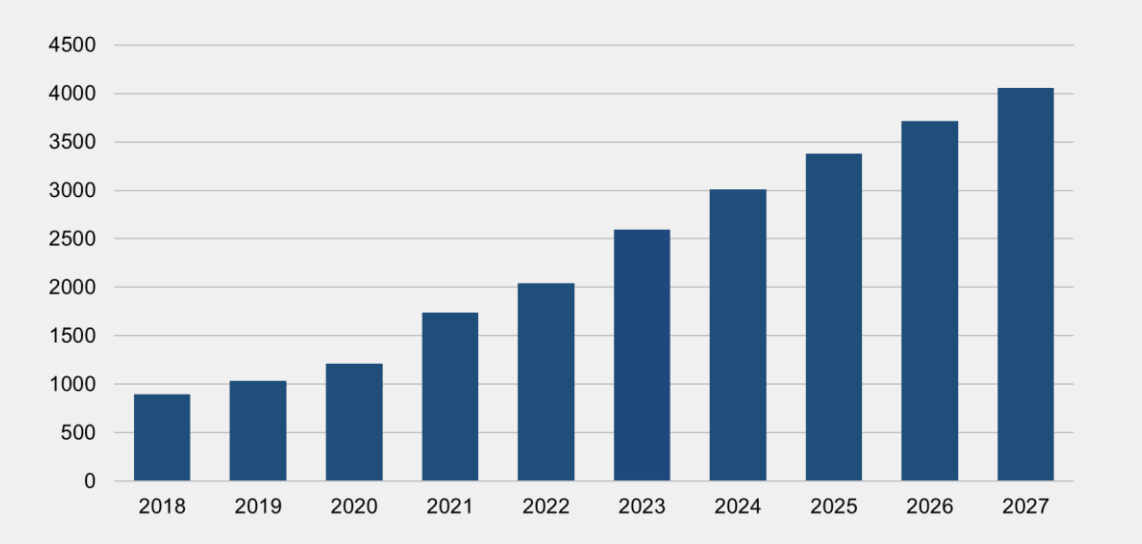
42 Norwegian Ministry of local Government and Modernisation (2021), p. 48f

43 See https://medium.com/@webmaster_86047/expansion-of-aws-in-the-nordic-countries-yumfog-820cbc610bbe and https://blog.yumfog.com on June 26, 2019

44 Statista Market Insights, September 2023. See Public Cloud - Norwegen. (n.d.). Accessed on 21 November 2023, from https://de.statista.com/outlook/tmo/public-cloud/norwegen

45 See https://www.idc.com/getdoc.jsp?containerId=prEUR250293723

Figure 2-7: Overall revenue cloud market in Norway 2018-2027 (in million U.S. dollars)



Source: Statista Market Insights, September 2023. See Public Cloud - Norwegen. (n.d.). Accessed on 21 November 2023, from https://de.statista.com/outlook/tmo/public-cloud/norwegen

The top four cloud providers in Norway are Microsoft (43%), Amazon Web Services (AWS) (18%), Google (7%), Oracle (3%)[46] but there is also a large group other smaller providers (26%).[47] In Europe, AWS, Microsoft, Google and IBM are the most used cloud services (in order), so Microsoft seems to be better positioned in Norway and IBM less.[48]

According to Statistics Norway, 64% of businesses with at least 10 employees used cloud services in 2020, an increase from 51% in 2018 and 29% in 2014. In businesses with at least 100 employees, 82% used cloud services in 2020, an increase from 73% in 2018. The general trend is for large businesses to use cloud services more frequently than smaller businesses. As of 2021, 92% of all government entities use one or more services delivered via the cloud. The need for video conferencing solutions and virtual meeting rooms is assumed to have played an important role in this development.[49]

According to the OECD, 5G brings another trend of moving towards edge and cloud computing, which is either sourced out to parties like Google or Amazon or being added to the service portfolio of existing telecom providers like BT.[50]

An interviewed Norwegian stakeholder noted that the conditions in Norway for a cloud provider are ideal with great performing access networks (low latency). In our market

46 Market share according financial statements
47 Statista Market Insights. Market share based on financial statements of the market players. See https://de.statista.com/outlook/tmo/public-cloud/custom?currency=EUR&locale=de&token=gL4fF4r5WzlhV3gXjXH8v-J9Ya6MKEH5euRpUJRVqBuWSW9noJVf5jsaZFs25dPHtD3Oi6WlpmJONosL62bFNfeiZRykjg%3D%3D#:~:text=Public%20Cloud%20%2D%20Norwegen%2C%20EU%2D27.%20(n.d.).%20Zugriff%20am%2021.%20November%202023%2C%20von%20https%3A//de.statista.com/outlook/tmo/public%2Dcloud/custom%3Fcurrency%3DEUR%26locale%3Dde%26token%3DgL4fF4r5WzlhV3gXjXH8v%2DJ9Ya6MKEH5euRpUJRVqBuWSW9noJVf5jsaZFs25dPHtD3Oi6WlpmJONosL62bFNfeiZRykjg%253D%253D
48 See https://www.idc.com/getdoc.jsp?containerId=prEUR250293723
49 Norwegian Ministry of Local Government and Modernisation (2021)
50 OECD (2022), p. 34 ff

survey in Norway, 65% of the survey participants are providing cloud services with the majority being active in the IaaS/PaaS segment.[51]

In 2020, the Norwegian National Security Authority (NSM) highlighted in its report on the digital risk profile several issues associated with using cloud services.[52] In the report its pointed out that the use of Norwegian data center should be further intensified for societally crucial functions and sensitive information systems than those that are located abroad. Hence, cloud services delivered from Norway contribute to safeguarding national autonomy and protect sensitive systems and information. In 2023, the Ministry of Justice and Emergency Preparedness, NSM conducted a concept selection study for a national cloud service for unclassified, sensitive information and other sensitive data.[53]

51 Infrastructure as a service, Platform as a service
52 NSM (2022)
53 See https://nsm.no/regelverk-og-hjelp/rapporter/konseptvalgutredning-for-nasjonal-skytjeneste

3 Structure of interconnection within the Internet ecosystem

This chapter describes first the trends in internet traffic in Norway followed by the underlying interconnection structure between the different market players and the related commercial agreements for exchanging internet traffic. Lastly, Norway's global interconnection position is summarised.

3.1 Trends related to Internet traffic in Norway

3.1.1 Data consumption of Norwegian users

Norwegian users enjoy high coverage of fast and superfast Internet. In the first half of 2022, Internet access with at least 100 Mbps was available to 93.6% (96.6% in 2023) of all households in Norway and Internet access with at least 1,000 Mbps to 92.5% (95.1% in 2023). This is a rather high level of availability in comparison to the European benchmark.[54] On average in the EU Member States, Next Generation Access (NGA) was available to 91.5% of households, lower than the 93.6% in Norway, despite the lower threshold of 30 Mbps internet access compared to 100 Mbps in Norway. In terms of 1,000 Mbps internet access, 73.4% of households are covered on average in Europe (FTTP/DOCSIS 3.1).[55] At the same time 5G baseline coverage in Norway was estimated to be close to 82% (82% in 2023) which corresponds to the European average of 81.2 %.[56]

However, the very high availability of fast and superfast Internet access does not always lead to a correspondingly higher data consumption of users. According to a recent Arthur D. Little study[57] Norwegian users in 2022 had a fixed data consumption of 222 GB per home per month (including FWA connections). This is slightly below the EU average of 224 GB (see Table 3-1). However, this study forecasts that fixed data consumption in Norway will grow at a slightly higher pace (21% CAGR) until 2030 compared to the European average of 19%. A major driver of mobile traffic in Norway is FWA (Fixed Wireless Access). This technology is used to provide fast internet to the remaining 3-5% of households that are not currently covered.

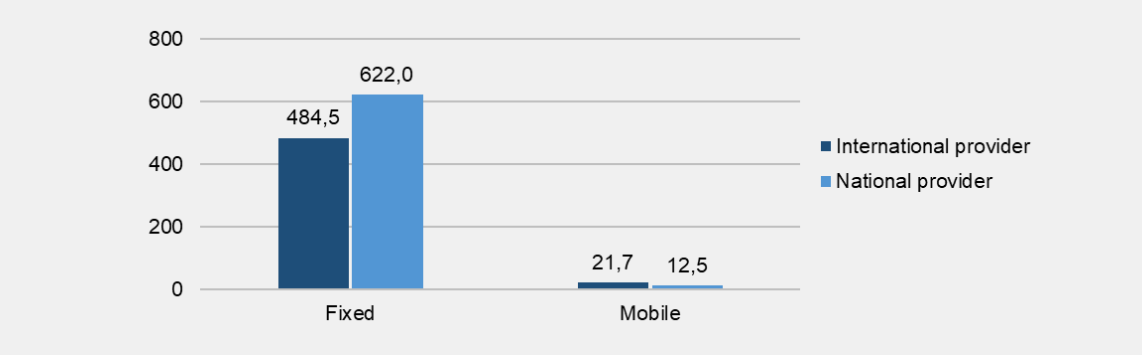
The same study finds with respect to mobile data consumption (excluding FWA) that Norwegians use around the same data as the European average (13 GB), but much less data than consumers in other Nordic countries. Similarly a higher growth until 2030 (27% CAGR) compared to 25% in the EU (see tables in the Annex) is expected.[58]

However, according to our survey in Norway among selected Norwegian market participants, the observed fixed data consumption is much higher. Following figure shows that Norwegian network operators observe between 485-622 GB per month per user on

54 Nkom (2023), p. 16
55 EC (2023a), p. 34
56 EC (2023a), p. 31
57 Arthur D. Little (2023), p. 21. See table in the annex.
58 Arthur D. Little (2023), p. 19. See table in the annex.

average in fixed broadband data consumption, which is roughly 2-3 time higher than the figures reported by Arthur D. Little. Figures on the observed and reported mobile data consumption from our survey and above study are more aligned and between 13-22 GB per month per user.

Figure 3-1: Current estimated average amount of data consumed in Norway for 2023 (GB per user per month)

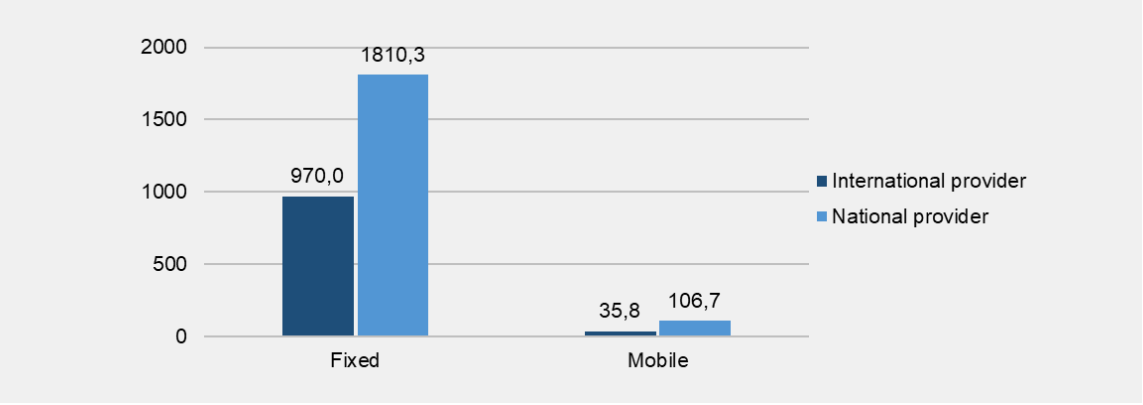


Source: WIK survey via LamaPoll, n=11 (5 international, 6 national)[59]

An interesting observation from the survey is the difference between the estimates of global players and those 'active only in Norway', who estimate higher fixed data consumption but lower mobile data consumption. One reason for this could be an overestimation of the impact of the extensive fiber footprint in Norway and an underestimation of the importance of FWA deployment in rural areas of Norway.

Survey participants expect data consumption until 2030 to rise to 970-1810 GB per user per month for fixed networks and to 36-107 GB per user per month for mobile networks respectively (see Figure 3-2).

Figure 3-2: Future estimated average amount of data consumed in Norway for 2030 (GB per user per month)



Source: WIK survey via LamaPoll, n=11 (5 international, 6 national)

59 Fixed operators indicated a missing of a mobile businesses by entering "0" for mobile data consumption, we have corrected this input for calculating the average.

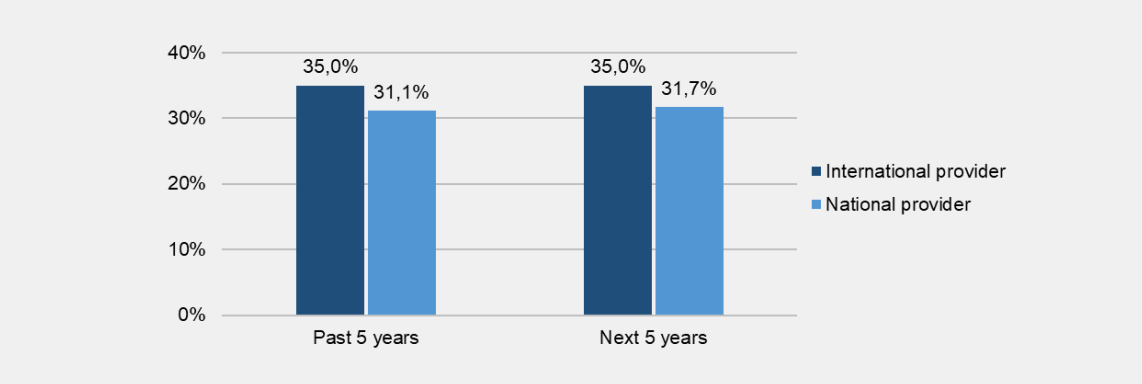
Interestingly, the market players being active only on a national level expected a much higher future mobile data consumption than global players.

3.1.2 Traffic growth

For the period from 2018 to Q1/2023, Nkom identified an annual growth at around 20-30% for Internet traffic in both fixed and mobile networks at an aggregated level.[60] For the earlier period including the year 2017, Nkom still had identified a smaller range of around 25-30% for annual traffic growth implying a higher CAGR.[61] This trend of lower growth rates may represent a normalization of the distorted traffic trends due to the COVID-19 pandemic.

Figure 3-3 shows that survey participants indicated on average a slightly higher annual growth in Internet traffic than Nkom for the last 5 years (between 31-35% on average) with the expectation that this growth remains stable for the next 5 years. International players in Norway estimated past and future growth of internet traffic in Norway a bit higher than those players only active in Norway.

Figure 3-3: Estimated average of annual growth of Internet traffic in Norway



Source: WIK survey via LamaPoll, n=13 (7 international, 6 national)

The Norwegian internet traffic development is also slightly higher than the European figures reported in the WIK 2022 study on the European Internet market[62] (since 2017: 22% for Western Europe and 27% for Central and Eastern Europe).

Nkom reported further in 2022, that internet traffic in mobile networks for ordinary mobile subscribers, so without FWA, totaled 763 Petabytes (PB), which is an increase of 22% from 2021. 5G connections also accounted for around 27% of total internet traffic on mobile networks, and in the last three years, the share of FWA traffic has increased from 15% to 60% of total traffic, which is not yet included in the 22% growth in mobile data for 2022, so this is additional as it is considered 'mobile' data.[63] According Nkom, IoT devices

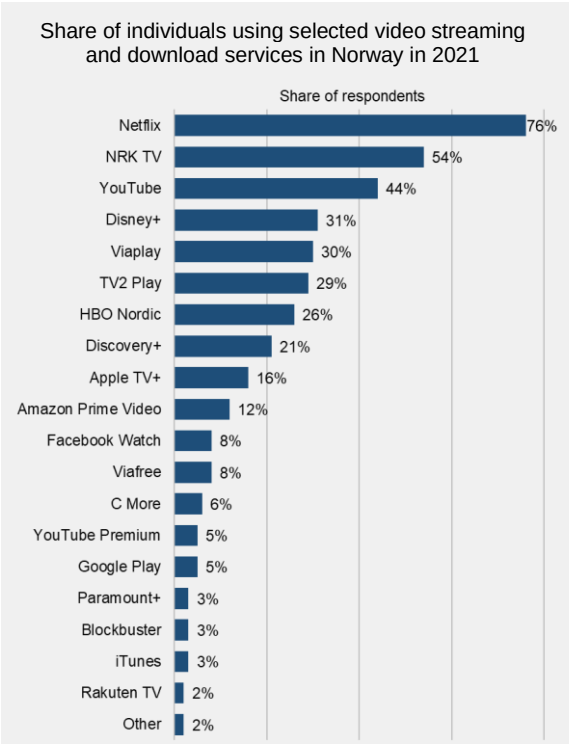
60 Nkom (2023), p. 17
61 Nkom (2022), p. 24
62 WIK (2022c), p. 6f
63 Nkom (2023), p. 17

contributed to the mobile traffic growth considering an increase of 30% in active SIM cards from 2021 to 2022 in Norway[64]. With the 5G roll-out well progressing in Norway, IoT relevance could even further increase in the near future.

3.1.3 Drivers of traffic growth

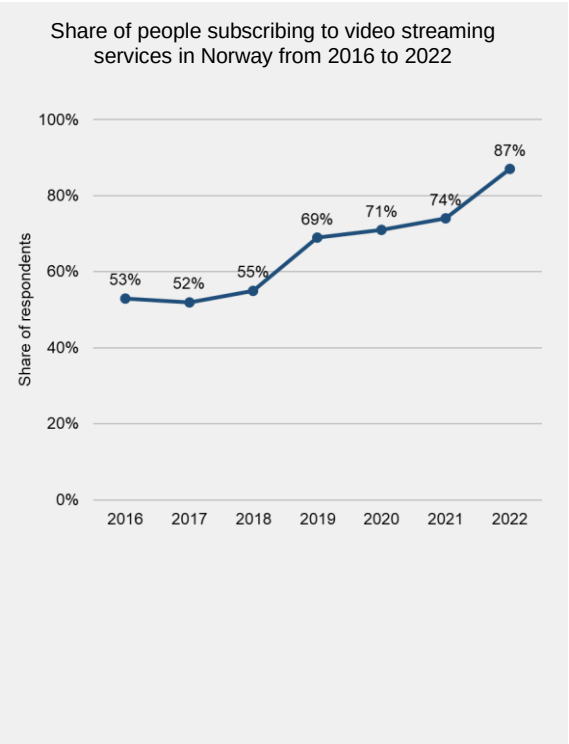
In 2022, in Norway video streaming was the biggest traffic driver with a network traffic share of ca. 70 % with web browsing and social media as well contributing.[65] As can be observed from Figure 3-4, the share of people using video streaming services in Norway has steadily increased from 2017 onwards (52%) to 2022 (87%). Most of the consumers view content from the global CAPs like Netflix, YouTube and Disney+, but also local content providers such as NRK, Viaplay, HBO Nordic are well viewed. This does not seem to be different from the EU situation.

