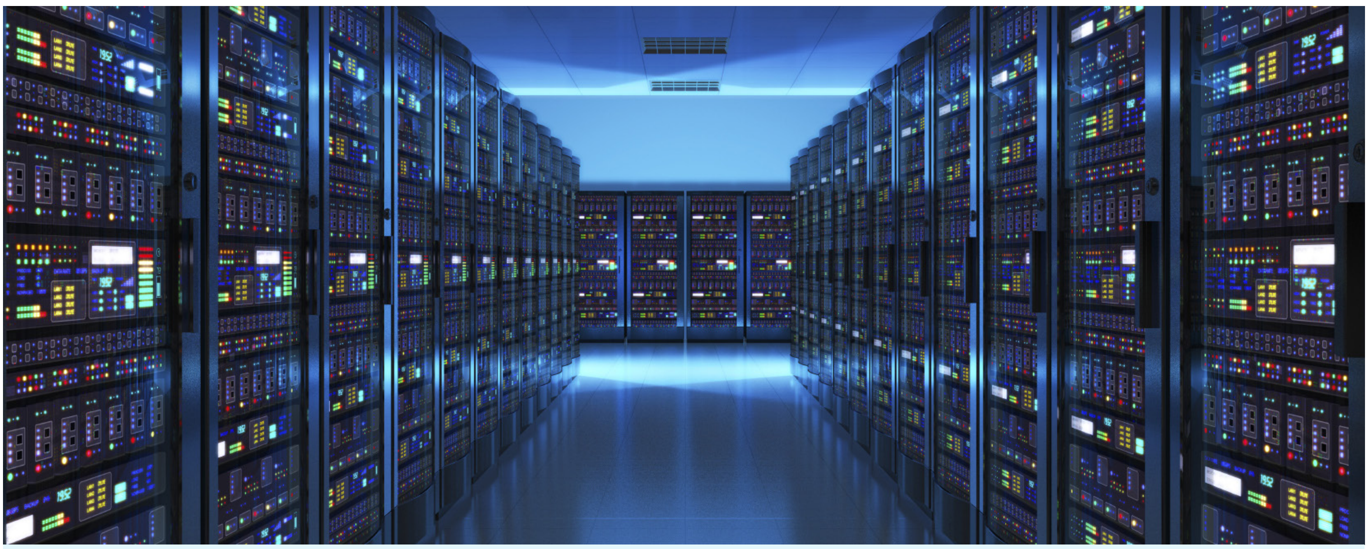
Locations for Data center enterprises (DCE) in Norway

Information to potential investors in Data center enterprises and to developers of new sites for DCEs



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CONTENT

1 FOREWORD

This report has two main objectives:

- To provide important information about advantages by choosing Norway as location for Data center enterprises (DCE).
- To provide useful information for developers concerning the most common criteria used in international selection processes of locations for DCEs.

The report is produced for the Norwegian power industry in order to visualize the benefits for location of DCEs in Norway as access to power based on renewable energy sources can give a competitive edge.

The scope of the project has been to identify a set of criteria that possible data center sites need to fulfill in order to be relevant for DCE investors. This can help communities, site developers and others interested in attracting DCEs to develop well prepared business plans for international marketing.

Energy Norway has initiated the work and several power companies in Norway have been contributing: Agder Energi, Akershus Energi, BKK, EB Nett AS, E-Co Energi, Eidsiva Energi, Helgelandskraft, Lyse Energi, Nord-Trøndelag Energiverk, Ringerikskraft, Salten Kraftsamband, Sogn og Fjordane Energi AS, Skagerak Energi, Statkraft Energi, Tafjord Kraft, Troms Kraft, Varanger Kraft and Østfold Energi.

Atle Haga (Statkraft) has led the working group. Dag Roar Christensen (Energy Norway), Ann-Mari Løberg Knudsen (BKK) and Øyvind Stakkeland (Agder Energi AS) have been part of the working group and contributed with valuable insight. The project also has a reference group consisting of representatives from the participating power companies.

Asplan Viak has been responsible of writing this report, in cooperation with Bjørn Vik and Anders Granberg. Vik is an expert regarding connectivity and fiber networks, and Granberg has been involved in the establishment of the Facebook data center in Luleå.

Sandvika, 15.03.2016

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2 INTRODUCTION

There is a growing international demand for new data centers. Due to positive underlying factors such as stable governments, stable natural conditions such as climate and geophysical stability, outstanding access to renewable power, and ease of doing business, the Scandinavian region is well suited for this kind of industry.

Sweden, Finland and Denmark have already seen such establishments take place, represented by Facebook in Luleå - Sweden, Google in Hamina – Finland and Apple in Viborg - Denmark.

Establishment of a Data center enterprise – DCE, with a need for power > 100 MW, in Norway would pave the way for further establishments of other types of data centers and colocations, demonstrating that Norway can offer competitive conditions for the data center industry.

This report is meant to stimulate processes that will lead to establishment of DCEs in Norway. On this background, the report focuses primarily on two objectives:

- It gives relevant background information about advantages by choosing Norway as host country for new DCEs. This information is mainly intended for international investors. (Chapter 5)
- It describes the most common selection criteria used by international actors when identifying new DCE locations. These criterions may to a certain extent also be applicable for developers of smaller centers. This information is mainly targeted at Norwegian site developers. A number of Norwegian sites currently in development process are included, mainly to illustrate how the criteria may be applied. (Chapter 6 and 7)

As an illustration, and perhaps also as inspiration, chapter 4 describes some important aspects about the Facebook establishment in Luleå, Sweden.

3 SUMMARY

For DCE investors, Norway scores relatively high on site selection criteria. Norway offers a stable democratic, well educated society with a strong national economy. The nature of physical conditions and climate are favorable, eliminating threats such as earth quakes, floods, hurricanes etcetera.

More important, Norway can offer vast amounts of power from renewable sources at favorable prices. The country has hosted power intensive industry for decades and is well used to doing business with foreign industrial investors. Based mainly on its hydropower resources, and its integration with neighboring countries, Norway can offer strong security of supply. Current reliability in the high voltage grid is 99,985%.

Norway is still expanding its renewable energy production capacity, thereby contributing to a climate friendly future. Via the Norwegian / Swedish elcertificate scheme, a DCE establishment in Norway will take part in this renewable expansion.

Norway has already a number of sites that offer well developed fiber access and connectivity. The infrastructure is constantly expanding and the number of sites able to offer redundant fiber connections to the European continent is growing accordingly.

Municipalities and regional authorities are generally positive towards DCE plans, offering necessary infrastructure and cooperation when it comes to necessary building permits etcetera.

The country can offer qualified personnel, and for a number of potential sites, a DCE will be able to connect to universities and/or R&D for developing technology and skill further.

Norwegians are used to communicate via foreign languages and do business with foreigners.

With easy access to substantial amounts of electricity from renewable sources, expanding fiber capacity and large areas suitable for developments, Norway represents interesting possibilities for DCE investors. A number of Norwegian actors are in the process of preparing sites that may be developed within a relatively short timeframe.

In order to present a well prepared location for a Data center enterprise, the most important criteria evaluated in this report are (not ranked):

- Access to power: redundant supply, N-1, voltage level >132 kV
- Access to fiber: N-2, direct routes to the international nodes, preferably dark fiber
- Area size: larger than 100 000 m2, preferably 400 000 – 500 000 m2
- Infrastructure:
  - Road access; paved 2-lane road
  - Airport: within 1 hour, preferably international airport
- City center < 40 minutes, with educational resources of relevant academic routes
- Proactive and professional landowner and regional cooperation in place

Also other criteria are used in the process of selecting locations for a DCE. The most common ones are mentioned in the previous text.

There is a rapid technological development within the data center industry. Thus, criteria that are common today, may prove insufficient or less relevant in a few years, even months. It is therefore important that the location developers take a responsibility to stay updated on new technology and developments in the industry, in order to position their locations for future investors.

The perfect location for a large data center is hard to find, and often compromises must be made in the location process. The criteria described in this report should be used as guidelines for development, in order to for instance intensify zoning processes. If one location has many good qualities, but lacks others, one should look for aspects that can compensate. This way, a good total location can be presented to the market, even if some of the criteria are not fulfilled.

In the process of attracting the DCE, commitment and participation from municipalities, regional authorities and government as well as energy companies, fiber suppliers etcetera is needed. Locations distant from city centers are more difficult to market. For these locations, the economic conditions as competitive parameters are of higher importance.

There is a lot of activity in development of the locations in Norway. A number of locations are not yet sufficiently developed, but may be suitable for DCEs in the near future. Several of the locations may also be well suited for smaller data centers or colocations.

There are probably also opportunities in locations not yet on the list that may be well suited for DCEs. During the project period, new locations have come forward that was not initially part of the project.