Figure 3-4: Usage of and subscription to video streaming services in Norway



Note(s): Norway; Q4 2021; 7,000*; users of streaming or download services to watch TV, series or movies within the last week; Online survey

Source: AudienceProject. (February 22, 2022). Share of individuals using selected video streaming and download services in Norway in 2021 [Graph]. In Statista. Retrieved November 16, 2023, from https://www.statista.com/statistics/750755/share-of-individuals-using-selected-video-streaming-and-download-services-in-norway/



Note(s): Norway; 2016 to 2022; 3,131**; 9 years and older*; Telephone interviews and online survey

Source: Statistics Norway. (April 24, 2023). Share of people subscribing to video streaming services in Norway from 2016 to 2022 [Graph]. In Statista. Retrieved November 16, 2023, from https://www.statista.com/statistics/1132317/share-of-vod-subscribers-in-norway/

64 Nkom (2023), p. 25
65 Nkom (2023), p. 17

Most popular web browsing was checking the weather (67 % of the population on an average day), banking services (57 %) and purchasing travel tickets (16 %). In addition other popular web services were health and public services, digital mailbox, purchasing other tickets, and dating sites.[66]

In Norway, for mobile networks, traffic growth over the past two years was particularly driven by the launch of fixed wireless access[67]. Also the increased data allowances have increased in recent years without pricing rising proportionally.[68]

Interviews with several Norwegian stakeholders confirmed the view that the introduction of (high quality) OTT services has increased annual growth rates since 2012, but that traffic growth starts to level off after 2020. Overall, traffic trends in Norway are not different from the rest of Europe.

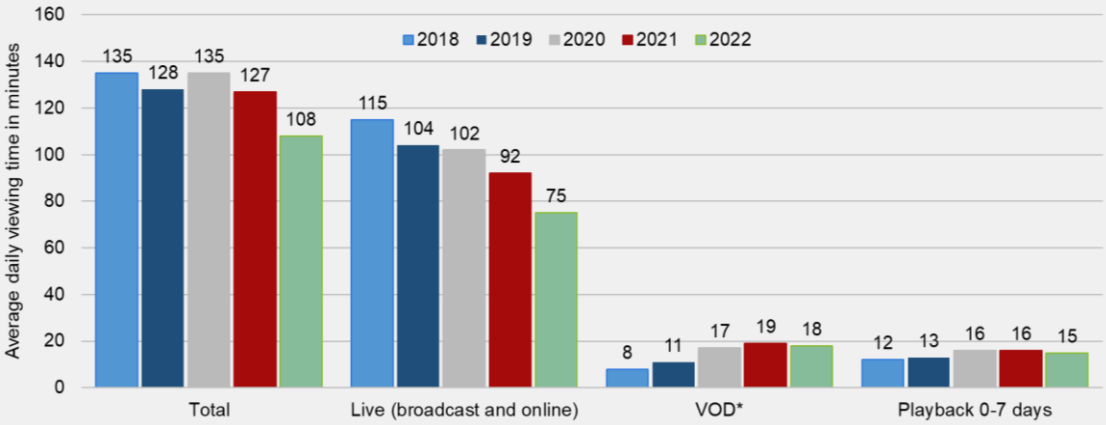
An interviewed content provider confirmed the growth until 2022, but noted that their traffic for Norway is now flattening due to stabilizing demand, but also due to their approach of spreading new content releases over the year, increased codec efficiency and better end-user devices. One CAP interviewed expected that more efficient codecs would halve the demand for data bandwidth.

There are also other factors that contribute to traffic in Norway, such as the popularity of sports content such as the Premier League, Champions League and specifically Norwegian winter sports events. In addition, local broadcasters such as NRK and TV2 use third party CDN providers with cache servers located outside ISP's access networks, which also results in additional traffic compared to having cache services 'on-net' in the ISP's access networks.

However, Figure 3-5 shows that in Norway, despite overall more consumers streaming video, average minutes spent daily is declining since 2020.

66 Statistics Norway (2023), p. 67
67 Nkom (2023), p. 17
68 Nkom (2022a)

Figure 3-5: Average daily time spend on video streaming services in Norway from 2018 to 2022 (in minutes)

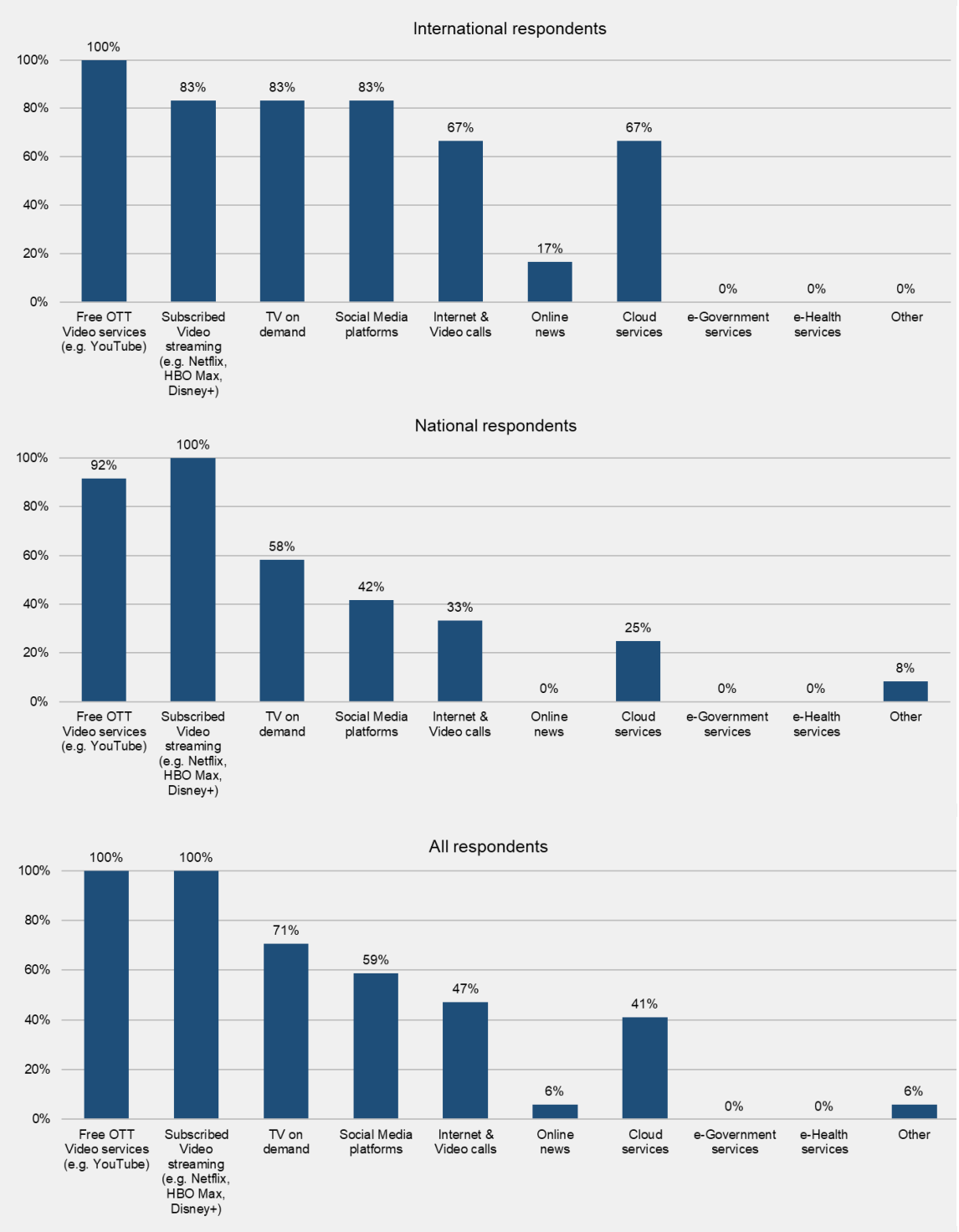


Description: The total TV and online TV time in Norway declined by nearly 20 minutes from 2021 to 2022. The viewing time of live television content dropped the most, while the consumption of broadcaster video-on-demand decreased by just one minute in the same time period. However, live TV was still the most popular among the population. Norwegians spent 75 minutes per day on average on live TV broadcasts and only 18 minutes watching online television in 2022.
Note(s): Norway; 2018 to 2022; 10-79 years; * Only for media houses NRK, TV2, Warner Bros. Discovery, and Viaplay Group; excl. viewing time of streaming services such as Netflix and HBO.)

Source: Kantar TNS (Norway). (January 18, 2023). Average daily television and broadcaster video-on-demand viewing time in Norway from 2018 to 2022 (in minutes) [Graph]. In Statista. Retrieved November 16, 2023, from https://www.statista.com/statistics/1130710/average-daily-tv-and-online-video-viewing-time-in-norway/

Our survey in Norway shows that international players see a wider range of services as responsible for traffic growth over the past 5 years than players operating only in Norway (see Figure 3-6). While national players agree with international companies that free and subscription video streaming are the main drivers of traffic growth, international respondents place slightly higher importance on TV on demand, social media, video calling and cloud services as drivers of traffic demand.

Figure 3-6: Main drivers of Internet traffic growth in Norway for 2019 to 2023



Source: WIK survey via Lamapoll, multiple selection, n=20 (6 international, 14 national)

WIK (2022c) observed that Internet traffic in Europe has become increasingly concentrated in a few sources, with 5-6 players accounting for well over 50% of all traffic. When market participants in the survey were asked about their expectations for trends in the concentration of Internet traffic in Norway, the responses from global players were

mixed, with either no change or more or less traffic concentration. New high performance computing (HPC) with artificial intelligence (AI) applications was cited as a reason for increased traffic concentration, while CDN deployment was cited as a reason for traffic decentralization.

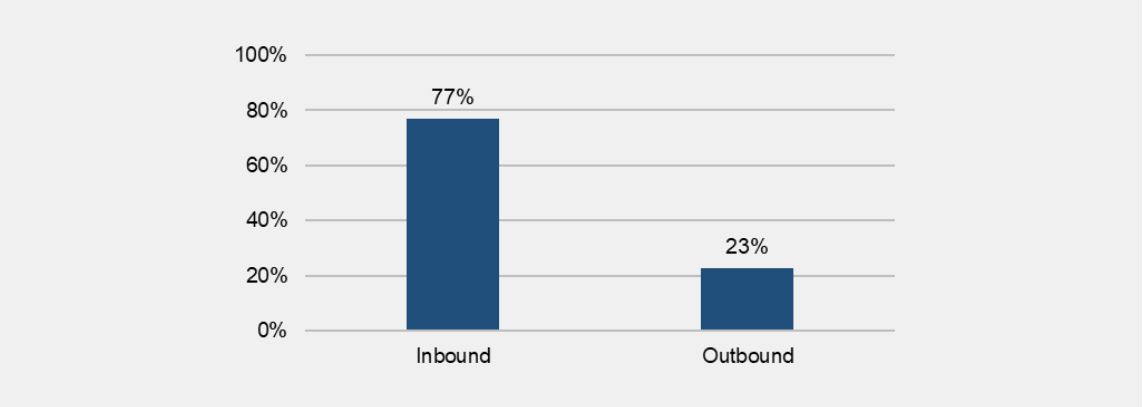
3.1.4 Symmetry / asymmetry of traffic

Feldmann et al (2021) reviewed the impact of the COVID pandemic and the lockdown on the asymmetry of data traffic in Europe and found that from 2019 to 2021 the inbound/outbound ratio decreased from 9,8 to 9 due to more upload traffic and especially video conferencing. As observed in 2022, in Europe, IP traffic was still asymmetric as the majority of end users have an asymmetric internet connection despite significantly more upload traffic due to increased home office use applications like video conferencing.[69]

In France, one of the few European countries closely monitoring and reporting on the symmetry of interconnection traffic, a growing asymmetry of outbound and inbound internet traffic has been observed for years. In 2022 this ratio was around 1:11 with a small decrease compared to 2021. This was according to ARCEP due to “traffic stream compression and optimisation efforts made by CAPs, which has reduced inbound traffic to ISPs” and “the development of new peer-to-peer video traffic transport methods that increase outbound traffic”.[70]

However as shown in Figure 3-7, participants of our market survey in Norway, indicated that the ratio is Norway shows significantly more upload / outbound traffic compared to France or Europe, resulting in a ratio of 1:3,3 (77/23).

Figure 3-7: Estimated share of inbound versus outbound Internet traffic in Norway for 2023 (% of total traffic)



Source: WIK survey via LamaPoll, n=14

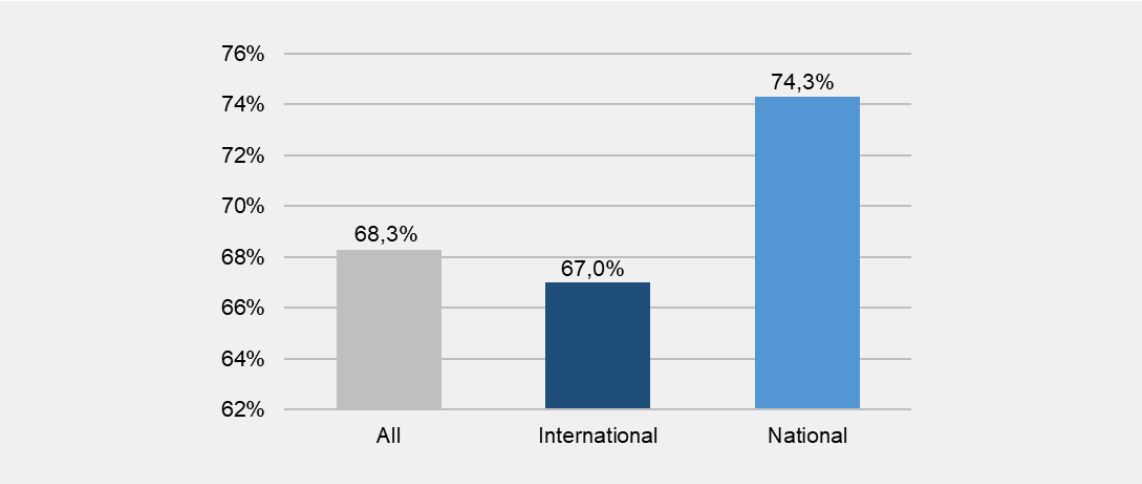
69 WIK (2022c)
70 ARCEP (2023), p. 4

3.1.5 Concentration of traffic

Internet traffic is relatively concentrated in terms of its origin/source. Over the years this concentration has increased. In 2007 several thousand networks accounted for 50% of the traffic, in 2013 this was already reduced to 35 networks[71]. Few countries in Europe, apart from France, report on this aspect. In France, regulator ARCEP reported that by end of 2022, 54% of the inbound traffic of the main French ISPs was accounted for by five providers Netflix, Google, Akamai, Meta and Amazon.[72]

Our survey in Norway showed that the concentration in Norway could be even higher. Figure 3-8 shows that the estimated amount of traffic related to the top 5 applications in Norway (free/subscribed VoD, TVoD, social media and internet and video calling) accounted for a total of 68% of all traffic. Stakeholders only active in Norway indicated an even higher concentration of 74%.

Figure 3-8: Internet traffic related to top 5 applications in Norway for 2023



Source: WIK survey via LamaPoll, n=16 (9 international, 7 national

Furthermore, stakeholders were asked about their expectations for the next 5 years. Several indicated that high quality video streaming will remain the main application causing traffic, but that increased 5G and FWA coverage will reinforce this. Additionally, new technologies like HPC, AI and the combination of these with social media are expected to concentrate the origin of internet traffic further in Norway.

3.1.6 Peering versus transit traffic

Interconnection between market parties physically can takes place at any Point of Presence (POP), data centre or IXP where both parties are present with their network. The related commercial agreements to exchange Internet traffic takes place via so called peering- and transit agreements. If peering is done via a public IXP it is called public

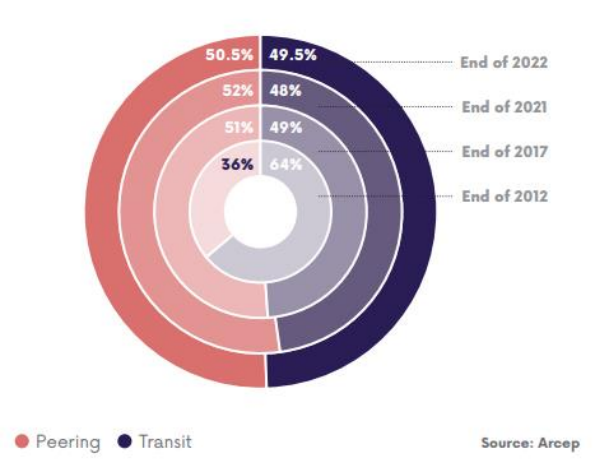
71 BEREC (2017)
72 ARCEP (2023), p. 7

peering versus private peering over a direct interconnection between parties in a data centre or POP.

Transit providers offer their customers access to the entire internet. In contrast, peering only enables mutual data exchange between two networks (and to their respective customers who are connected to those networks). The advantage of peering is the avoidance of (traffic dependant) transit costs and the increased quality of the network interconnection. This exchange is mostly often done settlement free, so without any direct payments, except for the case of paid peering. Usually both parties negotiate on how they share the costs required to establish the physical interconnection between each other.

In Europe, transit has been slowly but steadily replaced by peering and the strong shift to on-net CDN traffic. A European example, France, is shown in Figure 3-9. In the period from 2012 to 2022 , transit traffic reduced from 64% to 49.5% of total traffic volume for the main ISPs.

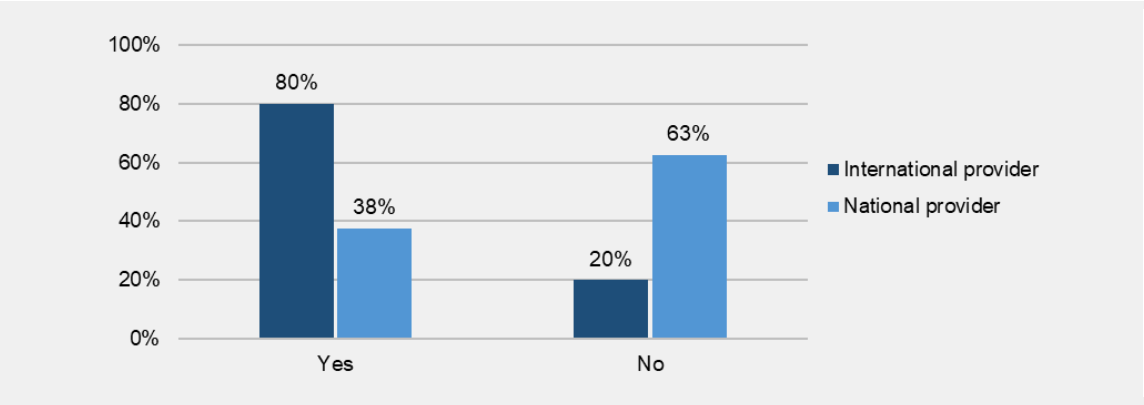
Figure 3-9: Peering vs Transit traffic in France 2012-2022 (as % of volume for the main ISPs)



Source: ARCEP (2023), p. 5

As shown in Figure 3-10, in our market survey in Norway, international players confirmed that increased direct peering contributed to a decrease in transit over time in Norway (80%). However, Norwegian-only actors in the survey had a different opinion (63% denying this trend). This could be explained as many smaller Norwegian market players might be too small for peering arrangements so still very much depend on transit. Looking at the data by type of market player does not provide any more insight; for all ISPs surveyed, 50% agree and 50% disagree.

Figure 3-10: Substitution of IP Transit by direct peering in Norway for the last 5 years



Source: WIK survey via LamaPoll, n=13 (5 international, 8 national)

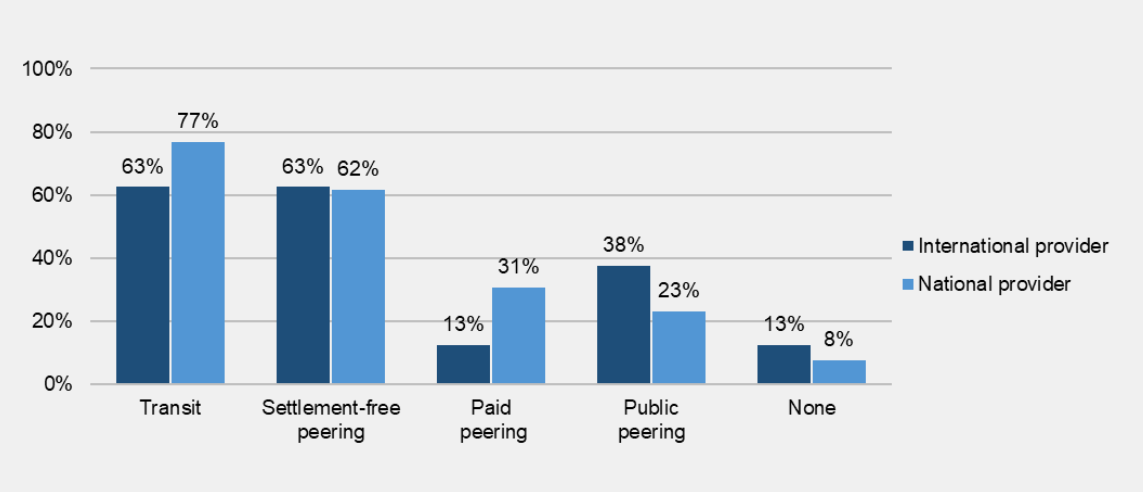
Irrespective of the geographical coverage, survey participants noted that transit will remain important to assure global connectivity and an option for 'overflow' traffic[73] and redundancy. Another reason for maintained use of transit is that the refreshing of CDN cache servers in Norway from servers outside Norway in the off-peak time is mostly based on transit. This was confirmed by an interviewed CDN provider, which noted that beside global coverage and redundancy, IP transit and peering are both important for 'cache filling' (refreshing the content of their cache servers, co-located in ISP networks). As an alternative to transit and peering for caching, CAPs could use their private network, if available in Norway. At this stage, it is not clear to what extent CAPs operate private networks in Norway.

An interviewed CAP stated however that it barely uses transit and the interviewed ISP confirmed the shift from transit to bi-lateral peering arrangements not only within Norway, but also in the Nordics and especially at the Stockholm IXP mostly because of the presence of international players (due to the professional approach of Netnod).

Respondents were also asked what form of commercial arrangements they currently use. Figure 3-11 shows that most respondents currently use a combination of transit, settlement-free peering and, to a lesser extent, paid and public peering arrangements to handle their Internet traffic in Norway. In addition, the survey asked what proportion of the parties' Internet traffic was handled via the different arrangements. It turned out that, despite the fact that the parties have several commercial arrangements, the majority of the traffic volume is still handled via IP transit, followed by settlement free and paid peering. This appears to be a general approach, as there is no correlation with the geographical area in which the participants are active. Paid peering agreements seem to be a kind of safety net in case one of the peering partners does not fulfil the conditions of the peering policy.

73 If the peering capacity between partners is unexpectedly completely utilised, there are secondary routes setup in the systems controlling the routing of the traffic, which can be transit partners offering termination to these destinations as well.

Figure 3-11: Used commercial arrangements for exchange of Internet traffic in Norway for 2023



Source: WIK survey via LamaPoll, multiple choice, n=21 (8 international, 13 national)

3.1.7 CDN traffic

With the transition to digital content progressing, the quality of electronic communication networks is becoming more important globally and CDNs could contribute to fulfilling the desire for higher quality in electronic communication.[74] According to the OECD, Akamai was one of the earliest providers of CDNs with an approach to cooperate with local partners in order to bring the content as close as possible to the end customer rather than focusing on establishing equipment to the largest cities.[75]

A distinction can be made between companies that use CDN to provide their own services (in-house CDN) and/or sell CDN services commercially to third parties (third-party CDN). There is also a distinction between how CDN services are provided, either through caching services within an ISP's access network (on-net CDN) or through servers located at the nearest POP or IXP (off-net CDN).

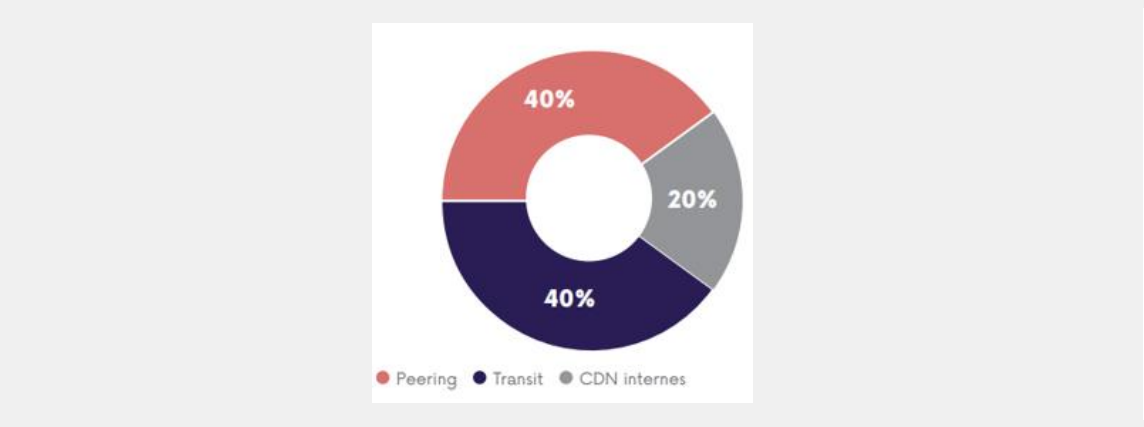
Nkom (2023) noted that 'Internet service providers in Norway reported that on-network CDN traffic accounts for more than 50% of the total interconnection volume in the network infrastructure today and this explains also the decline in transit traffic for internet service providers, which accounts for only 5-10% of the total interconnection volume.[76]

According to our market survey in Norway, the estimated average share of CDN traffic as part of a market player's total internet traffic is a bit lower, around 38,5 % (N=11). However, four CAPs, which mostly rely on CDNs, responded that CDN's in their Norwegian networks handle between 50-90% of the traffic with an average share of 76%.

74 OECD (2022), p. 43
75 OECD (2022), p. 33
76 Nkom (2023), p. 23

By comparison, in France, as shown in Figure 3-12, by end of 2022 CDN traffic was only 20% of all interconnection traffic and amounted to roughly 10,5 Tbit/s.

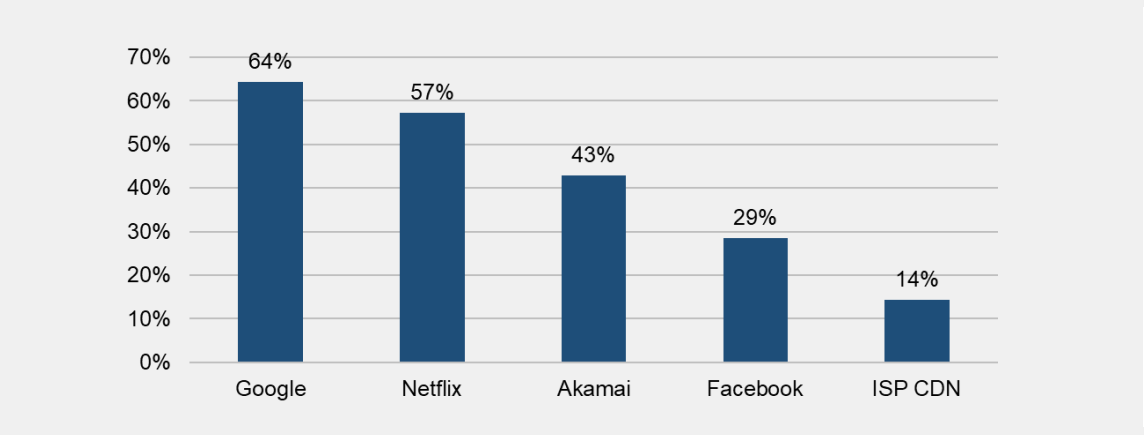
Figure 3-12: Interconnection traffic by type in France (end 2022)



Source: ARCEP (2023), P. 5

Figure 3-13 shows which CDNs are mostly co-located in Norwegian ISP's networks. The order of co-located CDNs reflects the share of total traffic across networks attributable to each actor. We note that the type of CDN provision differs between the players; major CAPs, Google, Netflix and Meta co-locate their CDNs on ISP networks to deliver their end-user applications to third-party CDN provider Akamai, and finally ISPs own CDNs (for their own content).

Figure 3-13: Co-location of CDN providers in Norwegian networks in 2023



Source: WIK survey via LamaPoll, n=14.

Furthermore, Norwegian ISPs highlighted in our market survey relevant aspects of agreements between CDN providers and ISPs for co-location in their networks:

1. The ISP determines the location of CDN servers. (39%)
2. The CAP develops and provides CDN servers. (33%)
3. The ISP provides space, power and manages devices. (24%)

Norwegian ISPs confirmed in our survey the well-known benefits of ensuring better quality service for end user with lower latency and decreasing costs for IP transit due to the deployment of on-net CDNs.

3.1.8 Traffic via IXP

WIK (2022c) observed that "As a consequence of more direct peering and on net CDN traffic, the importance of traffic exchange via Internet Exchange Points (IXP) has decreased, despite further growth in traffic." However, they also noted that "Nevertheless, the importance of IXPs remains central to the functioning of the internet; for smaller players relying on public peering at IXPs but also for larger players providing backup and resilience services.".

The major location for public peering in Norway, is the Norwegian Internet eXchange (NIX), which is owned and operated by The University of Oslo since its launch in March 1993. Today NIX operates a total of six separate peering LANs across Norway to facilitate both redundancy in the Oslo area (NIX 1 and 2), and regional peering in the less densely populated areas of Norway (Stavanger, Bergen, Trondheim and Tromsø). In early May 2023, German interconnection operator DE-CIX[23] also put two interconnection points in Norway (Oslo and Kristiansand) into operation.

According to the 2023 Nkom annual report, interconnection via public interconnection points is particularly important for smaller ISPs and an opportunity to meet major providers to exchange traffic with them. For the larger internet service providers, NIX can be used to supplement and back up their, mainly, private interconnections. As of Q1 2023, NIX had 70 domestic and international customers (connected networks), and most major international operators are present in NIX, such as Amazon, Microsoft, Akamai, Cloudflare, Dropbox, Huawei Cloud and NORDUnet.[77]

As Figure 3-14 shows, most of the public and private peering between Norwegian ISPs is still geographically centralised in Oslo.[78] The size of the circles illustrates the relative difference in inbound/outbound internet traffic volume in 2022.[79] The annual average for inbound/outbound internet traffic across the entire NIX infrastructure is 94 Gbit/s in 2022, with NIX1 and NIX2 in Oslo accounting for 88 Gbit/s (93% of the total traffic on the NIX infrastructure) and other NIX interconnection points together accounting for only 6 Gbit/s.[80]

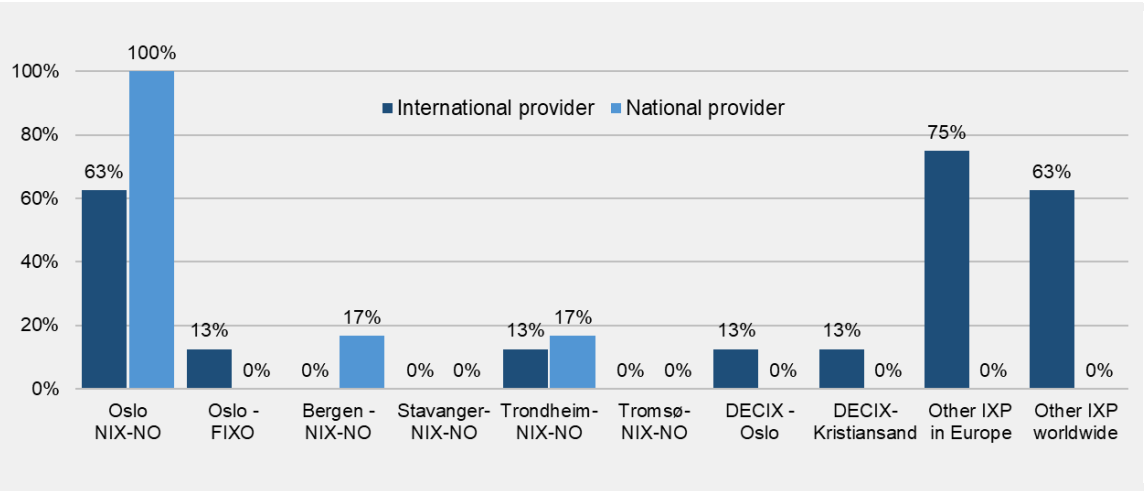
77 Nkom (2023)
78 See https://www.netnod.se/blog/peering-norway-traffic-growth-and-shifting-patterns
79 See www.nix.no/statistics
80 Nkom (2023)

Figure 3-14: Location and (traffic) size of the Norwegian IXPs in 2022

Source: www.nix.no/statistics

The centralization of interconnection in the Oslo area is also mirrored by responses in our market survey. Figure 3-15 highlights which IXPs are used by global and national market players. Unsurprisingly global players are also connected to other IXPs in Europe and worldwide and national players rely primarily on interconnection at NIX locations. Global players are also present in the newly established DECIX IXP in Norway and none of the surveyed market players is present at the Tromso NIX in Norway.

Figure 3-15: Connection to IXPs by Norwegian market players as of 2023



Source: WIK survey via LamaPoll, n=14

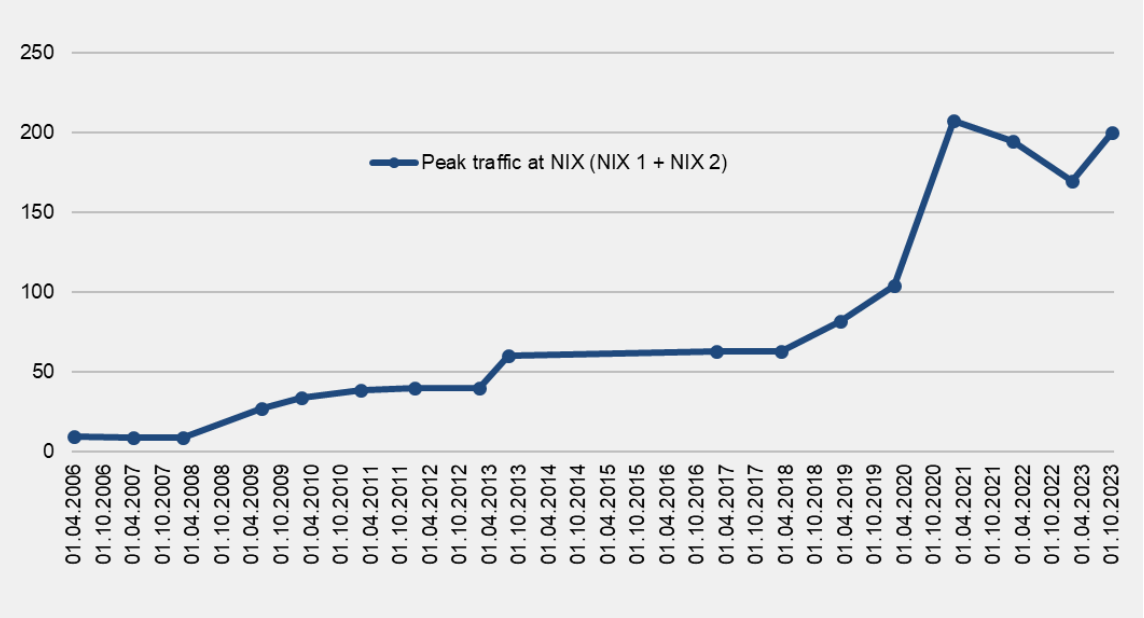
The traffic development since 2006 for the largest IXPs in Norway, NIX 1 and 2, is shown in Figure 3-16. In the early phase (2006-2013) there was a steady growth of internet traffic, with a step-up in capacity in 2013 from 40 to 60 Gbps. From 2018 onward, the growth accelerated and during the Covid-19 pandemic traffic doubled to 204 Gbps. In

2022 there was a dip in traffic, but traffic volume has picked up again from Q2 2023 and is now almost at the peak level experienced during Covid-time (200 Gbps).