4 DEFINITIONS AND ABBREVIATIONS

Abelia	Business Association of Norwegian knowledge- and technology based enterprises, associated with Norways largest employers' organisation; the NHO (Confederation of Norwegian Business and Industry). http://abelia.no/english/category255.html
Colocation	Type of datacenter, see point 5.1.2 for definition
Dark fiber	Dark fiber refers to unused fiber-optic cable, which is available for a third party without linking them to the fiber-owners services / products. Dark fiber connected forward to Metro/POP
DCE	Data Center Enterprise, see point 6.2 for definition
EEX	European Energy Exchange
Energy act	The Act relating to the generation, conversion, transmission, trading, distribution and use of energy etc. of 29 June 1990 No. 50 (the Energy Act) sets the framework for organization of thepower supply in Norway.
ENTSO-E	European Network of Transmission System Operators for Electricity
Innovation Norway	Supports innovation and development of Norwegian enterprices and industry
Jernbaneverket	Jernbaneverket is the Norwegian government's agency for railway services, providing train companies with a safe and efficient transport system.
Latency	Time delay used as measuring concept in IT industry (delay from one site to another site?)
METRO/POP (fiber)	Metro is a city network. POP is an physical location where technical equipment can be defined as a demarcation point or a location where network entities meet/connect. Definition on
MPE	Ministry of Petroleum and Energy
Ms	A millisecond (from milli- and second; symbol: ms) is a thousandth (0.001 or 10^{-3} or $^{1}/_{1000}$) of a second
NASDAQ OMX Commodities	Financial power trading exchange. At NASDAQ OMX, one can hedge prices for purchase and sale of power for up to ten years in advance.
Nord Pool	Nordic power exchange
N-1 related to power	A location should be able to offer at least two redundant power lines to the site
N-2 related to fiber	A location should be able to offer at least three redundant fiber routes to the site
NIX (IX)	National commercial fiber access point
NVE	Norwegian Water Resources and Energy Directorate
Statnett	Norwegian TSO – 100 % government owned
TDC	Tele Denmark Corporation
TSO	Transmission System Operator (power), in Norway Statnett
TWh	terawatt hour = 10^9 kWh = 1 billion kWh
WDM (DWDM)	In fiber-optic communications, wavelength-division multiplexing (WDM) is a technology which multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths (i.e., colors) of laserlight. This technique enables bidirectional communications over one strand of fiber, as well as multiplication of capacity. See point 7.3.2 for illustration

5 DATA CENTER ENTERPRICES (DCE) – A GROWING INDUSTRIAL SECTOR IN THE MODERN WEB-BASED WORLD.

Every time you click into a web-page from your mobile phone or lap top, pieces of information travels at the speed of light, often between continents. Your information is processed and stored somewhere - we might point at "the cloud", but actually the information goes into computers in specialized computer centers.

As this information flow increases, and more and more data needs to be processed, new data centers are built around the world. Data centers need access to IT infrastructure (fiber), large amounts of electric power and skilled personnel, all preferable available at places that can be described as socially stable. They represent large investments providing jobs and economic development. That's why there is an international competition going on, between companies, cities, municipalities and countries that all want to attract construction of new DCEs.

The following description of the Facebook DCE in Luleå, Sweden might explain the background for this competition further.

5.1 Effects of establisments of DCEs Example: Facebook datacenter in Luleå, Sweden

In October 2011, Facebook announced that Luleå in northern Sweden would be their site choice for a new "Mega data center" in Europe, the company's first large-scale investment outside the United States. The planned investments includes three data centers, and a total estimated power demand of 120 MW. The Facebook data center in Luleå is an example of how establishment of a large data center can create jobs, values and spin-off effects for a whole region.

The Facebook establishment has changed the regional self-image in the north of Sweden into regional pride to succeed attracting one of the world's strongest brands into the region. The new forms of regional cooperation in a joint marketing company as well as concrete initiatives to develop a new dynamic innovation environment are other results of a changed view concerning future opportunities.

In simple terms, there are three phases in a data center creation: construction phase, deployment phase and operational phase. A study from Swedish Agency for Economic and Regional Growth from May 2014 describes the direct effects of the establishment in terms of

- jobs
- the impact on the local/regional economy as well as indirect effects
- changes in applications to higher education
- a change in the regional attractiveness outwards and a developed internal self-image

The quantitative effects estimate to (with one of three planned data centers operational) about 120 new direct jobs plus about 30 indirect jobs in the form of monitoring missions. In March 2014 Facebook decided to begin the second building which is currently under completion and therefore not yet included in the study. The study forecast that a fully developed facility with three buildings will result in additional 260 new jobs. It will also create up to 300 construction jobs per year during the establishment period 2011-2017.

In another report the Boston Consulting Group predicts that the total economic impact of the Facebook investment by 2020 will be 1 billion EUR and 4500 new jobs in a 10-year perspective.

Other results are tied to expanded regional cooperation in the sales and marketing company The Node Pole. These results are based on a joint brand and participating municipality's proactivity with offerings that are priced and ready to build.

The Facebook investment paved way for further DCE investments in the region. In Boden, 35 km west of Luleå, the establishment of KNC Miner in Feb. 2014 and the establishment of yet another data center Hydro66, in May 2014, are effects of the proactive work by local and regional actors, also supported by the Swedish government. In short time it has created 100 new jobs in Boden, and the investments continue.

Research and Development at Luleå University, have led it into new areas and environments generating new dynamic innovation.

6 ADVANTAGES BY CHOOSING NORWAY AS LOCATION FOR DCE

This chapter provides investors and companies considering investments in power intensive industrial activity like DCEs in Norway, with background information about the Norwegian power system.

It also gives a description about fiber access and connectivity.

Lastly it summarizes some important cost factors and gives some guidance for those who want to investigate and follow up actual site candidates in Norway.

6.1 Access to renewable, reliable and favorably priced electricity

Access to stable, reasonably priced, renewable power is crucial when selecting sites for new DCEs. Numerous Norwegian sites under development will meet the most demanding requirements in this regard.

Having among Europe's largest hydro power capacity, Norway can offer electricity based on renewable sources, delivered via a grid with excellent operating performance. Increased renewable power capacity, including wind power, will be developed in the years to come. The balance between supply and demand will be favorable for DCEs, offering stable market conditions and reasonable prices. This chapter will explain how and why.

Almost all Norwegian electricity is generated from hydropower. The hydropower system, including a very well-functioning and stable grid has been developed since the late 1800s.

Norwegian hydro power resources have attracted energy intensive industry especially within aluminum and ferro alloys production. It has formed basis for Norwegian initiated companies like Elkem and Hydro.

Norway is the world's sixth largest hydropower producer and the largest hydropower producer in Europe. Metal-, together with pulp and paper industry has utilized roughly 30-40 TWh/year corresponding to 25-30% of the national generating capacity, the last 30-40 years.

In order to evaluate Norway as host country for establishment of DCEs, a short view into its power sector is therefore advisable.

6.1.1 HISTORICAL DEVELOPMENT

Since the energy act of 1991, the Norwegian power sector has been market based. In the period following the liberalization, Norway has had a net export in 13 years and a net import in 8 years. Total net export in the period 1991-2011 was 57 TWh.

6.1.2 ELECTRICITY RESOURCES

During the period 1998-2013, the average Norwegian electricity production has been approximately 135 TWh/year. In 2014 it totaled close to 142 TWh, of which 136 TWh was produced by hydropower, 2.2 TWh by windpower and 3.6 TWh by thermal power plants.

The corresponding capacity in beginning of 2013, was 32 860 MW, of which hydro power constitutes 30 509 MW, wind farms 705 MW and thermal power plants 1 646 MW.

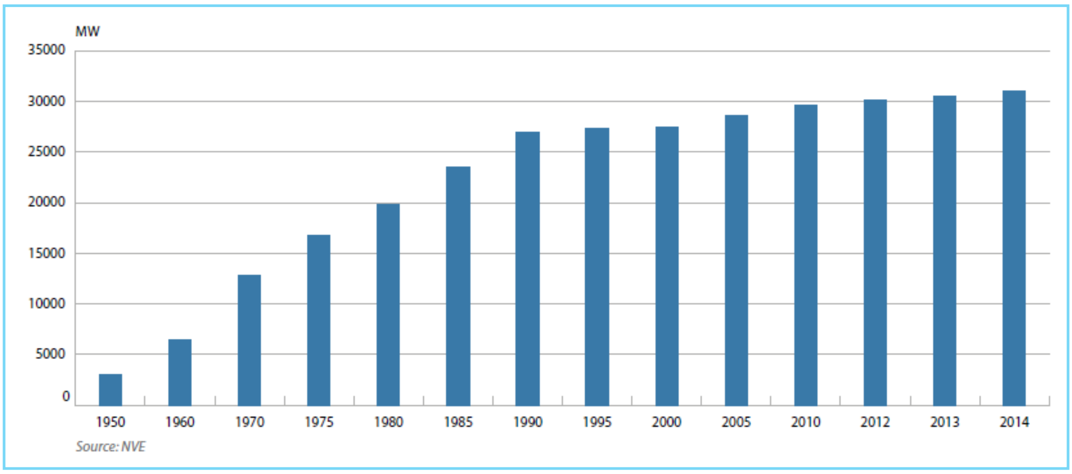


FIGURE 6-1
Installed hydro power capacity in Norway, 2014.