The strong growth in traffic on NIX from 2017 to 2019 is due to more, especially international, providers connecting. From interviews with Norwegian stakeholders, we conclude that, contrary to the trend seen elsewhere in Europe in recent years, there are no business customers beside network operators directly connected to NIX, which is a policy decision. NIX has considered changing this, but there has been no commercial interest from business customers due to the time required to manage such a peering relationship compared to using a transit provider.

Also from 2018 onwards, NIX started a technical and marketing cooperation with Netnod, the operator of the Stockholm IXP, which enabled Netnod's customers under the same contract to also use NIX services. An important aspect for NIX is the marketing support from Netnod, which has made NIX more visible.

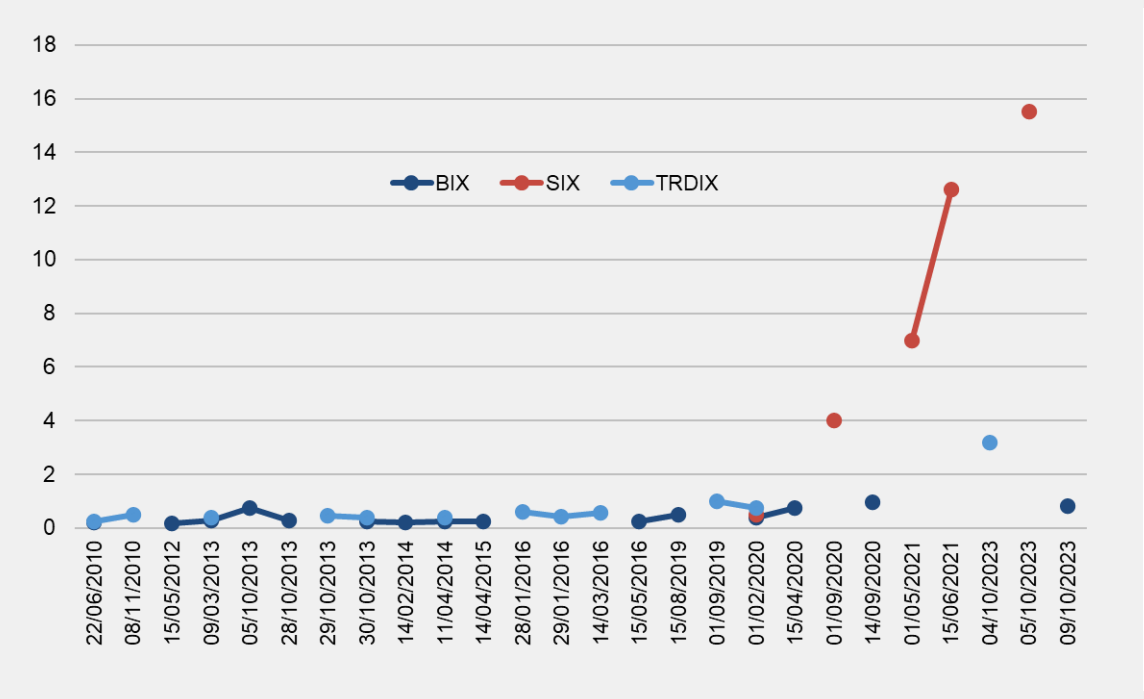
Figure 3-16: Peak Internet traffic at Oslo IXPs (NIX1 and 2) for 2006-2023 (Gbps)



Source: https://www.nix.no/statistics/ and webarchive – aggregated by WIK

For the smaller IXPs in Norway, not all developments are clear due to limited data points, but Figure 3-17 shows that until Q2 2020 their traffic was limited (below 1 Gbps) but thereafter accelerated strongly for certain IXPs. Especially the Stavanger IXP (SIX) jumped from below 1 Gbps to 4 Gbps peak capacity and continued to grow until the current traffic amount of almost 16 Gbps. But also the Trondheim IXP (TRDIX) has grown significantly during COVID; from below 1 to over 3 Gbps peak capacity. The following paragraph will discuss further details of traffic regionalization in Norway.

Figure 3-17: Peak Internet traffic for Bergen, Stavanger, Trondheim IXP for 2010-2023 (Gbps)



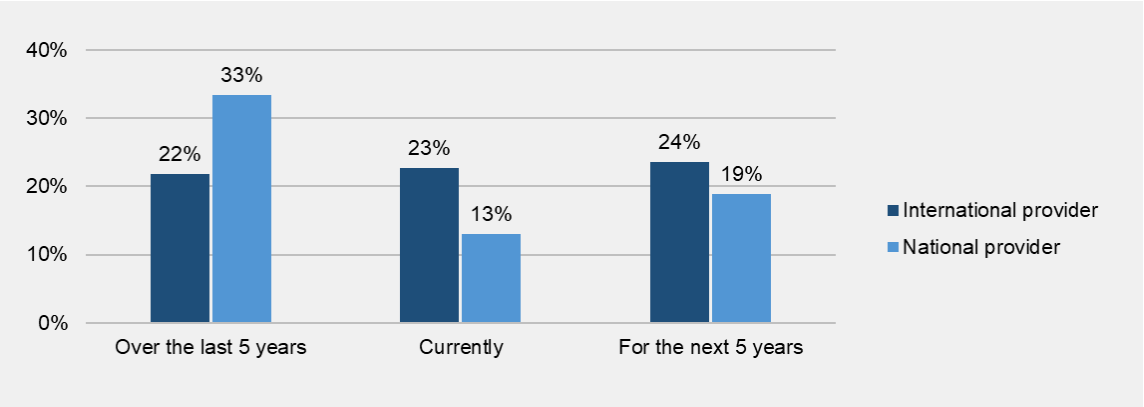
Source: https://www.nix.no/statistics/ and webarchive – aggregated by WIK

From the interviews it became clear that many ISPs in Norway also use extensively the IXP in Stockholm as they are also active in other Nordic countries and the performance of the Stockholm IXP is good. The same applies for CAPs, which can serve the complete Nordics from the Stockholm IXP.

The ISPs that participated in our survey confirmed that only a fraction of their Internet traffic destined for Norwegian customers is handled by IXPs in Norway (on average between 13% and 22%). Figure 3-18 also shows that the traffic share of national operators has on average fallen sharply to date (from 33% to 13% of their total traffic). However, on average national operators expect a slight reversal of this trend in the next 5 years. One reason for this trend and expectation could be the increased use of third party CDN providers by national players co-located in the Stockholm IXP in recent years, and the expectation that in the future some of these CDN servers will be located in, most likely, the NIX in Oslo.

In contrast, international providers reported a relatively stable share of their traffic handled by IXPs within Norway (22-23% of traffic) and do not foresee any significant change in this share over the next 5 years.

Figure 3-18: Share of Norwegian Internet traffic handled by Norwegian IXPs



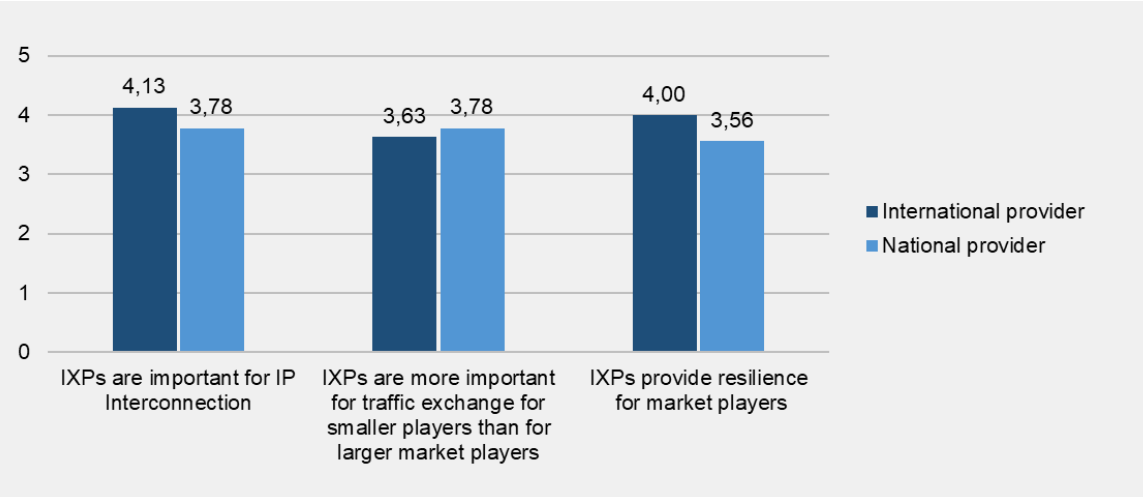
Source: WIK survey via LamaPoll, n=12 (6 international, 6 national)

To shed further light on the perceptions of IXPs in Norway, ISPs participating in the survey were asked how much they agreed with the following statements:

- IXPs are important for IP-Interconnection
- IXPs are more important for traffic exchange for smaller players than for larger market players.
- Please indicate to which degree the following statements apply for IXPs in Norway. IXPs provide resilience for market players.

Participants could express their agreement with values from 1 (strongly disagree) to 5 (strongly agree). As shown in Figure 3-19, all respondents have a high valuation for IXPs and their role for interconnection in Norway. International players value the importance of IXPs for IP interconnection and for resilience higher than national operators. At the same time, national providers value IXPs' importance for smaller market participants slightly higher than international players.

Figure 3-19: Importance of IXPs in Norway for market players



Source: WIK survey via LamaPoll, average figures, n=19 (9 international, 10 national), values range from 1 (strongly disagree) to 5 (strongly agree).

3.1.9 Regionalisation of traffic

According Nkom's 2023 report 'Internet in Norway'[81], the Stavanger IXP (SIX) is the second largest public interconnection point in Norway, with an annual average of 5 Gbit/s. SIX is located in Green Mountain's data center, where also CAPs and CDN providers are located. As described in the previous paragraph, there is not much traffic on the other regional IXPs in Norway. The jump in traffic for SIX is caused by a data center built by Microsoft for which they wanted to establish public peering.

Nkom furthermore observed a high demand for regional interconnection which is not met by corresponding supply. "Other than SIX, there is a limited degree of regional interconnection in Norway, and some of the small providers regret that data traffic from their networks and customers must be sent to Oslo in order to be connected to the largest providers' networks. However, all providers emphasize the importance of regional peering and see a need for regional/local interconnection points in order to optimize traffic flows. Nkom has registered an increased interest among several network owners in exchanging traffic in Tromsø (TIX) and Stavanger (SIX), which could also have an impact on robustness and diversity in a national context.".[82]

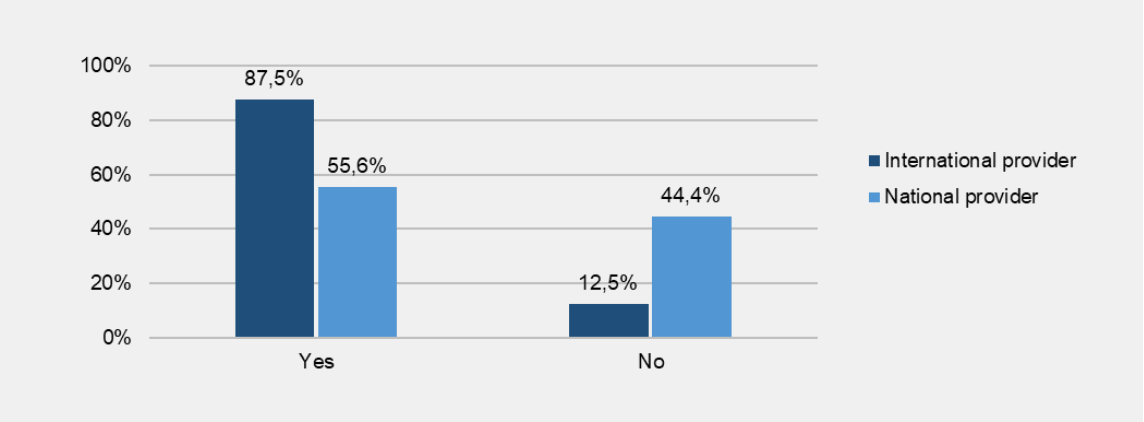
In the interviews, an IXP provider noted that a prerequisite for more regional traffic are local break outs for mobile traffic, which most likely will increase with 5G capabilities and Fixed Wireless Access (FWA) in Norway. Currently there are no break-outs which results in all fixed and mobile traffic being backhauled to Oslo and is from there re-distributed. Furthermore, it was noted that IXPs should also contribute to the well-functioning of the Internet, so resilience and redundancy of the Oslo traffic hub are important for the digital sovereignty of Norway as well. In regard to regionalisation of traffic, it was noted that the issue is not rooted in the port costs for ISPs but in ISP's own costs to restructure their networks to be able to connect to regional IXPs. Currently, many regional ISP's networks are optimized for costs and not for further regionalization of traffic exchange.

An interviewed ISP expects for the future more regional peering in other large Norwegian cities. Drivers of more regionalisation in the future could be regulatory requirements, regional autonomy or new services benefitting from regional peering.

Respondents were also asked whether or not they could confirm the assumption that Internet traffic in Norway is becoming more regional, i.e. whether Norwegian end-users receive more traffic from servers located in Norway than they did 5 years ago. The survey showed that international market players, confirm the trend of traffic regionalization in Norway more often than national players, see Figure 3-20.

81 Nkom (2023a)
82 Nkom (2023), p. 22

Figure 3-20: Regionalization of Internet traffic in Norway in the last 5 years (hence more traffic handled by servers in Norway)



Source: WIK survey via LamaPoll, n=17 (8 international, 9 Norway), averages, values from 0-100

International players see the reasons for this trend in CDN deployments as well as the deployment of new data centers and edge locations across Norway. Reasons noted by national players are lower transport costs and increased CDN deployment and data centers across Norway. An interviewed Norwegian Data center provider noted that regional DC's are considered due to increasing performance requirements.

3.2 Internet interconnection in Norway

The Nordic region[83] has a high level of interconnectivity between different networks due to its early adoption of the internet and strong governmental support to build the national infrastructure also in more remote areas.

In general, there are relatively good fiber connections between the regions in Norway, forming a robust national network. However, the robustness is lower north of Trondheim. The availability of dark fiber is relatively good, as new players have entered the wholesale market, leading to new dark fiber projects, and more projects are in the pipeline.

In addition, a number of terrestrial and submarine cables connect the Nordic countries to each other, as well as to the UK, Ireland, mainland Europe and North America. In recent years, new direct connections have been established between Norway and the USA and the UK. Norway and Sweden have had a large number of terrestrial cables for many years, and the links between Denmark and Norway have been strengthened in recent years with new submarine cables.

RIPE NCC, as regional internet registry, examines Internet routing within the region, monitors access to the global Domain Name System and investigates connections

83 Sweden, Finland, Denmark, Norway, Iceland and the three independent regions Greenland, Aland and the Faroe islands

between the major networks. Over time it has observed three important indicators of a functioning and mature internet market in Norway:

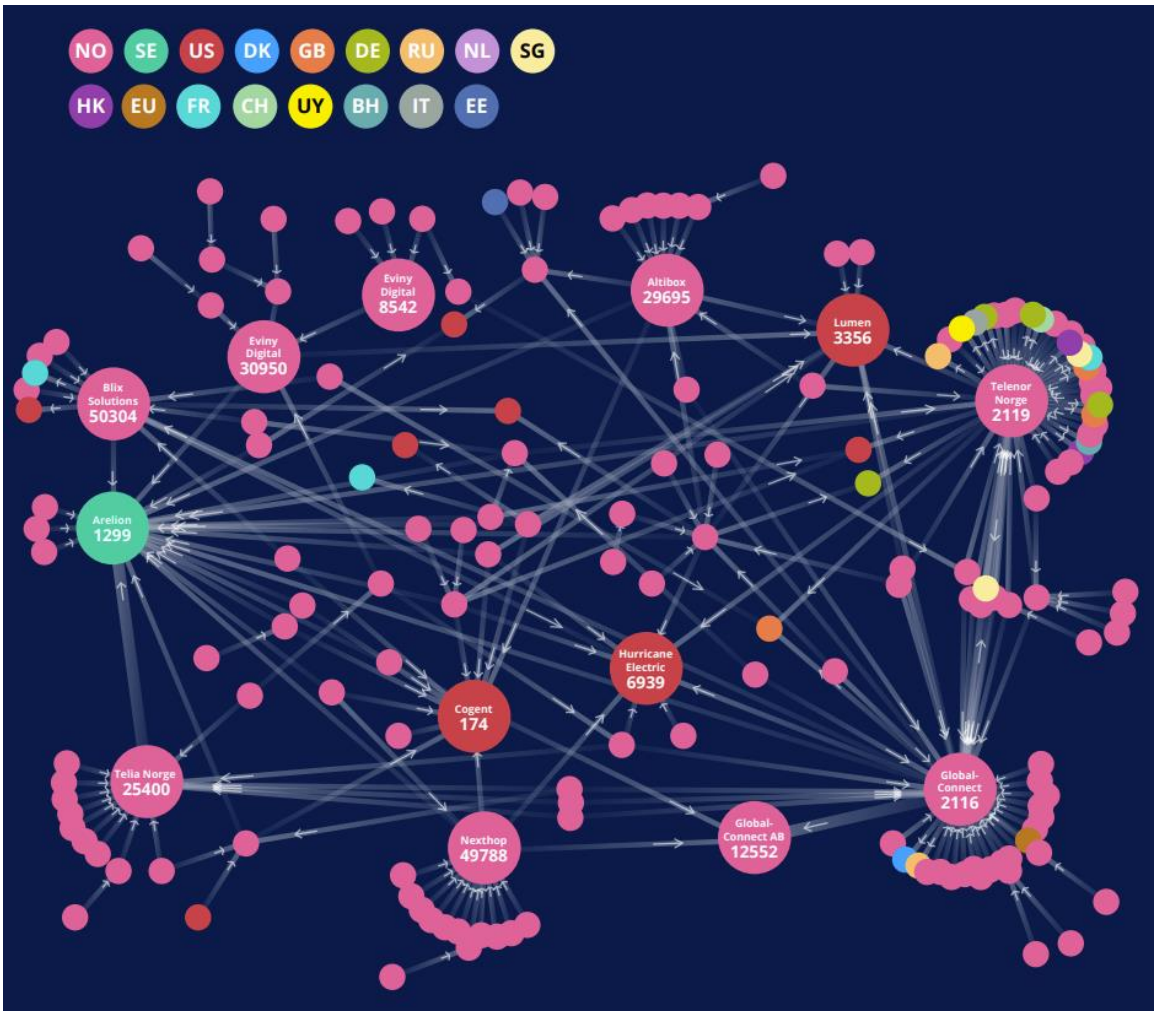
- The growth of the number of local internet registries (LIRs); the higher the more diversified the markets due to more service providers operating their own network. The whole Nordic region saw significant growth in LIRs between 2012 and 2020 (hence service providers), but this levelled out since indicating a mature internet landscape that developed early on. In the last years RIPE observed that the increased number of LIRs is mainly due to a more diverse set of organizations requiring IP addresses to run their own networks, including hosting providers, government agencies, universities etc.
- The number of Autonomous Systems (ASNs[84]) indicating the number of independently operated IP networks. There was a healthy growth in ASNs from 2004-2022. In 2004 around 100 AS were operating in Norway. This number increased to around 350 in 2019 (8,7% annually).
- The number of IP addresses. Due to the early internet adoption in Norway and Sweden, these countries have the largest number of IPV4 addresses held per capita (2.9) across Europe, Middle East and partly Asia. However, despite increasing numbers of assigned IPV6 addresses in the Nordics, they are not all actually used. For Norway, only around 46% of the IPV6 addresses are actually routed, seemingly due to a lack of demand from business.[85]

One of the interviewed stakeholders noted that overall in terms of end-user latencies the performance of Norwegian networks is great, which is a sign of a healthy internet ecosystem.