The annual water inflow, largely determined by precipitation, adjusted for changes in reservoirs, determines the produced power volume. The water inflow varies from year to year, as much as 60 TWh from a wet to a dry year.

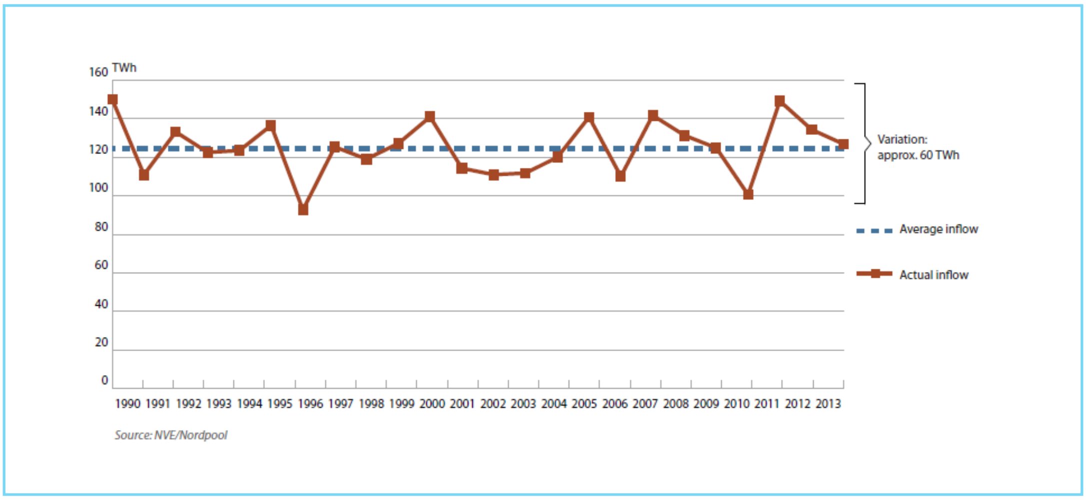


FIGURE 6-2
Annual inflow in the Norwegian hydropower system, 1990-2013.

The annual power production varies with the inflow, and is shown in the figure below. Note that capacity has increased approximately 0.5-1 TWh/year the last 10 years.

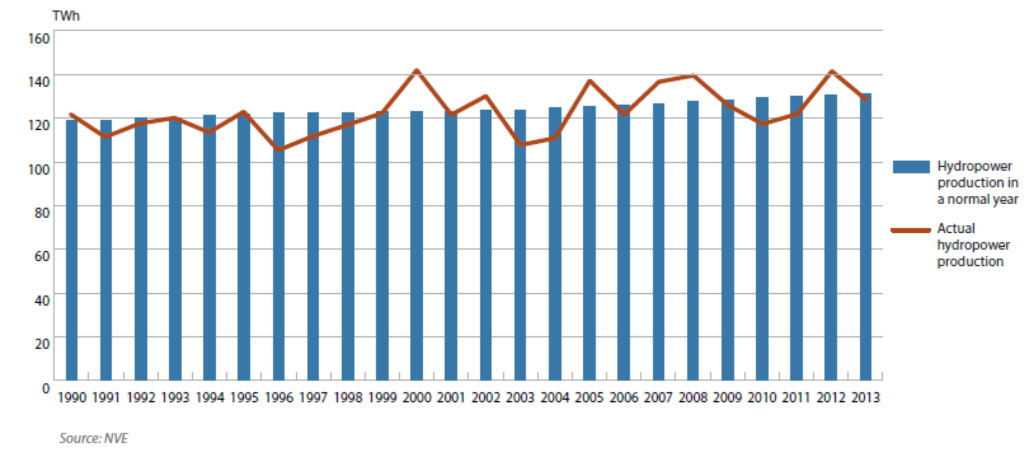


FIGURE 6-3
Annual inflow in the Norwegian hydropower system, 1990-2013.

In principle, Norway has the possibility to expand its hydro power production significantly. But various environmental, technical, financial and political factors determine the growth rate. In recent years, the increase has come largely through upgrading and expanding existing hydropower plants.

In addition to its hydro power, Norway also has vast wind power resources.

Norway and Sweden have established a common support regime – the electricity-certificate market with incentives for new power production based on renewable resources – mainly wind and hydro. From 2012 to 2020 the aim is to increase the power production in Norway and Sweden by 28.4 TWh/year, see 6.1.9.

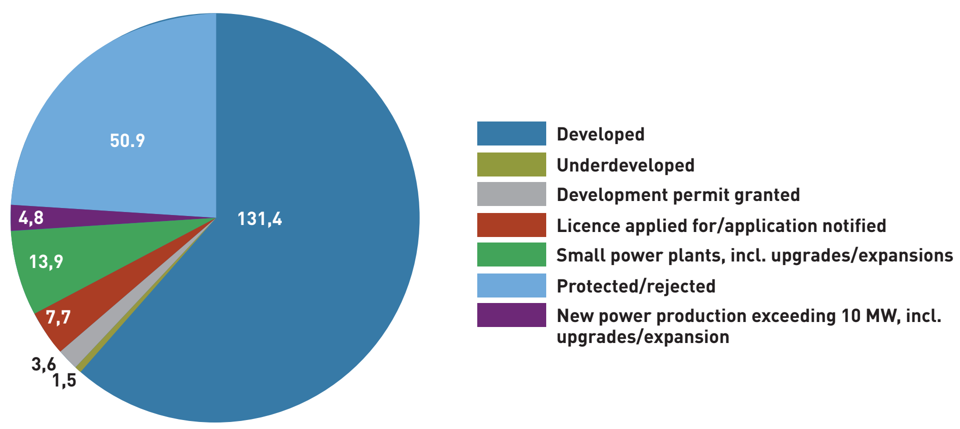


FIGURE 6-4
Overview of the Norwegian hydropower potential as of January 2014, in TWh/year. | Source: NVE.

6.1.3 NORWEGIAN POWER SECTOR, ORGANIZATION AND OWNERSHIP.

The Norwegian power sector is owned and operated by a large number of actors within generation, transmission and trading of power. In 2014 there were 183 producer companies, and 159 grid companies (Ministry of Petroleum and Energy (MPE), 2015). A number of the actors are involved both generation and trading.

Municipalities, counties and the Norwegian State own approximately 90% of Norway's electricity generation capacity. The State owns about one third of the capacity through the state owned enterprise Statkraft. Many production companies have several owners and there is a significant level of cross-ownership.

All producers, grid owners and/or traders of power must have an electrical license from the Norwegian Water Resources and Energy Directorate (NVE).

6.1.4 ELECTRICITY INFRASTRUCTURE

The transmission grid links producers and consumers in a national system. The transmission grid is tied to corresponding grids in the Nordic countries as well as mainland Europe.

In the Norwegian power sector, it is common to differentiate the transmission grid in three levels:

- The central grid represents the "highways" in the power system. It normally carries a voltage of 300 to 420 kV, and down to 132 kV in some parts of the country. The total length of the central grid is about 11 000 km.
- The regional system links the central grid with the distribution grid (see below). It may also include production and consumption radials carrying higher voltages. In other countries this part of the grid is often given the term distribution grid, with voltage levels between 50 and 132 kV.
- The distribution grid supplies power to end users (households, services and industry). It has a normal voltage of up to 22 kV.

DCEs will normally be connected to the grid at voltage levels of 132 kV or more.

As other types of infrastructure, the electricity grid is operated as a natural monopoly, and grid operations are therefore not exposed to competition. The monopoly role of the grid companies is controlled through detailed legislation and control by the NVE. An important task for NVE is to make sure that the grid companies operate the grid so that consumers experience high availability within reasonable costs, and at the same time avoiding these companies to gain monopoly profit.

Statnett is a government owned enterprise, serving a role as the transmission system operator (TSO) in Norway. Its main responsibilities include ensuring a stable and secure supply of electricity by coordinating production and consumption, developing the transmission grid and offering equal access to the transmission grid to market actors.

Its main tasks are to balance generation and consumption of electricity, and take responsibility for operation and development of the transmission grid. Statnett is subject to monopoly controls by the NVE. In addition, Statnett has so far been responsible for development and operation of cross-border interconnectors. Statnett represents Norway in the European Network of Transmission System Operators for Electricity, ENTSO-E.

6.1.5 SECURITY OF SUPPLY

Norwegian power supply is known to be very stable. During 1996-2013, the reliability was 99.99%, and is currently at 99,985. See figure 6-5.

Over the years, interconnectors have integrated Norway into the Nordic and North European power system. Initially, this was largely done to prevent shortages in years with precipitation below average. More recently, new interconnectors have been built to tie Norway closer to other power markets in order to optimize operation of the thermal power systems on mainland Europe with the storage capacity in the Norwegian hydro power system. The import/export capacity is expected to increase in the coming years, also contributing to strengthen security of supply.

High security of supply is also achieved by cooperation with power intensive industry actors. Such actors can through a market solution offer important flexibility by reducing production levels in times with low grid and/or generating capacity. This can also be a commercial opportunity for DCEs.

The Norwegian power system is already almost 100 % based on renewable sources. Unlike many other European countries, Norway will therefore not need to undergo large system changes when shifting from oil, coal and nuclear power to renewable generation. These transition processes are believed to represents a risk element concerning security of supply – and that is not the situation in Norway.

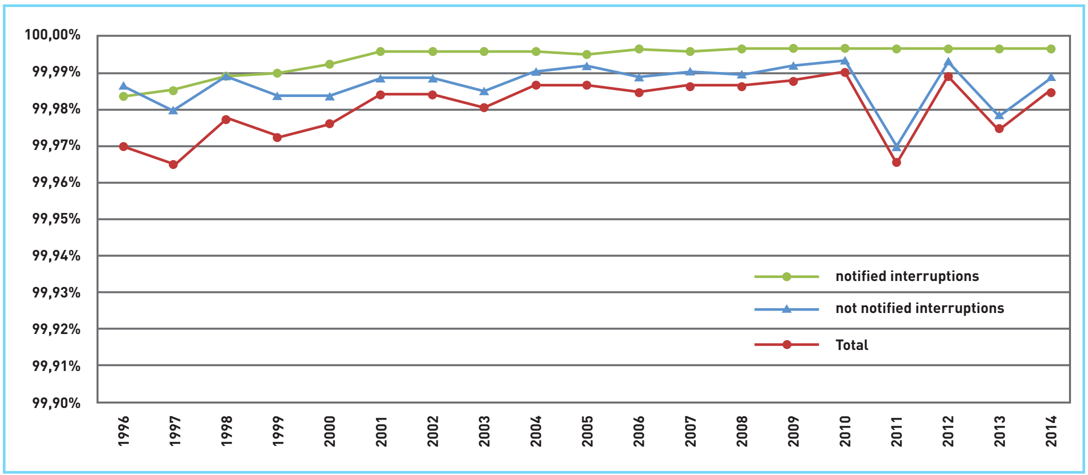


FIGURE 6-5
Delivered reliability in the Norwegian central grid. 99,985% in 2014 | STATNETT.NO

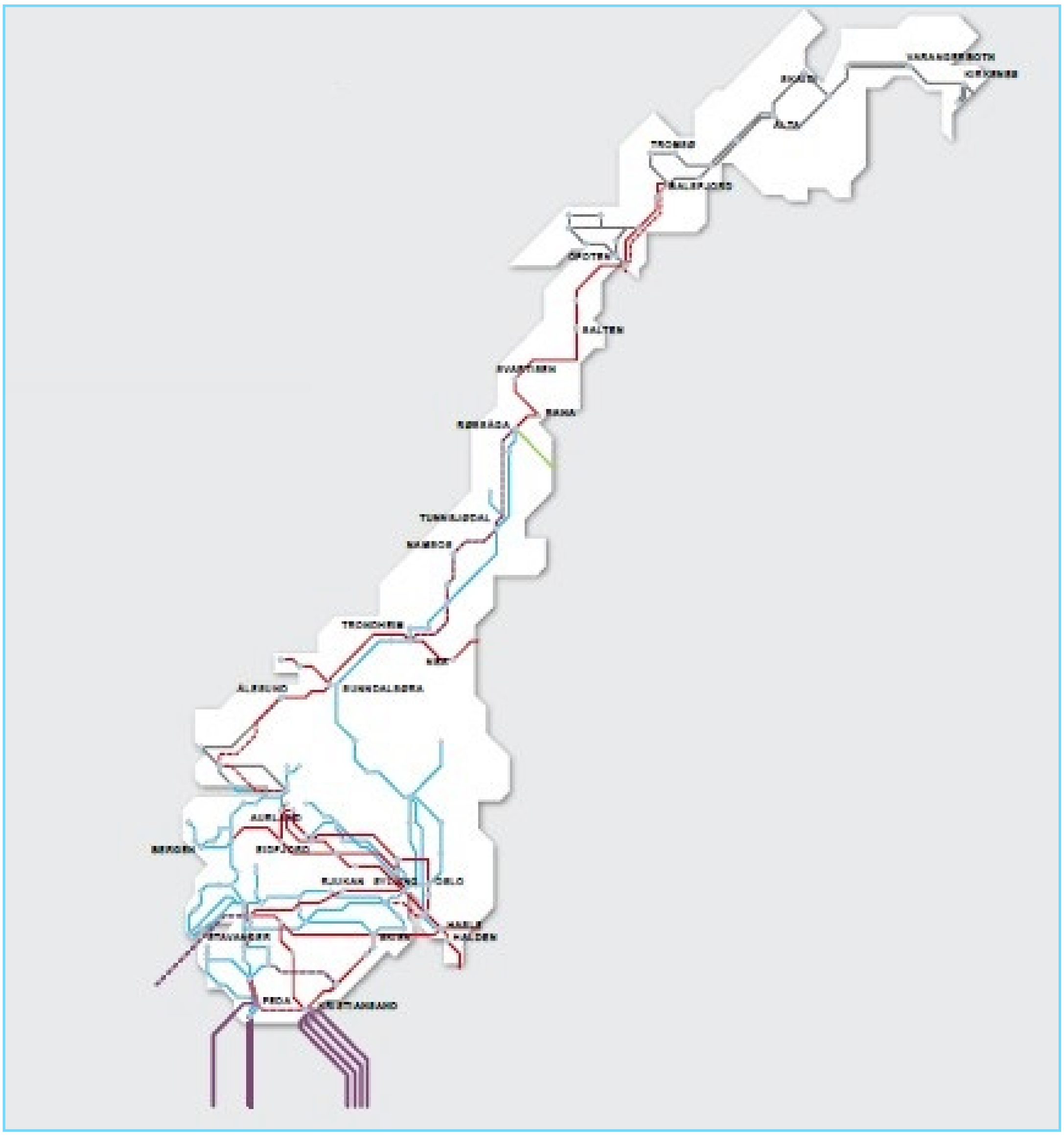


FIGURE 6-6
Norwegian transmission grid overview map. | Source: Statnett.

A more detailed map can be studied at the NVE web-site: http://gis3.nve.no/link/?link=nettanlegg

6.1.6 GRID TARIFFS

Grid companies, being natural monopolists, may not collect tariff revenues that exceed a revenue cap set by the NVE.

Grid tariffs on the central and regional levels consist of a variable charge component per kilowatt hour (kWh), and a fixed capacity charge per kilowatt (kW) load. Grid companies may also collect investment contribution charges from actors that need special investments (connection lines, substations etcetera) in order to connect to the grid.

The grid tariff is supposed to cover costs occurring at all three grid levels. However, consumers directly connected to the central grid, for example most power-intensive industry, pay a tariff based solely on costs at this level. Consequently, the grid tariffs are normally lower for power-intensive industry compared to other consumers.

In the central transmission grid operated by Statnett, the standard tariff for 2016 is 23 EUR/kW. This tariff changes annually, usually with minor adjustments. The tariff is reduced on individual basis depending on flexibility, up to a maximum of 90% for large consumers (more than 15 MW) with constant load all year around. A DCE may typically qualify for such reduced tariffs. In addition, large consumers may obtain reduced tariffs (up to 50%) in areas where the consumption is co-located to power production, due to the co-location's reduced demand for central grid capacity.

Many regional grid owners have implemented similar models for large customers. In order to forecast the fixed component for a DCE one would need detailed knowledge of the grid level, the point of connection and the consumption and production in that particular node. The grid tariff for each location should be checked individually with the relevant regional grid owner.

If a DCE requires upgrading or building of extra grid capacity, a share of the total cost may be allocated to the consumer. This cost will depend on the measures that need to be taken to build suitable capacity and connection for the data center.

The regional grid tariff differs throughout the country. The differences are caused by factors like challenging natural conditions and population distribution. The tariffs can be obtained from the regional power company in the area. Contact list to some key regional grid owners can be found in appendix 1.

6.1.7 THE NORWEGIAN AND NORDIC POWER MARKET

Since 1991, the Norwegian power sector has been market based. Determination of power prices has been a question of supply and demand. Sweden, Denmark and Finland, and many other EU countries, have followed suit with similar legislation. This market model has been instrumental in ensuring cost-efficient utilization of the power system. The power trading takes place in a physical market and a financial market.