Figure 3-21 provides an overview of connectivity between networks in Norway. It shows that in Norway, a relatively large number of networks are multihomed and connect directly to international providers like Cogent, Lumen and Arelion. Nevertheless there is still a sizeable number of networks that only connect to one of the larger providers Telenor Norge, Global Connect or Altibox, which indicates a dependency.[86]

84 An ASN is characterized as a group of IP networks that use a single, clearly defined routing policy.
85 RIPE (2022), p. 5.
86 RIPE (2022), p. 14

Figure 3-21: Connectivity between Autonomous Systems (networks) in Norway



Source: RIPE (2022), p. 15, Figure 12.

3.3 Norway's global connectivity

Norway is well connected in the global network of networks. Norway's global connectivity is in line with that of the Nordic region as a whole, although each country's situation is different.[87] Norway's global connectivity is affected by the fact that the Nordic region is largely served by mostly the same ISPs.[88] To illustrate this: In Denmark, the incumbent TDC and Telenor are major ISPs in fixed and mobile networks. In Norway, Telenor, Altibox and Telia are major ISPs. Telenor and Telia also dominate the fixed and mobile markets in Sweden. In Sweden, TDC also is a relevant player.

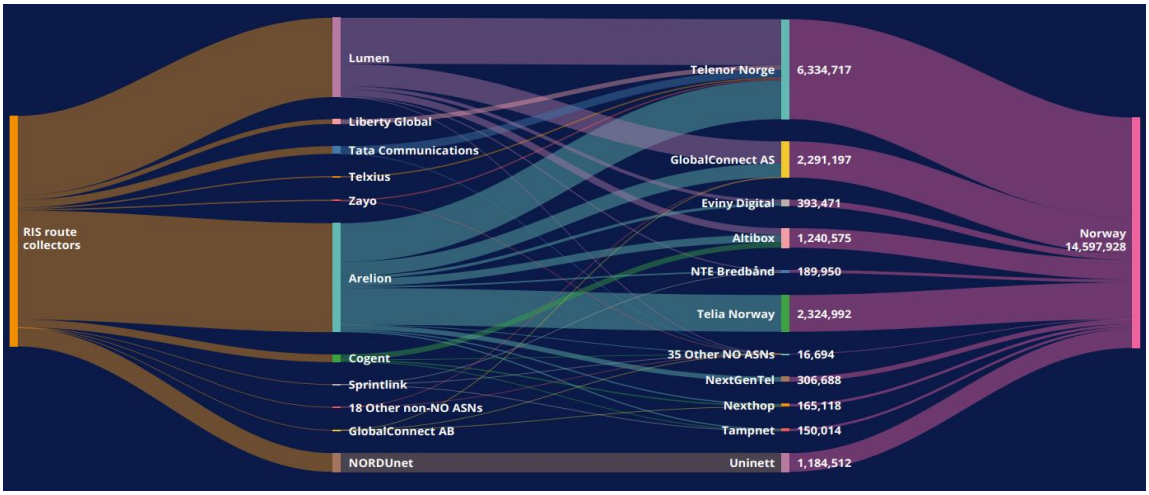
87 We refer to RIPE (2022) for a systematic analysis for all Nordic countries.
88 RIPE (2022)

Figure 3-22 shows an indication of the international connectivity between the different ISPs in Norway at the right to Tier 1 and other international backbone providers at the left. This is based on the number of IP addresses reached via each connection, which form an indication for the number of end users are served and related exchanged Internet traffic.

In Norway, Lumen and Arelion are the dominant transit providers for Telenor Norge, GlobalConnect, Altibox and Eviny Digital. In addition, also Cogent, Liberty Global and Tata Communications are used as transit providers, but to a lesser extent. Only Telia Norway relies fully on Arelion, as Arelion emerged from Telia's former carrier division and Uninett is part of NORDUnet, which is the international collaboration between the National research and education networks in the Nordic countries. **89**.

It can also be observed that, for redundancy Norwegian ISPs use multiple transit providers to exchange their internet traffic.

Figure 3-22: Norways international connectivity**90**



Source: RIPE (2022)

A number of submarine cables connect the different Nordic countries to each other and to other regions, e.g. the UK, mainland Europe and North America. In 2020, Nkom identified a vulnerability of the country's backbone connectivity because of great shares of interconnectivity going through and coming from Sweden. Nkom pointed out "…the need to strengthen the geographical diversity of the routing of internet traffic to and from Norway, against the background of national security and emergency preparedness. This is becoming increasingly important as internet-based cloud services, which are often produced outside Norway's borders, constitute a more and more significant input factor for key functions in society."**91**

89 Nkom (2023), p. 25
90 RIPE (2022), p. 21, Figure 17
91 Nkom (2022)

Consequently, the government subsidized fiber connections (mainly via private projects) to contribute to Norway's international connectivity. The following submarine fiber connections were established since 2020: [92]

- Bulk, 2020: "Mermaid" from New Jersey (USA) to Blaabjerg (Denmark) and Kristiansand
- Altibox, 2020: "Skagenfiber West" from Larvik to Hirtshals (Denmark)
- Altibox, 2021: "NO-UK" from Stavanger to Newcastle (UK)
- Bulk, 2022: "Havsil", from Kristiansand to Hanstholm (Denmark)

Dreibholz et al.(2022) modelled and analyzed the various routes traffic may take from Norway to Sweden, Germany, and China. They found that the number of traffic detours increases with distance between the locations (i.e. traffic between neighboring countries, intra continental traffic to intercontinental traffic). Furthermore, they found that because of the yet limited number of IPv6 links, the variation of routes taken is smaller in the IPv6 traffic as routes seem to be more direct for IPv6 traffic than for IPv4 traffic[93]. Given that Norway is well underway to full IPv6 migration which is planned by 2025 (with an adoption of 36.6 % by 2023), it could be assumed, that relevant parts of Norway's intracontinental traffic may be routed with a limited share of transatlantic detours, hence with better quality.[94]

92 Nkom (2021), p. 42 and https://www.submarinenetworks.com/en/systems/intra-europe/havsil, accessed on Sep 27th 2023
93 Dreibholz et al (2022)
94 Nkom (2023), p. 2, 18

4 Interconnection agreements, pricing and costing of interconnection

4.1 Price and cost trends

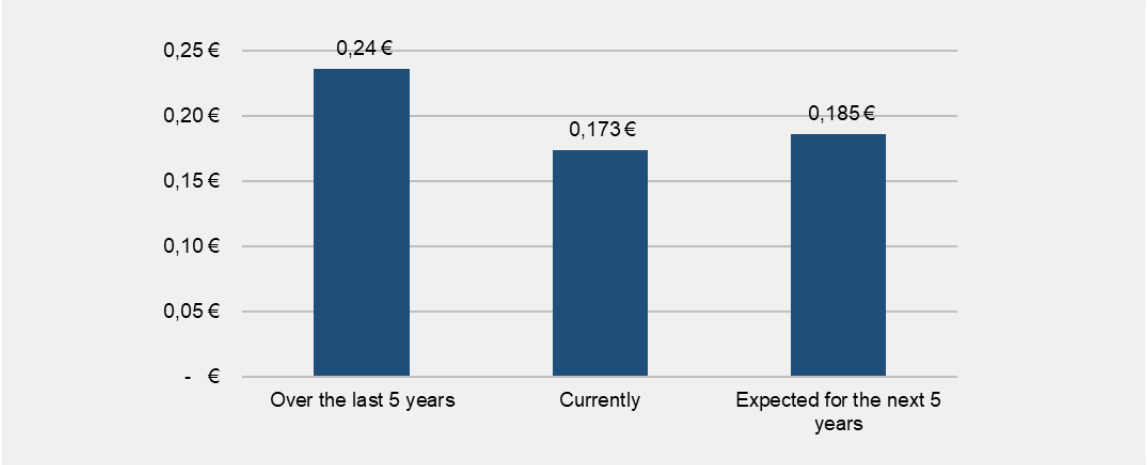
Peering and transit prices

WIK (2022c) observed that costs of network components used for peering and transit in Europe continued to fall steadily and the price development of transit and IXP services seems to correspond to the degree of this cost reduction. It indicated decreasing transit prices of 20% on average per year. (In 2015, USD 0.63/Mbps to USD 0.20 in 2022 and in many cases less than USD 0.10).

This trend is also confirmed for Norway by interviewed stakeholders, however, they noted this trend was slowing down. Figure 4-1 shows results from our market survey in Norway. Participants using IP transit and/or peering indicated that on average IP transit prices have fallen 26% in the last 5 years and for the next 5 years participants predict that prices remain stable (of 13 respondents only 1 indicated to expect to price to increase with 20%).

For paid peering and public peering the number of responses was too low to derive a reliable average. It can only be noted that based on the few responses we obtained the price in the last years for paid and public peering seems to have decreased in a similar manner as transit prices.

Figure 4-1: Estimated average price for IP Transit per Mbps in Norway for 2018 – 2028



Source: WIK survey via LamaPoll, n=13

Interconnection costs in general

We also asked participants to provide a qualitative statement on the underlying costs trend for offering transit. Respondents indicated that costs have decreased, which confirms that transit prices reflect lower costs of handling larger traffic volumes.

There was no specific information on costs of network components specifically for Norway, so it is assumed that cost trends in Norway follow the general trend as the same components are used globally. One interviewee confirmed that hardware component costs are still decreasing, but added that due to increasingly complex technical setups of components, e.g. for increased redundancy and resilience, the overall costs for interconnection are driven up. In addition, it was mentioned that the manpower costs increased, as there is a lack of skilled workforce.

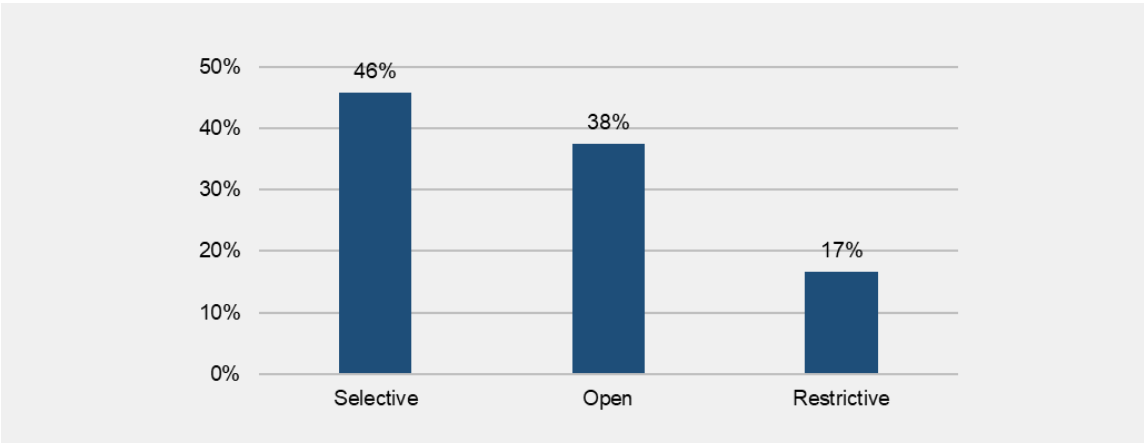
Furthermore, one interviewee noted that interconnection pricing for IXPs is port and capacity based, but for ISPs it is about their own network costs. For example, what does it cost an ISP to connect its network to a specific local IXP or to a POP for peering with other networks.

4.2 Peering policies

WIK (2022c) concluded that “Many CAPs have an open peering policy and have only few prerequisites for peering. However, ISPs have more restrictive peering policies, with many requirements for a number of parameters.”.

Based on publicly available information in the PeeringDB it seems that almost 70% of all listed entities in Norway have an open peering policy, versus 26% having a selective policy and only 5% having a restrictive peering policy. Survey participants however answered quite differently, as shown in Figure 4-2, with 46% indicating that the nature of their general peering policy is mostly selective and 38% being open. This could be explained by stakeholders with more open peering policies opting more frequently to list their offers publicly on PeeringDB, whereas more selective or restrictive providers are more likely to select their peering partners via community events, closed forums or private contacts. Distinguishing between ISPs and CAPs in the survey responses revealed that CAPs on average have a more open peering policy (50% open versus 33% selective) compared to ISP (56% selective and 25% open).

Figure 4-2: Nature of the general peering policy of surveyed actors in Norway



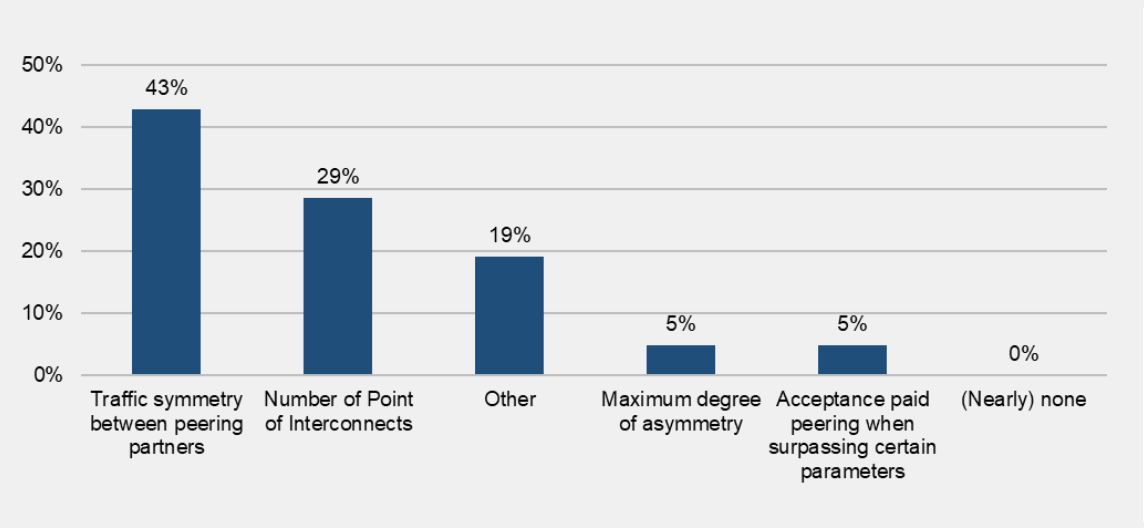
Source: WIK survey via LamaPoll, n=23

As public listings on www.PeeringDB.com contain limited information on conditions to establish peering, survey participants were asked about their policies in Norway. However, an interviewed CDN provider in Norway noted that the requirement of traffic symmetry is an outdated criterion as the majority of their peering relations worldwide are settlement free including those where the traffic ratio is asymmetric.

Figure 4-3, traffic symmetry between peering partners and a (sufficient) number of interconnection points are still the most important conditions mentioned by 43% and 29% of respondents respectively.

However, an interviewed CDN provider in Norway noted that the requirement of traffic symmetry is an outdated criterion as the majority of their peering relations worldwide are settlement free including those where the traffic ratio is asymmetric.