In the physical market, price of power is determined every day on the Nord Pool Spot power exchange (www.nordpoolspot.com). Prices in a shorter time frame are functions of parameters such as precipitation and temperature, grid conditions (e.g. bottlenecks), and the inflow situation. In a more distant time frame, prices are dependent on how capacity matches demand. In recent years the Nordic power market has experienced relatively low prices due to power production increase, energy efficiency measures and reduced demand from power intensive industry.

The prices also depend on transmission conditions, both between areas and countries within the Nordic region and between the Nordic region and the rest of Europe. Since there are periodically congestion / bottlenecks in the grid, power prices may vary from one area to another.

Norwegian authorities have chosen a market-based system for handling the bottlenecks which arise in the grid as a result of the power market, so called "elspot areas". This is a geographical area for buying and selling power between other elspot areas. "Elspot" refers to the spot market for physical power turnover (wholesale) on the Nordic power exchange Nord Pool Spot AS. Norway is divided into five such areas, Sweden into four and Denmark two, while Finland constitutes of one elspot area. (Figure 6.7)

The physical Nordic power market consists of three separate markets:

- "El-spot" constitutes the day-ahead market
- "Elbas" represents the continuous intraday market.
- "Balancing market" operated by Statnett and designed to maintain balance in the physical market.

Each day, the Nord Pool Spot power exchange calculates the system price for each hour of the following day. The system price is the same for the entire Nordic market and reflects the overall generation and consumption conditions. The price of power in Norway is mainly determined by supply and demand in the Nordic market, but also by power markets in countries outside the Nordic region, in which the Nordic market interacts.

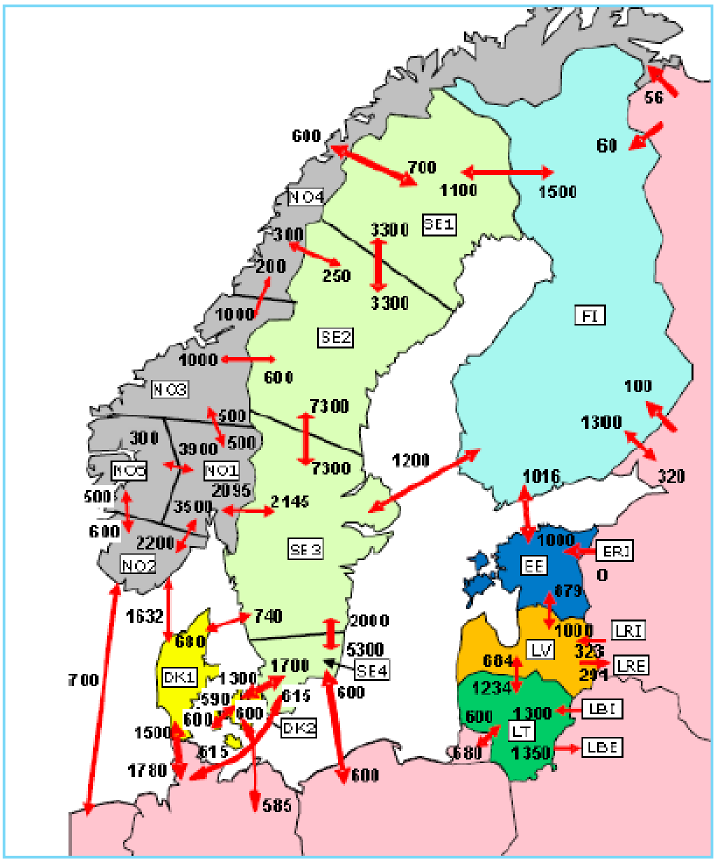


FIGURE 6-7
The Nordic elspot areas, including import/export capacity between the areas, and between the Nordic region and neighboring countries (in MW). | Source: Regional Investment Plan 2014 Baltic Sea, ENTSO-E

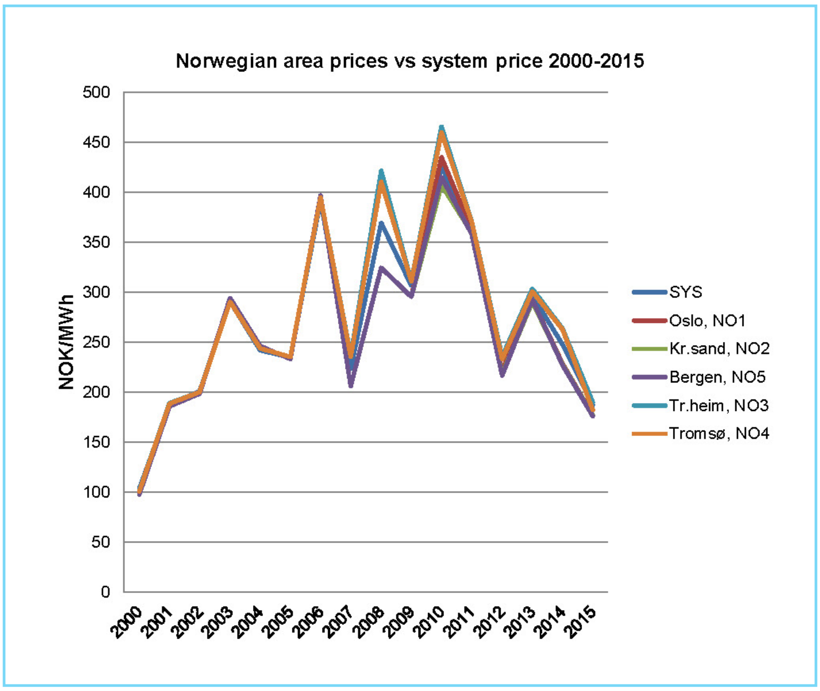


FIGURE 6-8
Norwegian area prices vs. system price 2000-2015. | Source: Nordpoolspot.com.

As figure 6-8 shows, the area prices will differ from the system price. Historically, area prices in south and western Norway (NO2 and NO5) have in significant periods been lower than the system price.

The financial market includes future and forward contracts, contracts for difference and options. Financial power trading can take place both bilaterally and on the power exchanges. In the Nordic countries, financial trading takes place mainly on the NASDAQ OMX Commodities exchange. At NASDAQ OMX, one can hedge prices for purchase and sale of power for up to ten years in advance.

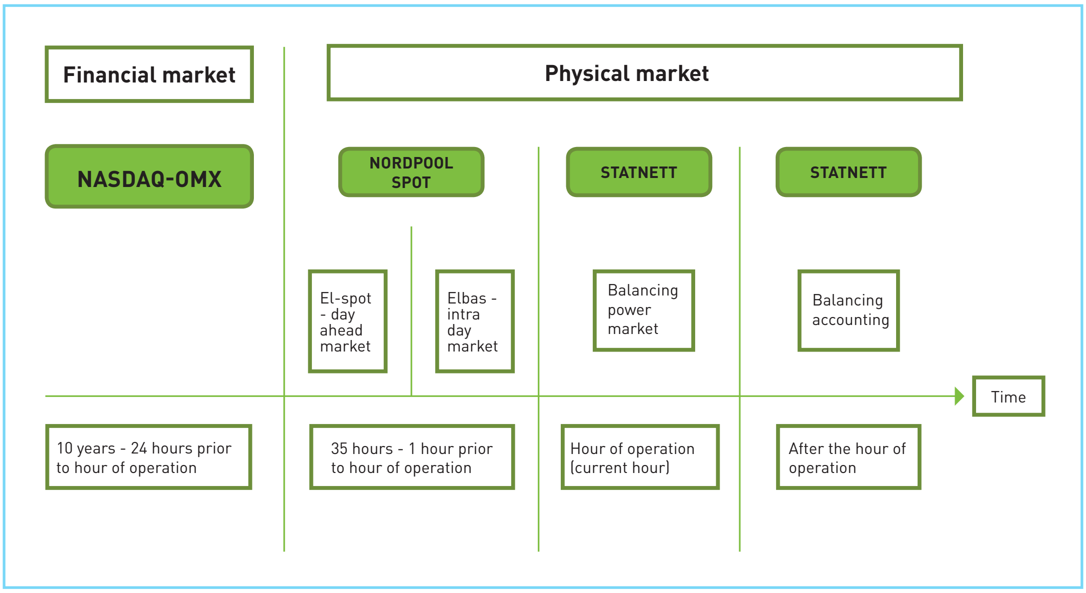


FIGURE 6-9
The Norwegian power markets. | Source: Ministry of Petroleum and Energy (MPE)).