Figure 4-3: Requirements for allowing peering in Norwegian networks



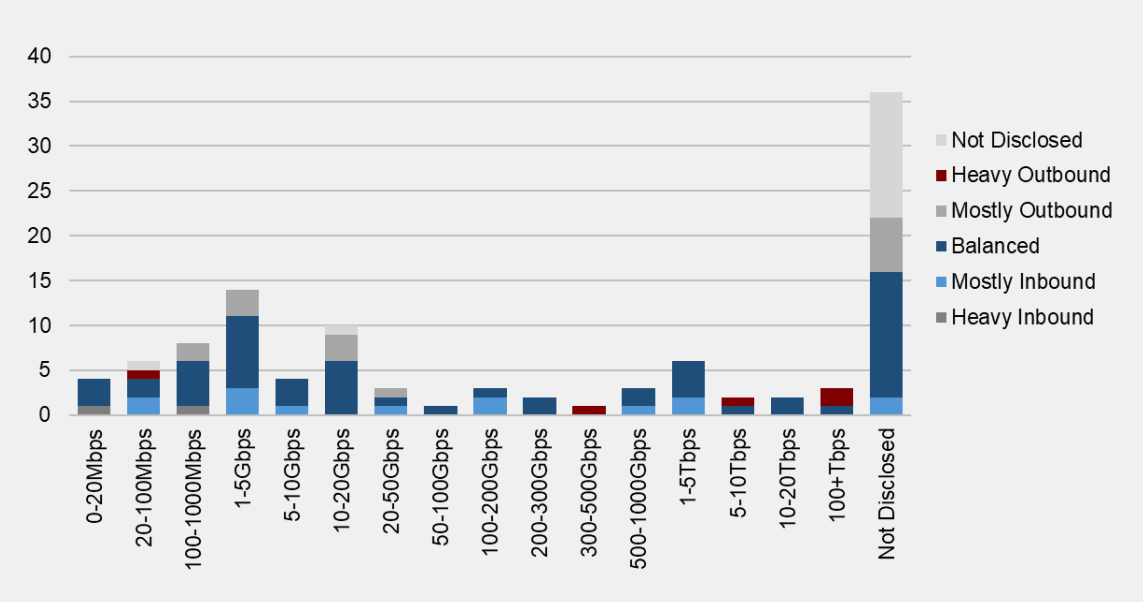
Source: WIK survey via LamaPoll, n= 21

PeeringDB is a freely available, user-maintained database of networks in which peering partners list their own data in search of interconnection partners.[95] We have analysed the available data from PeeringDB for more than 750 Norwegian peering partners in the following graphs. This database may contain a certain bias if peering partners with a preference for transparency and/or open peering policies are more likely to rely on PeeringDB.

Figure 4-4 reveals that more than 50% of all entities listed in Norway have a balanced traffic ratio irrespective of traffic volume. The number of entities with either more inbound or outbound traffic seems to be balanced, both around 15%.

95 See https://www.peeringdb.com/

Figure 4-4: Number of listings on PeeringDB by share of inbound and outbound Internet traffic in Norway for 2023



Source: PeeringDB, own analysis

Regarding an expansion of peering capacity between partners, the survey showed that this is mostly done based on load factors (e.g. the utilisation of the connection between peering partners cannot exceed 80%) and some respondents indicated resilience, localisation of traffic and/or new DC/POP locations as reasons.

With respect to peering policies we analysed several presumptions for Norway based on data from PeeringDB:

a) Smaller entities have a more open peering policy and larger entities a more selective

b) Most of the peering partners in Norway are active only in either Norway or the Nordics

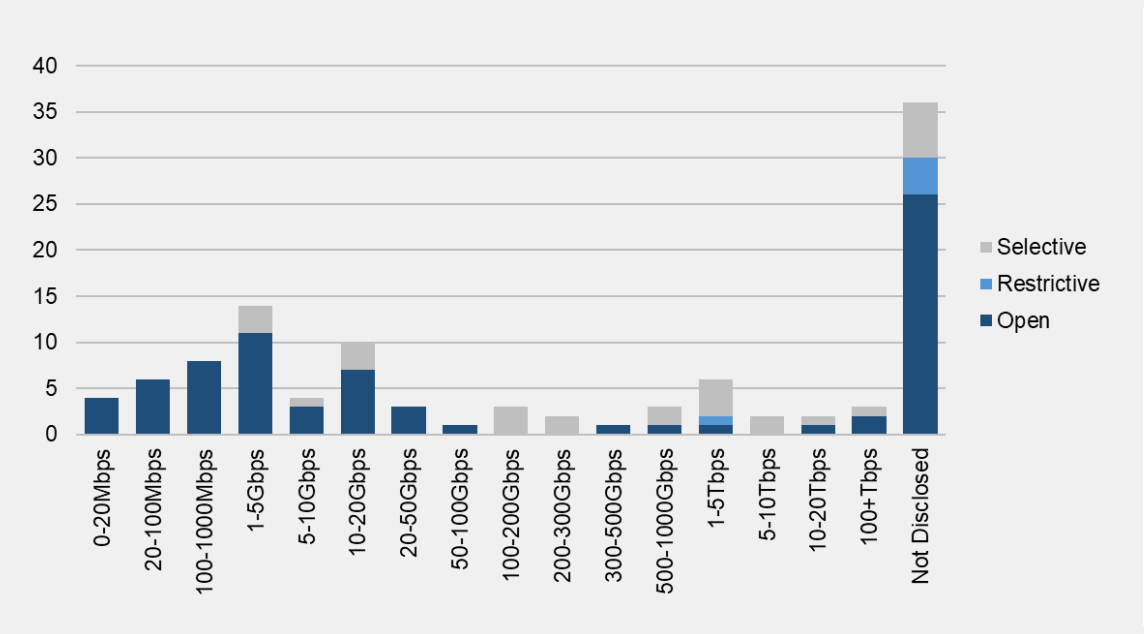
c) National players have less outbound traffic as globally-active ones

d) The more inbound traffic an entity receives, the more selective its peering policy

Ad a) ‘Entities with more traffic are more selective and vice versa’

In respect to the relation of traffic (size) to peering policy, it seems that the more smaller entities have an open peering policy. As can be seen in Figure 4-5, entities with a certain traffic size (200 Gbps +) apply selective policies. Then with growing size, from 300 Gbps onwards, there is a mixed image. There are entities with significant amounts of traffic which apply restrictive policies, but on the other hand, entities with the largest traffic volume of 1-5 Tbps do not apply them. However, this image might be skewed as for a third of the ASNs no traffic data was available (first bar to the left). Hence this assertion is not always true in Norway.

Figure 4-5: Number of listings on PeeringDB by peering policy and traffic volume category in Norway for 2023



Source: WIK, based on data from peeringDB as of Oct 2023

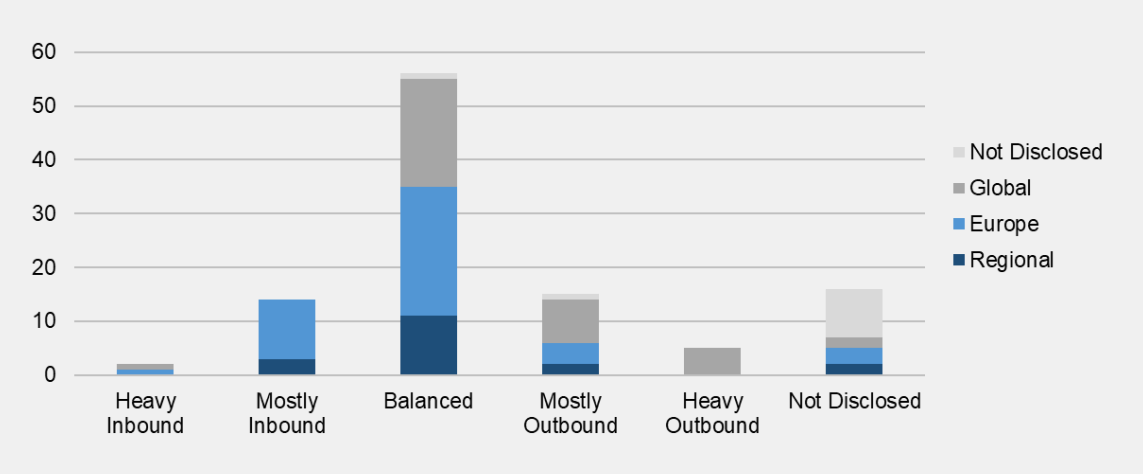
Ad b) 'Most of the peering partners are only active in Norway or the Nordics'

In contrast to the presumption in our survey, the majority of peering partners in Norway is either active at EU or global level (more than 75%) and only 17,5 % of peering parties is active only at the national level.

Ad c) 'National players have less outbound traffic as international ones'

As shown in Figure 4-6, global parties have proportionally more outbound traffic in Norway, which makes sense as they collect traffic to be terminated in Norway globally. The same applies for European parties but to lesser extent, as they have a smaller geographical coverage to collect traffic from.

Figure 4-6: Number of listings on PeeringDB by geographical area and traffic ratio in Norway for 2023

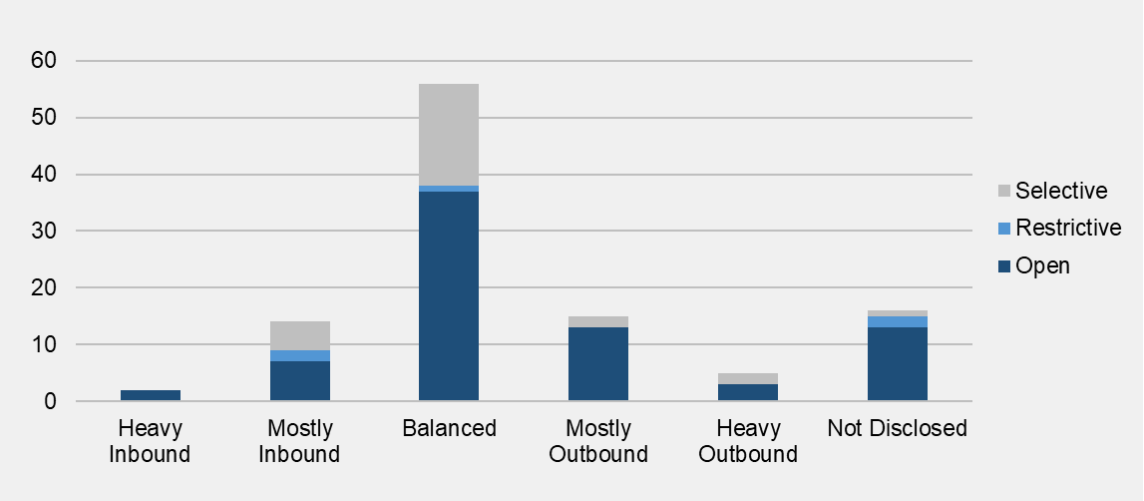


Source: WIK, based on data from peeringDB as of Oct 2023

Ad d) 'The more inbound traffic an entity becomes, the more selective its peering policy'

Below Figure 4-7 confirms that the more inbound traffic an entity has, the more selective its peering policy becomes. However, there are also a significant number of parties with a balanced inbound/outbound traffic that have a selective peering policy, and even some parties with more outbound traffic that have a selective policy.

Figure 4-7: Number of listings on PeeringDB by traffic ratio and peering policy in Norway for 2023



Source: WIK, based on data from peeringDB as of Oct 2023

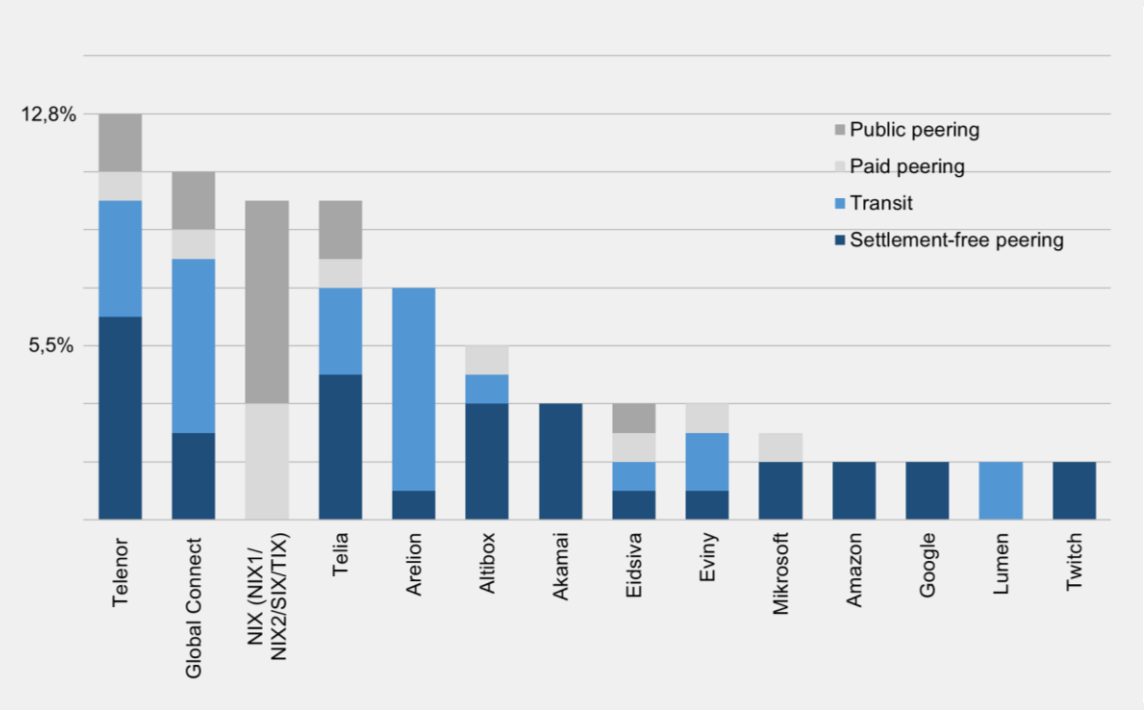
4.3 Charging principles

Packet Clearing House (PCH) performed a world-wide survey in 2021 on the characteristics of more than 15 million Internet carrier interconnection agreements. The study concluded that almost all agreements have an informal character and symmetric terms, with only a few exceptions having asymmetric terms such as paid peering for certain parts of the traffic. However, the numbers of exceptions have gone down since 2016.[96]

Figure 4-8 shows from left to right the 14 market players with the most interconnections in all categories together (transit, settlement-free peering paid and public peering). So for example, 12,8% of all agreements of surveyed stakeholders are with Telenor.

The colour division within the bars reflect the type of interconnection arrangements with the specific market player and varies with their role in the internet ecosystem. From ISPs like Telenor, Telia, Altibox and Eidsiva with a mix of all types, Data center provider Eviny with peering and transit, transit providers Arelion, Global Connect and Lumen with mainly transit and some free peering, IXP NIX with only peering and CDN provider Akamai and CAPs Microsoft, Amazon and Twitch having only settlement free peering.

Figure 4-8: Share of all Interconnection agreements in Norway and the different types per entity in 2023



Source: WIK survey based on LamaPoll, n=18[97]

96 PCH (2021)

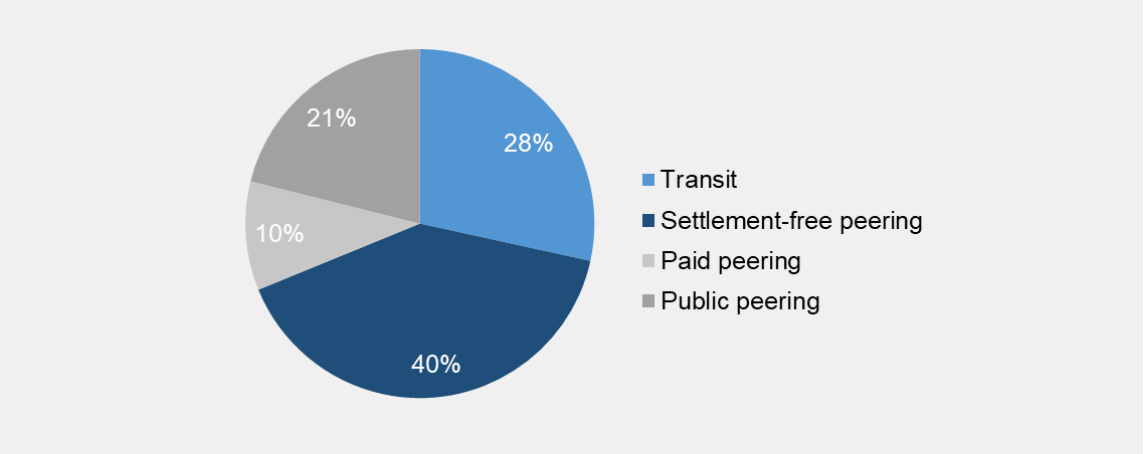
97 Note: 13 of the 109 specific market players are not represented in this graph as they were unspecific. However, 4 of these confirmed also IC agreements in Norway, where the remaining 9 denied any IC agreements in Norway.

The share of different types of interconnection agreements in Norway is shown in Figure 4-9. Respondents could indicate several types of agreements used. The majority of interconnection agreements relate to settlement-free peering (40%), followed by IP transit (28%) and public peering (21%). Paid peering accounts for only 10% of all interconnection agreements in the Norwegian interconnection market. However, as shown in Figure 3-11, measured in traffic, transit is the most relevant form of interconnection followed closely by settlement-free peering.

WIK (2022c) noted that in Europe for IP interconnection, that interviewed CAPs unanimously reported that settlement-free peering was dominant in Europe. However, figures from French regulator ARCEP showed that in 2020 still 47% of ISPs Internet traffic was handled via paid peering versus 53% free peering. . Observed trend in France was a small decline in paid peering from 2019 to 2020 due to the increase of settlement-free peering between partners of comparable size and secondly, due to the substitution of paid peering traffic between CAPs and ISPs by on-net CDNs.

An interviewed CDN provider noted that the business is a ‘step-ladder’, so depending on the amount of traffic, one goes from transit to public peering and thereafter to direct (settlement free) peering. However, it also noted that peering enables the localisation of traffic and therefore increases the quality for end-users. Due to this, CDN provider observes a positive trend overall including in Norway to do settlement-free peering irrespective of the network size.