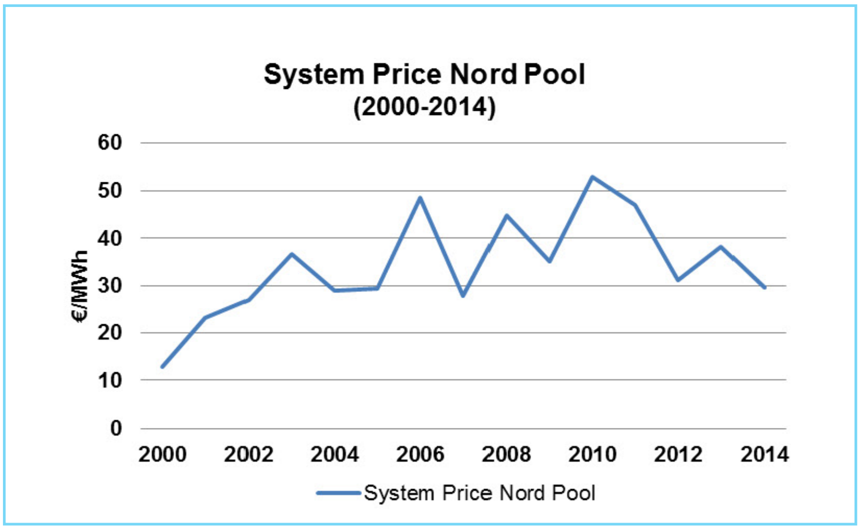


FIGURE 6 -10
http://www.nordpoolspot.com/Market-data1/Elspot/Area-Prices/SYS1/Yearly/?view=table

6.1.8 THE NORWEGIAN AND NORDIC POWER MARKET- HISTORIC AND FUTURE DEVELOPMENTS

Figure 6.10 shows historical power prices in the Nordic area 2000-2014. The Nordic power price varies considerably mainly due to weather trends. This is mainly because the Nordic area has a very high share of renewables in the electricity production, but also because electricity is the main energy supply in households. In simple terms, the price tends to be high if it is a dry and cold year, and low in wet and warm years. The Nordic power price also depends upon fuel prices and carbon price, largely because the market is connected to thermal generation capacity in Germany, Poland and the Baltics.

As figure 6.10 shows, the power price increased dramatically after year 2000. This was mainly due to increased fuel prices internationally, but also because of a strained power balance in the Nordic market. The introduction of EU emissions trading system (EU ETS) in 2005 also affected the power prices in the Nordic, as it increased the costs of fossil generation.

After a period of scarce power balance and high power prices in 2006-2009, the demand was gradually affected by the structural change in pulp and paper sector and by the large downturn in industrial activities caused by the financial crisis. The power prices are also largely affected by weaker fuel-prices the last few years.

EUs 20-20-20 targets for renewables and energy efficiency has also affected the power balance in the Nordics, by adding more renewables and focusing on energy efficiency measures and conversion from fossil fuels to renewable energy sources. Norway was through the 20- 20- 20 targets, obliged to increase the share of energy from renewable sources to 67.5 per cent of its gross end consumption of energy in 2020. Norway chose to solve this mainly through the joint Swedish-Norwegian electricity certificate scheme to encourage new renewable production adding up to 28.4 TWh generation capacity. This increase will come in the period from 2012 till 2020 in Norway and Sweden combined.

The Norwegian government has also had an energy efficiency policy through the state enterprise Enova and by imposing increasingly stricter building codes. This has resulted in reduced growth rate in power consumption.

All these factors – and a similar development in Sweden - have led to a general market expectation of a large surplus of power in the Nordic area the next 15-20 year. The size of the expected surplus varies according to marked analysts' forecasts, but a sketched area of expectations is outlined in figure 6-11.

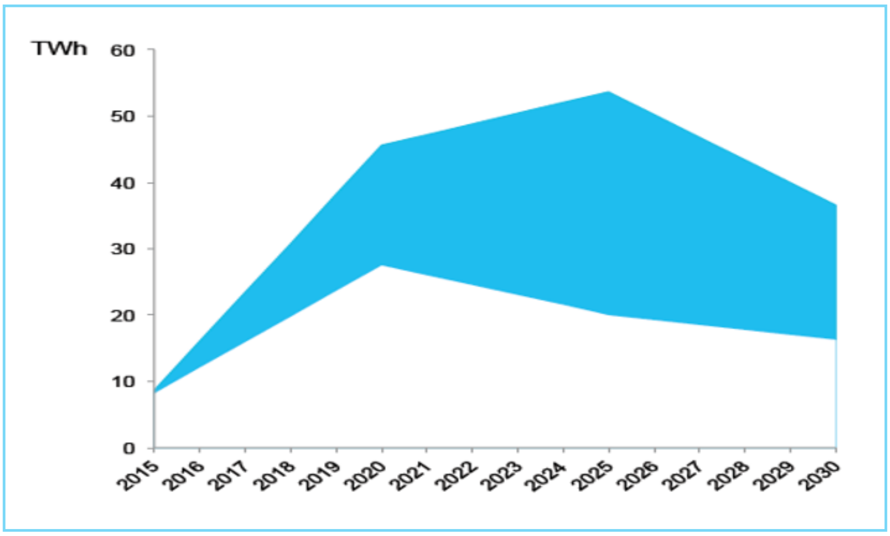


FIGURE 6 -11
Expected surplus of power in the Nordice power market in coming years including highest and lowest expectations according to external analysis companies | Source: Statkraft.

This expected power surplus, combined with the tumbling prices of fossil fuels, provides an outlook of further weak Nordic power prices for the next years. The last few years there has been an increased interconnection between the Nordic countries and Germany, but the utilization of the interconnections has been declining. Because of the rapid expansion of new on- and offshore wind power in the north of Germany along with lagging grid expansions in Germany, the grid operators have had to make considerable restrictions on the usage of the interconnectors. This problem has been increasing over the last few years, and the situation will probably persist until the German grid is adequately enforced or German market has been split in several price areas.

There are several planned increments in interconnection capacity from the Nordic countries to both Germany and UK within 2025.

As figure 6-12 shows, the market prices for the next 10 years reflects an expectation of persisting weak prices in the Nordic market.

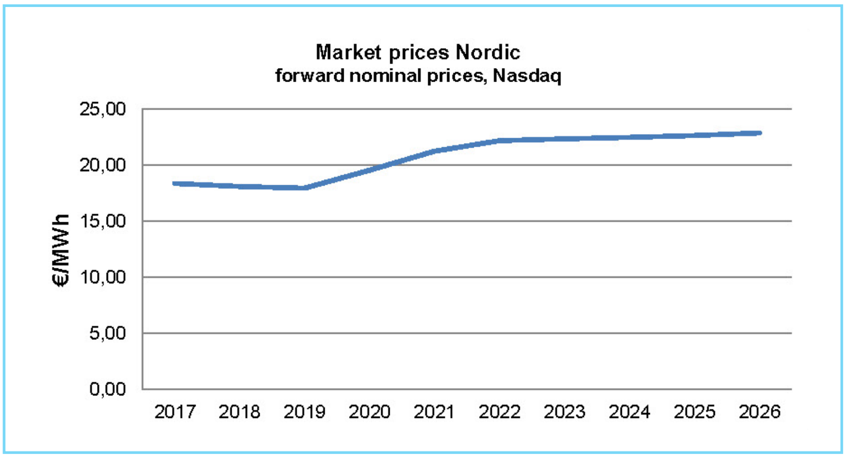


FIGURE 6-12
Nordic power contracts for the next ten years, currently trading at all time low at NasdaqOMX. Closing prices 11. March 2016: http://www.nasdaqomx.com/commodities/market-prices/history

6.1.9 ELECTRICITY CERTIFICATES

As a measure to stimulate investments in renewable power production, the Norwegian-Swedish electricity certificate (elcertificate) market was established 1 January 2012. Norway and Sweden have a common goal of increasing the renewable electricity production by a total of 28.4 TWh in the period 2012-2020.

An elcertificate is an electronic document proving to a final customer that the corresponding 1 MWh of electrical energy was produced from renewable sources. New built renewable power plants are entitled to elcertificates following certain criteria and approval by NVE in Norway (and similar in Sweden).

Power consumers, with some defined exceptions, are obliged to cover a certain amount of their consumption with elcertificates (quota obliged consumption). This creates the demand for electricity certificates in the market. In 2016, power consumers in Norway have to pay for electricity certificates corresponding to 11.9 percent of their electricity consumption. When the quota curve peaks in 2020, the consumer will have to pay for electricity certificates for 19.7 percent of their electricity consumption. From this peak level it will gradually be reduced towards zero in 2035, when the system is scheduled to be phased out.

Electricity-intensive industries have an elcertificate cost only for the proportion of the electricity which is not used in the manufacturing process. DCEs will have to pay for elcertificates – as is also the situation in Sweden.

For most consumers the power suppliers handle the elcertificates obligation.

The actual additional costs for the consumer are determined by the electricity certificate price, which will vary according to supply and demand.

For a DCE with an annual power consumption of 700 GWh, annual cost for elcertificates in 2016 - with certificate prices in March 2016 – will be approximately 12 mill NOK and in 2020 approximately 19 mill NOK.