Figure 4-9: Share of different types of Interconnection arrangements in the Norwegian market in 2023



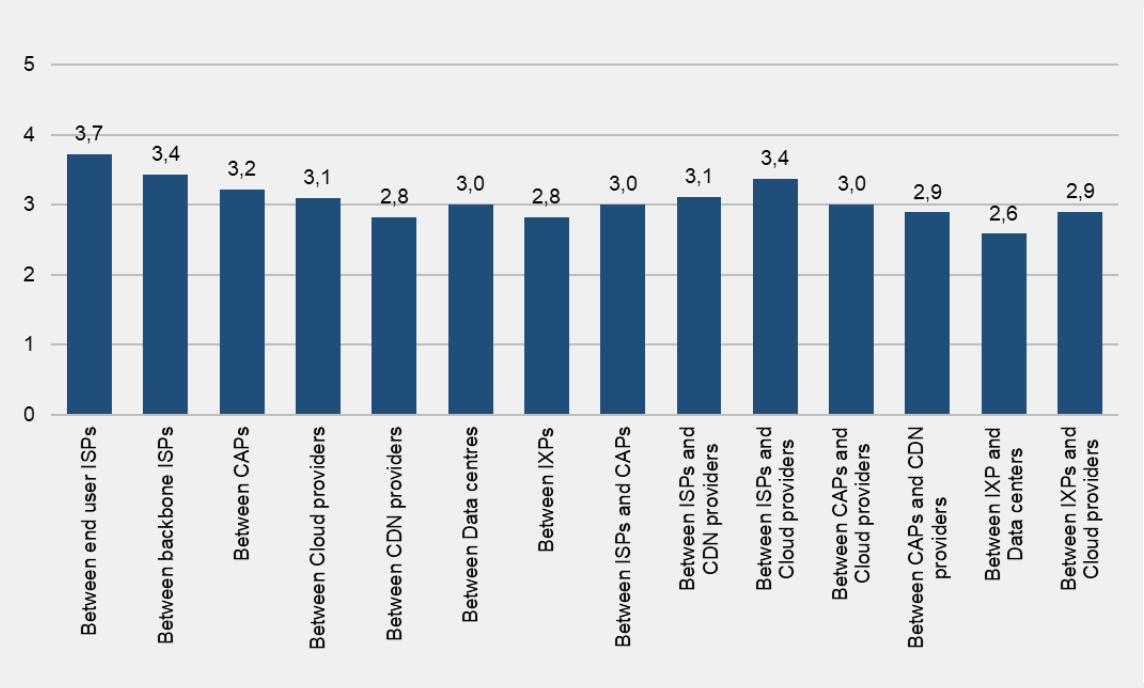
Source: WIK survey based on LamaPoll, n=18

5 Competition dynamics in the interconnection market

Participants in our survey were asked about the competition intensity in Norway with respect to services enabling IP interconnection. Figure 5-1 provides an overview of the responses based on a scale from 1=no competition to 5=highly competitive.

The highest levels of competition were reported between end-user ISPs, between backbone ISPs and between ISPs and cloud providers. The lowest levels are between IXPs themselves and between IXPs and data center providers. Other competitive relationships are considered neutral on average. In the following paragraphs, specific details per category of market player are discussed.

Figure 5-1: Rated competition intensity between market players in Norway in 2023



Source: WIK survey via LamaPoll, n=14

5.1 Competitive conditions and (relative) market position of stakeholders

5.1.1 End-user ISPs

The fixed broadband market in Norway is mainly shared between the four large operators Telenor, Altibox, Telia (GET), and GlobalConnect with an aggregated market share of 84 % in the combined market for private and business customers[98]. As pointed out in paragraph 2.1, for the private market, Telenor and Altibox have approximately identical market shares with 29% and 33 % respectively.

98 Nkom (2023), p. 16

In contrast, the mobile broadband market in Norway is more concentrated with three operators Telenor, Telia and Ice having an aggregated market share of 89 %.[99]

The level of competition in fixed broadband markets is vastly determined by availability, i.e. only a minority of end users can choose between two ISPs (38.7 % fiber/cable) or three ISPs (10.2 % fiber/cable) or even more very high capacity networks or multiple fibre networks.[100] FWA is also part of the fixed broadband market, but is likely to be used where there is no alternative network technology available. In these areas, Telenor can either offer itself retail internet access over FWA or offer wholesale access over FWA so that other ISPs can provide retail internet access services.

Norway has quite a unique approach towards municipality/utility networks. Across European countries these networks are often an enabler for competition whereas in Norway the majority of these providers cooperate exclusively with major national ISPs or TV providers which mostly is Altibox.[101] Based on these conditions, it is not expected that the competitive conditions on the end-user ISP market will change significantly in the near future with the exception of some regional areas where multiple fiber networks become available. See also WIK (2022c)

5.1.2 Backbone ISPs

WIK (2022c) observed that the position of European backbone ISPs offering transit and/or international circuits has weakened in the last years due to the strong expansion of (inter)national privat networks of CAPs. For this reason, this aspect was also covered in our market survey in Norway. Surprisingly, this trend was not confirmed for Norway as the majority of respondents indicated that the position of backbone ISPs in Norway remained the same and an equal amount noted a weakened versus a stronger position of backbone ISPs (n=12). A possible explanation is that CAPs do not have yet such an extensive network in Norway and/or the Nordics.

According to Nkom statistics, the wholesale market for dedicated point-2-point connections (including dark fibre, wavelengths and leased lines) in Norway has become more competitive in recent years. GlobalConnect still has the largest market share in 2022 (35%), but its position has weakened, as has that of Telenor (20%), while competitors Andre (22%), Eviny (8%) and especially Altibox (14%) have grown.

This is an important development as dedicated connections are critical for connecting for example a regional data center to Oslo or to a foreign hub.

99 Nkom (2023), p. 17
100 WIK Consult (2022), p. 5-6
101 WIK (2022b), p. 11

5.1.3 CAPs

WIK (2022c) noted that large CAPs have strongly expanded their own international backbones, which puts pressure on the business model of transit providers but also backbone ISPs. Furthermore, WIK mentioned that on-net CDN traffic globally almost tripled from 2017 to 2020 and almost doubled again by 2022 (+180%).[102] This is not only a matter of scale but enables CAPs also to finetune the performance of their CDN to their specific content and/or application.

The vertical integrating of CDN technology by CAPs is at the expense of third-party CDN providers (which were used before). However, the main focus of CAPs in regard to CDNs is still on improving the quality of their content delivery to end users and not on commercial resale of CDN services. This is reinforced by the very low margins on the commercial CDN market.

An interviewed data center provider in Norway views the business of CAPs as complementary, as they are currently their largest customers. This provider does not expect that CAPs will built their own data centers in Norway as this requires Norway specific building and construction procedure knowledge, which can be complicated due to the many municipalities involved.

5.1.4 CDN providers

An interviewed third-party CDN provider stated that the CDN market in Norway is a very competitive space with margins shrinking to the same degree as transit prices. For the near future it is expected that CDN prices will continue to fall and margins will be further compressed. Scale is therefore a crucial factor for success in this industry. Consequently, another interviewed stakeholder expects further consolidation in the CDN market, pointing to the recent acquisition of selected assets of Lumen by Akamai.[103]

An interviewed ISP expects this trend to intensify with more CAPs building their own CDN platform in the future instead of using third-party CDN services. This requires of course a certain scale, but will put even more pressure on third-party CDN providers and ISPs also offering CDN services. Nevertheless, the interviewed CAP views its relationship with ISPs in Norway as complementary. A third party CDN provider stated that it does not consider ISPs offering CDN services to be a competitive threat.

One data centre respondent believes that the main competition in the next 5 years will come from hyperscalers, but this is not yet certain. It is also possible that other large European data center providers will come to Norway (e.g. Orange, which bought a Norwegian data center basefarm a few years ago).

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102 See Cisco Systems. (February 27, 2019). Data volume of global content delivery network internet traffic from 2017 to 2022 (in exabytes per month) [Graph]. In Statista. Retrieved December 08, 2023, from https://www.statista.com/statistics/267184/content-delivery-network-internet-traffic-worldwide/

103 See https://www.nasdaq.com/articles/akamai-technologies-acquires-select-assets-from-lumen-technologies

5.1.5 Cloud computing providers

WIK (2022c) noted that cloud markets in Europe have been very dynamic, with large cloud providers offering services not only to enterprises but also to large CAPs such as Netflix, Apple and Spotify. They are responsible for a significant amount of traffic and rely heavily on their own backbone networks. Through their own infrastructure, they have contributed significantly to the interconnectedness and flatter hierarchy of the Internet. With their own networks, they can largely bypass the Tier 1 ISPs. The public cloud market in Europe is dominated by Amazon, Google, IBM and Microsoft.

Respondents in Norway indicated that 65% provide cloud services, with the majority active in the IaaS/PaaS segment. When asked whether their other activities (ISP, CDN, IXP, etc.) compete with cloud providers, most of them at least cooperate, although they compete in some other activities. ISPs are also active in cloud services and compete with cloud providers in this respect.

Regarding their competitive position, ISPs in the survey expressed the view that their position in Norway is the same or weaker than that of other cloud computing providers, regardless of the segment (IaaS, PaaS, SaaS, other). When asked about their competitive position vis-à-vis global cloud providers, Norwegian cloud providers gave only a few answers, expressing the view that the position of national cloud providers is significantly weaker.

5.1.6 Data center providers

In a 2016 report, Nkom noted that IT operations providers such as Evry and Telecomputing operated data centers for their own services, without the intention to develop data center services in particular.[104] Today, data center operators like Digiplex and Green Mountain, who focus primarily on data center services and are neutral with regard to IT- and transmission provider, have succeeded in attracting customers to their Norwegian data centers.[105]

An interviewed data center provider in Norway noted that the 2018 data strategy of the Norwegian government is considered successful, as the international fiber capacity in and out of Norway was expanded, which results in a very low latency (15ms) and high performance connections. This performance and the related marketing has ‘put Norway on the map’ for data center providers.

104 Nkom (2016), p. 5-6
105 Nkom (2016), p. 15

Furthermore, interviewees noted the following competitive advantages of Norwegian data centers:

- Low electricity prices: Not only because of hydropower generation, but also because Norway was one of the first countries to introduce market-based electricity sales energy prices are currently the lowest in Europe. Today all Nordic countries are closely integrated in a common electricity market, both physically and financially.
- Green energy: Norway's 'green' label is based on its natural cooling mechanisms and abundant hydroelectric power. Norway is one of the few countries in the world whose electricity production is already virtually emission-free and based on renewable sources.
- Energy storage capacity: Another competitive advantage is that hydropower is highly flexible due to its ability to store energy. One of the main challenges for large data center locations in Europe is that the local transmission grids do not have enough capacity to store renewable energy. This is one of the reasons why, for example, Amsterdam temporarily halted the expansion of its data centre industry in 2019. In contrast to that, half of Europe's total storage capacity is located in Norway, and more than 75% of Norwegian hydropower capacity is flexible.

Trends such as HPC and AI, which require large energy and cooling capacities, will therefore benefit Norwegian data centers. Also European ISPs could use Norwegian data centers as main location for providing their services in other countries. Even today, only a small proportion of customers in Norwegian data centers actually serve the Norwegian market.

An interviewed ISP shared its expectation that European data centers like Equinix, currently serving Norway from IXP in Stockholm, will extend their presence to Oslo IXP, which will contribute to a vibrant internet ecosystem. Further professionalisation of the Oslo NIX[106] like the Stockholm IXP under Netnod would certainly also contribute to this development.

An interviewed data center provider does not expect CAPs building their own data centers in Norway in the short-term, but with rising demand the competitive dynamic might change in the next 5 years. A relevant aspect, according interviewed data center provider, might be the bureaucratic complexity in obtaining building permits and organizing power supplies for foreign entities. This process might take up to 3 years, while the construction itself takes at maximum 1.5 years. This may discourage foreign investors from investing in Norwegian data centers. Currently, CAPs are predominantly seen as complementary in nature with the services of data center's.

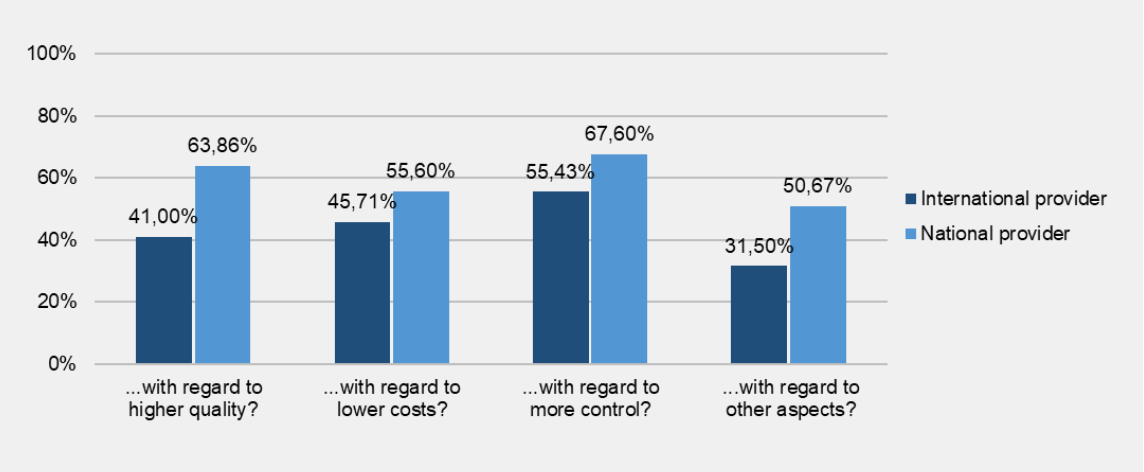
106 According the ISP, NIX is a 'department within the University of Oslo'.

5.1.7 IXPs

In Europe, WIK (2022c) observed that the relative importance of traffic exchange via IXPs has declined despite continued traffic growth. Although the importance of IXPs remains central to the functioning of the Internet, European IXPs have become more exposed to competitive pressure from data center service providers, which can offer their users low-cost options for bilateral interconnection via cross-connects in addition to traditional collocation.

This competition between IXPs and data centers was also researched in our market survey in Norway. Figure 5-2 shows that, ooverall, a significant part of respondents perceive data centers to compete with IXPs in Norway in respect to interconnection. Interestingly national players perceived the competition even stronger than international players irrespective of the respective dimension of competition (i.e. quality, costs or control).

Figure 5-2: Estimated degree of competition between data centers and IXPs in Norway in 2023



Source: WIK survey via LamaPoll, n=16 (8 international, 8 national)

A stakeholder interviewed in Norway noted that the primary goal for IXPs is to facilitate connectivity and a well-functioning Internet ecosystem, not to get more traffic. There are also competing providers offering connectivity, but this is mainly between Norway and the rest of Europe rather than within Norway. It is interesting to note that the commercial IXP DECIX started in Norway with 2 IXPs, one in Oslo and one in the southwest part, Kristiansand, both of them are located inside the bulk infrastructure .

One Norwegian IXP interviewed commented on the role of IXPs when asked whether the growth of (regional) data centers automatically requires additional IXPs. Their answer was that IXPs move to the most connected areas where there are market parties to connect. This could be a data center, but only if there are enough market players. A lot of traffic creates no incentive for IXPs to move there.

6 The policy dimension of interconnection

6.1 Policy objectives for interconnection in Norway

The Norwegian government launched its data center strategy in 2018, which was one of the first in the world. Its main objective was to make Norway an attractive location for data centers and other data-based industries. In addition, the government supported initiatives to expand fiber connectivity, which connects the Norwegian internet to other parts of the global internet. As described, both actions have been successful and have contributed to a growing internet ecosystem In Norway.

Apart from these initiatives, there has been no specific regulation in the area of IP interconnection. This chapter examines whether there are areas where specific action may be required and/or supported.

6.2 Interconnection disputes in Norway

Interconnection disputes are always an important signal for regulators as to whether the market for interconnection services is functioning well without intervention and/or guidance. In the case of Norway, this appears to be the case, as there have been very few disputes in the past and, according to one ISP interviewed, the few disputes that have occurred in the past have been resolved in good faith. All interviewees and survey respondents confirmed that there have been no interconnection disputes or abusive behaviour in Norway in the last 5 years.

The last interconnection dispute was around 2000, over whether IXPs should be used only by ISPs and not by CAPs. At that time, NIX decided that anyone with an AS number was allowed. As a result, Norwegian ISPs tried to set up an ISP-only IXP, which failed.

A CAP confirmed that the deployment and use of on-net CDNs is not an issue in Norway and that they are not forced into paid peering or partial transit agreements, as has occasionally been the case in Europe in recent years. The spirit seems to be that there is an ongoing dialogue between peering partners about the capacity used and any necessary upgrades and/or connections to other locations, as this is to the benefit of both parties. One CAP even indicated that Norwegian ISPs provide good to excellent peering services in terms of quality and capacity.

This does not mean that there is no room for improvement with regard to IP interconnection and the wider Norwegian Internet ecosystem.

6.3 Possible improvements to support the Norwegian Internet ecosystem

Based on our review, we have identified several policy aspects that could be considered by the Norwegian regulator and/or government in order to further develop the Internet ecosystem in Norway. It should be emphasized that all stakeholders are currently very

positive about the Internet ecosystem in Norway as a whole and have clearly stated that it functions well without regulation. Therefore, we have not identified any bottlenecks or immediate issues that require regulation, but we would like to highlight considerations for future improvements. Nevertheless, this cannot be seen as a full assessment of all options, which is outside the scope of this report.

Resilience and redundancy

In terms of overall infrastructure, resilience and redundancy are becoming increasingly important due to the importance of and growing dependence on internet infrastructure in our society, and especially in a highly digitized society such as Norway. In addition, digital sovereignty has become an issue in the context of political power blocks in the East and West and recent conflicts in Europe.

The following infrastructure issues could to be considered:

- It was noted that there is now sufficient submarine cable capacity, but that most traffic to/from Norway is still routed overland to Stockholm, Sweden. Politically this is appreciated and the repair time for land cables is much shorter (hours) compared to submarine cables (weeks). If not done already, it should be reviewed whether the overland capacity in/out of Norway is also sufficient and resilient.
- Market players in Norway indicated that they rely heavily on the Stockholm IXP and that within Norway the interconnection structure is very much focused on Oslo, NIX. This raises the question of whether resilience at the Nordic level is sufficient or whether it should also be sought at the national level, which also touches on the concept of national sovereignty.
- Strengthening the regional Internet ecosystem, including backbone connections between regions, could make the whole system more resilient to natural disasters or fiber cuts. IXPs could play a role here as intermediaries in the system, but the backbone ISPs that provide fiber between regions can also be financially supported by the government to increase resilience.. DECIX, which is also starting in south-west Norway, could be an opportunity to convince more providers to deploy their network there.
- The policy decision not to connect business customers directly (beside network operators) to NIX may be reconsidered as business customers in Europe increasingly rely on IXPs to improve the redundancy of their Internet interconnection.
- In terms of traffic routing, regional breakouts could be created for mobile traffic (and/or more for fixed traffic), so that traffic originating in a particular region and destined for the same region remains within that region (rather than being centrally routed to Oslo and then back to the region).
- A specific feature of Norway is the structure of many smaller (municipal) ISPs that are dependent on large ISPs offering transit for the national and international exchange of Internet traffic. RIPE (2022) has also observed this and even stated that many smaller ISPs are only connected to one of the larger providers such as

Telenor Norge, Global Connect or Altibox. This means that if the transit services of one of these large players are affected, all connected smaller players and their customers will experience internet connectivity problems.