DCEs will need to cover cost for elcertificates, thereby contributing to expansion of renewable power capacity in Norway. For more information, see

http://necs.statnett.no/(S(3mpnez554bvae4v1pgr3bsue))/default.aspx

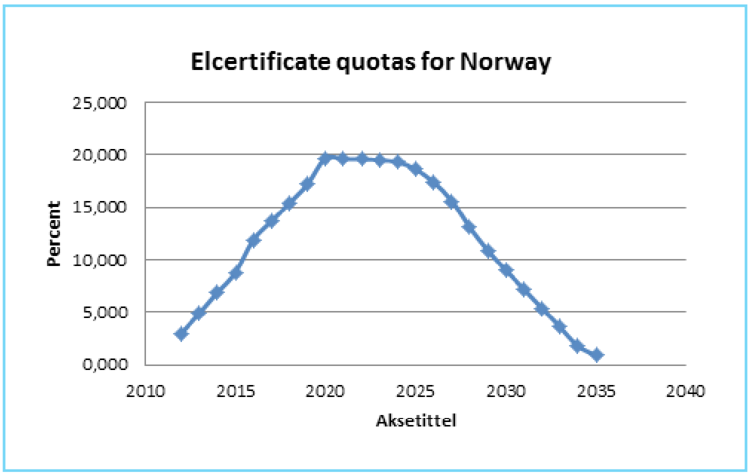
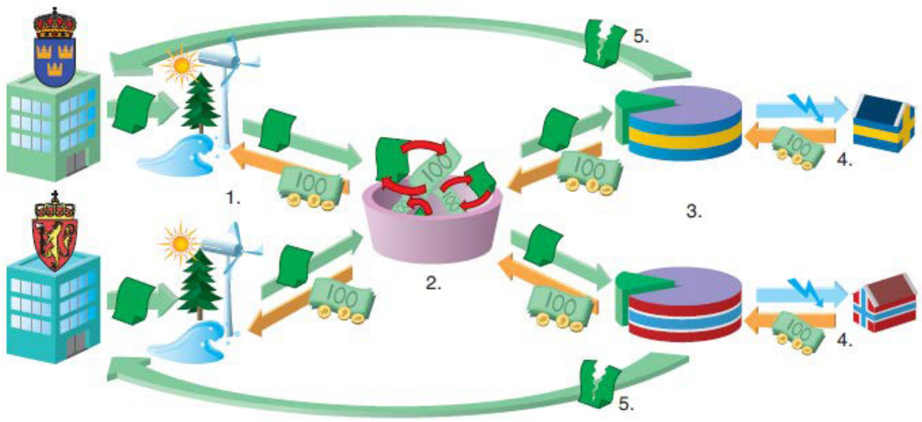


FIGURE 6-13
Certificate quotas for Norway.



1.
Electricity producers receive one electricity certificate for each megawatt-hour (MWh) of renewable electricity produced for a maximum of 15 years.

2.
The electricity certificates are sold on the electricity certificate market, where supply and demand govern the price. In this way, the producers receive an extra income from the electricity production in addition to the price of the electricity.

3.
Demand for electricity certificates is created by electricity suppliers and some electricity end users being obligated ly law to buy electricity certificates corresponding to a certain proportion (quota) of their electricity sales or usage.

4.
It is the electricity end users who finally pays for the expansion of the renewable electricity production, as the cost of the electricity certificate is part of the electricity invoice.

5.
Each year, the body with quota obligation must cancel electricity to fulfil its quota obligation.

FIGURE 6-14
Illustration of the electricity certificate market.

6.1.10 GUARANTEES OF ORIGIN

The European scheme of Guarantees of Origin (GO) is also relevant for increase in renewable production. A GO is an electronic document proving to a final customer that a corresponding 1 MWh of electrical energy was produced from renewable sources somewhere in the power system. This guarantee is unique.

The Renewables Directive 2009/28/EC specifies that all producers of renewable power have a right to receive guarantees of origin for their renewable power production, on a request from the producer. The Norwegian Energy law § 4-3 states that Statnett has a duty to issue GOs.

A GO is in other words simply a product declaration guaranteeing that one MWh of electricity has been produced from renewable energy sources. Customers who choose to purchase GOs can be certain that a similar amount of electricity is produced based on renewable soruces as the amount of electricity he has bought GOs for.

A large majority among Norwegian hydro power producers issue GOs, and the guarantees may be purchased in the voluntary GO market. There is no fixed price for a GO, and their value depends on market demand. The prices of standard Nordic GOs has been low the last few years, typically ranging between 0.05-0.20 €/MWh. GOs of Nordic power are, however, currently trading at 0.30 €/MWh (Feb 2016).

FIGURE 6-15
Market development GOs in Europe Europe – TWh/year. | Source: AIB (Association of Issuing Bodies), February 2015.

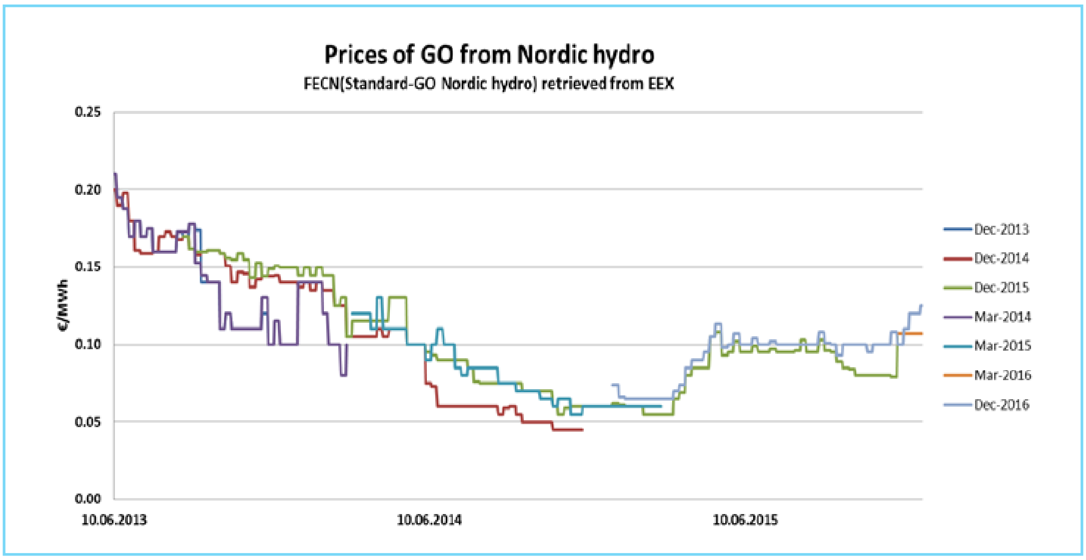


FIGURE 6-16
Price development of Nordic GOs 2013-2015. | Source: EEX.

6.2 Fiber access and connectivity in Norway

The fiber market or availability in Norway is characterized by a relatively large number of suppliers with separate fiber grids and privately owned infrastructure. The main national market actors are Telenor, Broadnet and Altibox. There are also several other semi-national fiber operators;

- TDC - Tele Denmark Corporation
- BKK - Bergenshalvøens Kommunale Kraftselskap
- NTE - Nord-Trøndelag Elektrisitetsverk
- Eidsiva Energi

There is no national entity with a responsibility for regulation or operation of the fiber infrastructure, and the market of fiber capacity evolves in response to the market demand.

Telenor and Broadnet are the two national providers of fiber capacity in Norway. These suppliers have coverage all around the country. Both suppliers have dark fiber in the portfolio to be rented on request.

Regionally, many power companies have established separate entities that provide dark fiber for rent. Examples may be Eidsiva who can provide dark fiber within own region, to Sweden and Oslo-Trondheim.

BKK, Lyse Energi and others, including Statnett (Norwegian TSO), may also have available capacity on request. On the route from Oslo to Europe dark fiber may be available from Level3, Ip-Only, Telenor and others may also have available capacity on request.

Information about dark fiber is not publicly available, but suppliers such as Statnett and Broadnet have indicated interest in selling capacity of dark fiber. Telenor is providing optical lines with their WDM system.

6.3 Some important cost factors and general guidance

6.3.1 COST OF POWER FOR END USERS

The total electricity cost consists of the following elements:

- Electricity wholesale price (power price)
- Connection to and use of the power grid (grid tariff)
- Consumption tax on electricity (electricity tax)
- A fee earmarked for the Energy Fund (Enova)
- Payment for elcertificates
- Value added tax. Note that the value added tax is calculated on basis of all the other price elements

The cost of electricity itself is determined in the power markets, see 6.1.7.

The grid costs will vary in accordance with actual grid owner tariffs, see 6.1.6

The electricity tax in general was set at NOK 0.16 per kWh for 2016. For certain industrial end users a reduced rate was set at NOK 0.0048 pr kWh. The Norwegian Parliament has decided that DCEs with power demand higher than 5 MW will be eligible for the reduced rate.