- NIX (and other regional IXPs) could receive more support from the government, as IXPs play an important role in creating a vibrant Internet ecosystem, as can be seen in Frankfurt, Germany, but also in Stockholm, Sweden. Market participants noted that IXPs are important, among other things, to provide redundancy in addition to their direct connections.
- IXP noted that the increasingly complex infrastructure set-up to account for redundancy and resilience also requires a skilled workforce, which sometimes seems to be in short supply. This could be addressed by supporting specific training programs in schools and universities.

Data centers

Data centers are the 'hotels' that house all the data from e.g. CDNs and cloud applications, and are therefore an increasingly important component. In this respect, the well-functioning 2018 strategy and the hydroelectric approach, which ensures low-cost green energy, are praised. However, given the significant economic impact of this sector in terms of employment (potentially 11,000 in 2023 and almost 25,000 in 2030)[107], there are points to consider in order to ensure future development:

- According an interviewed data center provider, the bureaucracy in obtaining building permits and organizing power supplies takes up to 3 years, while the construction itself takes a maximum of 1.5 years. This may discourage foreign investors from investing in Norwegian data centers.
- An interviewed CDN provider indicated that they serve the entire Norwegian market from 1 data center in Oslo, where they would normally use multiple data centers to localize traffic and provide redundancy. This is due to the geography and size of the country.

Cloud services

This sector has seen healthy growth of 30% in Norway in recent years, slightly above the European average. The same global cloud providers as elsewhere in Europe are present and competing with local Norwegian providers.

In 2020, the National Security Council conducted a risk assessment on the use of cloud services.[108] It concluded that the use of Norwegian data centers (rather than foreign ones) should be increased for societally critical functions and sensitive information systems. This could contribute to safeguarding national autonomy and protecting

107 Implement Consulting Group (2020): Datasentre i Norge – Ringvirkningsanalyse av gjennomførte og potensielle etableringer
108 NSM (2022)

sensitive systems and information. In this context, it is noted that certain CDN providers serve the Norwegian market from data centers in Stockholm.

End user broadband connections

Finally, we found in our survey that the ratio of inbound to outbound Internet traffic is significantly lower in Norway than in Europe, suggesting that Norwegian end-users may have a higher demand for more symmetrical broadband connections compared to offers in Europe. This could be taken into account in future reviews of broadband offers in the market.

Other

Norway is seen as an excellent environment for all stakeholder groups providing relevant Internet services. Moreover, on the end-user side, Norway has excellent high-speed broadband connections, creating opportunities for various CAPs, and there is a successful production of local content, benefitting the Norwegian content industry.

Competition between market players in the Norwegian internet ecosystem also appears to be within reasonable limits, although in certain segments there is more intense competition between the same type of players (e.g. third party CDNs, CAPs).

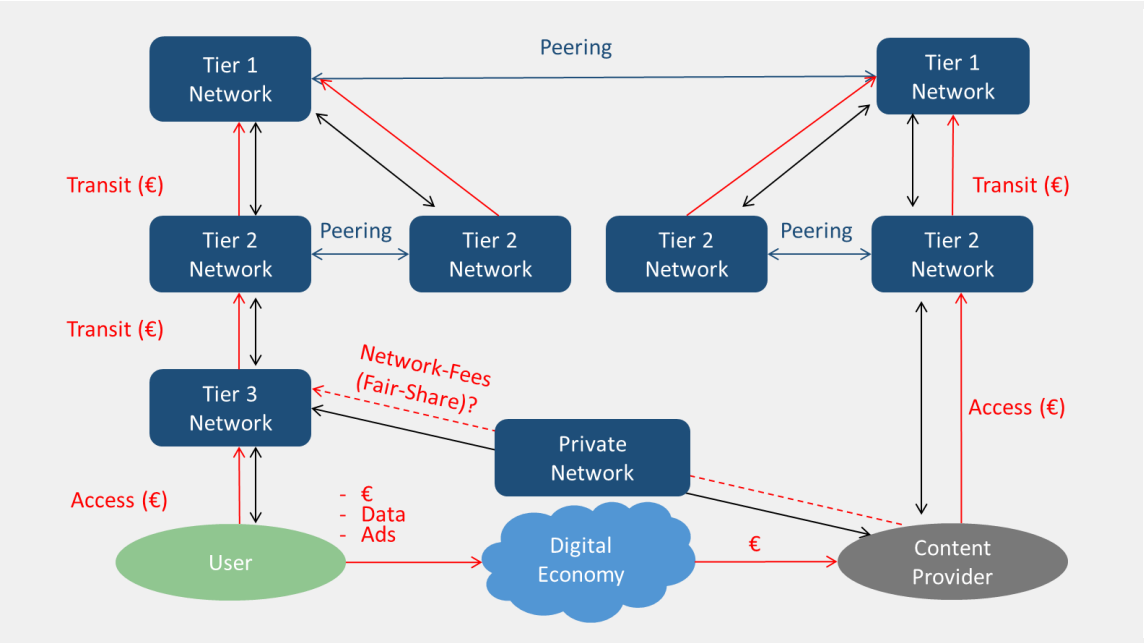
6.4 Debate about network fees

6.4.1 Subject of the debate

In Europe, large ISPs, mainly incumbents under the umbrella of ETNO, argue that due to an imbalance in bargaining power, they have to bear all the costs of rolling out next generation fixed and mobile networks, as well as the costs of handling an increasing traffic volume on their networks. As a large part of the overall traffic volume can be attributed to the demand of broadband consumers for content and services offered by large CAPs, these ISPs have launched a lobbying campaign to persuade regulators to move to a system that strengthens their position to charge CAPs for data transmission to their customers.

Below figure summarizes the relevant traffic flows between CAPs and network operators in black and the related opposite payment flows in red to describe the proposal to pay network fees graphically. Note that network fees could as well be requested by Tier 1 or Tier 2 ISP who also directly serve end customers.

Figure 6-1: Traffic and payment flows between networks



Source: WIK Consult

CAPs on the other hand argue that they already invested in creating their content, long-distant data transmission infrastructure, better video codecs and CDN services, to facilitate an efficient delivery of their content. Furthermore, CAPs argue that the attractiveness and high-demand for their services is also reflected in higher demand and willingness-to-pay for internet access services, directly benefitting the core business of ISPs.

In October 2022, European regulators, through BEREC, published their preliminary assessment of the assumptions underlying the debate. It found no evidence that "direct compensation mechanisms" as proposed by ETNO are justified given the current state of the market.

The European Commission's exploratory consultation on this issue, which also covered other forms of financial contributions from CAPs to Europe's digital infrastructure, revealed limited support from stakeholders other than (large) ISPs. In its summary report, published in October 2023, the European Commission omitted any mention of such contributions.[109] It is expected that the debate will continue in 2024 with the work on a "…game-changing Digital Networks Act to redefine the DNA of our telecoms regulation" (Thierry Breton via Reuters, 10.10.2023).[110]

109 EC (2023b)
110 https://www.reuters.com/technology/eus-breton-likely-set-out-strategy-big-tech-telco-funding-debate-next-year-2023-10-10/

6.4.2 The position of Norwegian market players

In spring of 2023, Nkom held dialogue meetings with the major Norwegian internet service providers on the fair share topic. Responses to Nkom indicated that the market in Norway was working rather conflict-free[111]. Nkom decided to await Berec's final assessment.

In its response to the 2023 European exploratory consultation, Norwegian ISP Telenor noted that there is a disconnect between increasing data volumes carried by networks and the revenue growth of network operators, resulting in suboptimal incentives to invest in network infrastructure. It also highlighted the disproportionate bargaining power of CAPs versus ISPs as "…the high-quality delivery of their services are a 'must have' for the customers of any ISP".[112] In Telenor's view, a traffic-based contribution would bring significant benefits to consumers by supporting the roll-out of 5G and fiber networks and thus improving the customer experience, provided that competitive distortions are avoided. It would also encourage large traffic CAPs to become more efficient, which would have a positive impact on energy consumption.

Respondents to our survey in Norway were also asked if they agreed with the position that ISPs should be compensated for network costs by large CAPs, as the majority of ISPs' traffic to their end users is related to the use of CAP services. Despite the large proportion of ISPs participating in our survey, the majority of respondents (55%) disagreed, 35% were neutral and only 10% agreed. Looking at the type of market player, it is not surprising that CAPs are clearly against the proposal and that other categories of market players (CDN, IXP, Cloud) are mainly neutral or against the proposal. What is surprising is that among the ISPs in Norway themselves, more than 60% are either neutral or against the proposal.

This more moderate view in Norway compared to other EU operators on this issue was also confirmed by one ISP interviewed. However, the ISP acknowledged the need for a broader debate on the costs of local fixed and mobile connectivity and the related regulatory framework.

In the survey, one of the respondents described this more precisely as follows "The debate is about the broader investment challenge in the telecommunications sector after the EU estimated that at least €174bn of new investment will be needed by 2030 to deliver the connectivity targets. The telecoms sector is currently not strong enough to meet that demand, with many operators at times barely earning their cost of capital including due to high capital requirements of the sector, continuous technological shift, high level of regulation and fragmented markets. This investment requirement for the coming years is believed to be a threat for the telecommunications providers, even in countries where network deployment has been successful until now, such as in the Nordics."

In addition to the opposing views from CAPs that ISPs are already compensated via retail revenue and that CAPs have also invested significantly in their infrastructure, there are

111 Nkom (2023), p. 3
112 Telenor (2023)

also net-neutrality concerns about potential fast lanes and the basic principle of efficient internet routing.

- Third party CDN provider, CloudFlare elaborated the 'fast lane' argument and its concerns at large on the fair share debate in a 2023 blog post.[113] It stated that network usage fees (paid peering) would create fast lanes for big tech content and slow lanes for anything else, hence overall slowing down the internet for consumers and SME.
- Regarding the violation of the principle of efficient Internet routing, one IXP respondent described the Sending Network Party Pays (SPNP) principle as originating from the traditional telecom world, implying that each additional route adds value and cost, which is a different incentive than in the Internet world where traffic is always routed via the most efficient and shortest route. Any additional cost in the SPNP model is ultimately borne by the end user.

A Norwegian ISP described in our interview a policy proposal that 1) supports the possibility of fair commercial negotiations and cooperation on future business models, 2) improves its own understanding of investment and competence gaps in the regions, and 3) adapts to new perspectives on how the telecom sector can remain an important asset and vehicle for network innovation in the future, thus contributing to the realization of a fully digitalized, consumer-centric and resilient society.

Other respondents argued that further consolidation of the market, as envisaged by EU Commissioner Thierry Breton in the proposed Digital Agenda, would change the market dynamics, as ISPs with a strong market position would be more likely to charge CAPs an unaffordable premium to reach their end users.

The latest update on the debate in Norway came from Telenor's CEO in October 2023, which submitted a letter together with the CEOs of the largest 19 mobile operators in Europe, to the European Commission demanding that content providers are being forced to pay a fair contribution for using their mobile networks.

Regarding the general arguments of ISPs that their revenues remain flat in the face of increased data volumes, we note for Norway that this is true for the period 2017 to 2019, but that from 2020 onwards revenues have grown overall between 3% and 4% per year. However, it should be noted that total network investments have increased, with an average annual growth of 7.4% from 2019 onwards. This is mainly due to increased investment in mobile networks, as investment in fixed networks declines from 2020 onwards. This is most likely due to the unique situation in Norway, where almost every end user is covered by fiber and the remaining white spots need to be covered by FWA.[114]

113 See The European Network Usage Fees proposal is about much more than a fight between Big Tech and Big European telcos (cloudflare.com)
114 See Electronic communications statistics - Nkom

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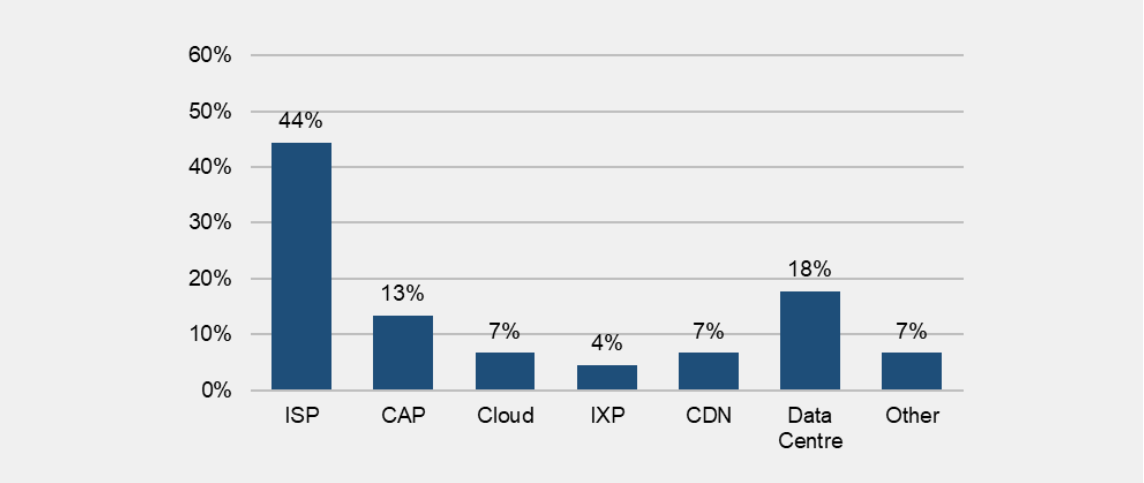
8 Annex

Details on the respondents in our online market survey on Norway.

Following Figure 8-1 shows that there is a diversity of respondents with a large representation of ISPs (44%) and data centers (18%). In addition, most respondents are geographically active only in Norway (48%, hereafter referred to as "national respondents"), and a slightly smaller share has a global footprint (42%, hereafter referred to as "global respondents").

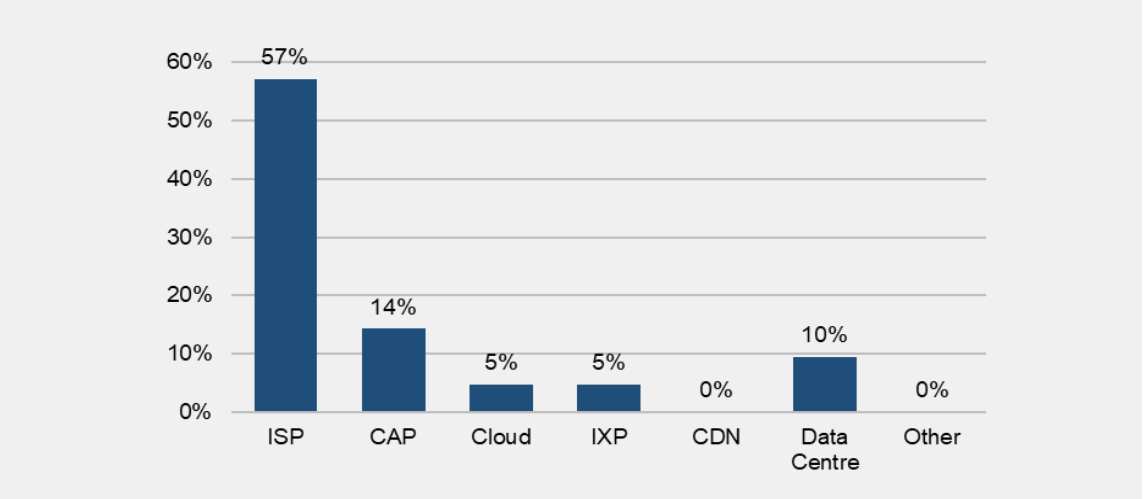
Figure 8-1: Areas of business of all survey respondents



Source: WIK survey, LamaPoll, multiple selection possible, n=31

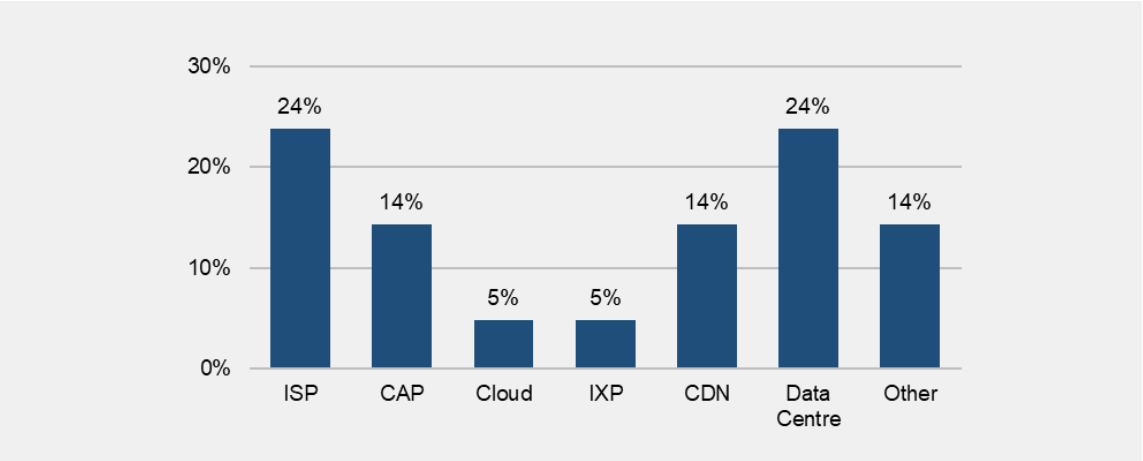
As can be seen in Figure 8-2 and Figure 8-3 the majority of Norwegian respondents are active as ISPs (57%), followed by CAPs (14%) and data centers (10%), whereas among global players the distribution is more evenly split between ISPs (24%), data centers (24%) and CDNs, CAPs and others (14% each).

Figure 8-2: Areas of business of national respondents (only active in Norway)



Source: WIK survey, LamaPoll, multiple selection possible, n=15

Figure 8-3: Areas of business of global respondents (with a global footprint)



Source: WIK survey, LamaPoll, multiple selection possible, n=13