End users pay grid tariff, taxes and Enova fee (NOK 0.01/kWh) to the grid company.

The power supplier is responsible for collecting payment for electricity certificates. These vary according to the certificate market which is described in 6.1.9

Below is a summary of cost component that make up the total power cost.

Example: Total cost of electricity for a DCE located in the Oslo area in Norway for the year 2017. Assumptions: 100MW load 8760 hours per year, VAT not included.

Electricity wholesale price	16,50 €/MWh	1)
Adjustment for area price/basis risk	- 0,60 €/MWh	2)
Electricity tax	00,49 €/MWh	3)
Energy Fund fee	01,03 €/MWh	4)
Elcertificate	02,08 €/MWh	5)
Guarantees of Origin	00,30 €/MWh	6)
Electricity cost exclusive grid tariff=	19,80 €/MWh	
Grid tariff	XX.XX €/MWh	7)
Total electricity cost:	XX.XX €/MWh	

1. Closing price NasdaqOMX 10/02-16.
2. Closing price NasdaqOMX 10/02-16.
3. Datacentres >5 MW pay 0,0048 NOK/kWh. EUR/NOK 9,70 (10/2-16)
4. Compulsory payment to ENOVA, 0,01 NOK/kWh. EUR/NOK 9,70 (10/2-16)
5. Closing price NasdaqOMX 10/02-16. See chapter 6.1.9 for details. EUR/SEK 9,53 (10/2-16)
6. Not compulsory, but guarantees that a similar amount of power is produced from renewable sources. See chapter 6.1.10.
7. Dependent on various factors, and must be calculated case by case.

6.3.2 CONNECTION TO THE NORWEGIAN POWER GRID

Large power consumers like DCEs will be connected to the high voltage grid owned by Statnett and/or the local DSO (Norwegian terminology; regional grid operators). To clarify costs, connection obligations and requirements etcetera one will need to contact the local grid company. A selection of grid companies is listed in appendix 1. The local grid company will support DCEs concerning concessions and other relevant issues towards regional and national rules and regulations.

When developing a DCE location, one will in most cases need a separate permit from Norwegian Water and Resources directorate, NVE (Konsesjonsbehandling av nettanlegg) for construction and operation of the DCEs part of the necessary power infrastructure.

6.3.3 FIBER CONNECTION

Within most Norwegian cities there is often more than one provider of physical fiber, and consequently, there is also a market for «dark fiber». One example can be Oslo, where TDC/GET, Broadnet and Telenor offer dark fiber lease. Further information in Appendix 2.

6.3.4 PROPERTY TAX

Norwegian municipalities can choose to avoid or impose a property tax, both on private property and enterprises. The value of the property establishes the basis for the calculation of the tax. The municipality each year determines the rate of the tax and basic allowance.

The property tax is normally 0.2% as a minimum and 0.7% as maximum for enterprises and agriculture. On this basis, the total tax will depend upon how the value of the property is evaluated and the taxation rate selected by each municipality. Property tax will vary from municipality to municipality, and must therefore be investigated individually for each location.

Property tax is a political issue, and far from all municipalities have imposed such taxes.

The present general rule for taxation of industrial property is that machinery and equipment should not be included when property is appraised. However, a special property category has been defined in which machinery etcetera should be included in the appraised value. That is when machinery is an integrated element in an industrial building complex.

Some of the locations mentioned in this report are situated in municipalities that presently collect property tax, and some do not.

The Norwegian government has signaled an intention to end taxation of machinery and industrial equipment as separate elements in taxation of business properties. Two alternative taxation proposals were presented in June 2015, and a corresponding hearing process ended September 18, 2015.

Both alternatives will mean that the taxation of industrial machinery and equipment in the special category no longer will be permitted. The Parliament has not yet concluded, but it is expected that the new property tax reform in general will lead to lower taxation on industrial property, and a less complex and more predictable tax regime. The issue has large impact on the taxation of DCEs and should be closely followed up.

6.3.5 AREA PRICE LEVEL

The cost of buying land area is important because it directly influences the profitability of the DCE. With reference to the DCE development in Luleå, it has been indicated a cost level of 3.0-8.0 EUR/m^2.

6.3.6 INVESTMENT SUPPORT

Innovation Norway has generally different types of grants and loans that could be of interest, possibly with regional differences, and further contact could be made to identify possibilities.

Regional business development funds may be available for planning and preparation of the locations. Such funds may for example be used to cover part of costs for architects, city planner's etcetera. The general advice will be to clarify possibilities for investment support by contact with Innovation Norway, governmental and regional authorities.

7 THE DATA CENTER INDUSTRY

This chapter is meant to give a short introduction about the data center industry to individuals, developers, companies and municipalities, interested in developing locations to attract DCE.

7.1 Types of data centers

The nature of data centers vary, but in this report we have divided them into the following three categories: In-house data centers, colocation data centers, and data center enterprises (DCE), like Facebook, Google, Amazon etc.. This report focuses on the data center enterprises / DCE.

7.1.1 IN-HOUSE DATA CENTER

These are the most common type of data centers, mostly serving one customer and located within the premises of the company using the center for its own business.

7.1.2 COLOCATION DATACENTERS

Colocation data centers are often developed by actors having such facilities as main core business, e.g. a site developer, offering the following services:

- Robust power supply including back up capacity
- Robust cooling capacity
- Connectivity
- Safety (fire, crime, surveillance etcetera)

A colocation center can offer services to a number of different customers. Norwegian examples of colocation centers are:

- Green Mountain Datacenter in Rennesøy
- Lefdal Mine Datacenter in Nordfjord
- Digiplex in Oslo (Ulven, Rosenholm and Fetsund)

Colocation centers are normally developed step by step, depending on the client's needs. The size varies often between 1 – 10 MW.

7.1.3 LARGE DATA CENTERS, DATA CENTER ENTERPRICE - DCE

Large data centers are often called "Mega datacenters" or "Data center enterprises", DCE.
The largest of DCEs consumes more than 100 MW on average. International companies establish their own data centers by buying/renting large areas of land and build and operate the centers themselves.

DCE are connected to the company's datacenters in other countries. Such centers have high emphasis on cost efficiency and are often built in less than a year.

When developing a DCE, a large number of possible sites are evaluated by specialized selection teams. After initial screening processes a number of sites are chosen for further evaluation. In order to be short-listed, certain minimum criterions must be met. Power and fiber capacities are among the most important ones.

Although Norway so far does not host any DCEs, it offers interesting qualities for DCE developers.

Important criteria used in international rankings are:

- Energy; availability of electricity from renewable sources, security of supply and costs
- International connectivity (fiber availability and latency)
- Ease of doing business
- Tax levels, see also paragraph 6.3.1
- Political stability
- Robust, stable national economy
- Stable climate and minor risks for natural disasters like flooding and earth quakes
- High education level
- Favorable cooling conditions with regard to outdoor temperatures and water resources

The ideal location for DCE would meet the following criteria:

- N-1 access to high voltage electricity grid with sufficient capacity
- Access to electricity from renewable sources
- N-2 access to dark fiber routes to international nodes
- Area size of 400 000 – 500 000 m2
- Final zoning prepared – ready to build
- Located close to city center with university
- Access to road, international airport and harbor/railroad
- Proactive and professional regional cooperation partners
- Low costs (grid, electricity, fiber, taxes etcetera)
- Low risk for natural hazards
- The following chapter discusses these issues in more detail.

8 DESCRIPTION OF SITE SELECTION CRITERIA – WHAT ARE DCE DEVELOPERS LOOKING FOR?

This chapter is meant for individuals, companies and municipalities, interested in developing locations to attract DCEs.

A number of Norwegian locations available for DCEs are in the planning phase. Some commercial entities are already offering sites and the necessary infrastructure, while others need more developing work.

8.1 Locations

Specific locations referred to in chapter 8 are taken from the location list in appendix 3.

8.2 Set of criteria

This report defines criterions that presumably need to be fulfilled in order to attract site selection teams for a DCE development. Such criterions will be a matter of individual evaluation, and may be changed. The criterions below are set up on basis of input from sources like Data Centre Risk Index, Innovation Norway, Anders Granberg (representing experience from the Facebook DCE in Luleå) Statnett, Abelia etcetera.

In the identification and development of suitable locations, some requirements are essential, whereas others are less important. In the following these criteria will be defined, and examplified.

Criteria numbered 1-10 below have been prioritized in this project analysis, based on the assumption that these have greater importance than the others in the selection processes. There will be differences of opinions and investor preferences differ. This list is therefore to be used as a guide, and not as a final blueprint.

	Criteria	Specifications	Lower limit	Chapter
	Priority criteria			
1	Grid connection point	Minimum 132 kV grid point nearby, at least two lines connected grid point	132 kV, N-1	8.3.1
2	Fiber access and connectivity	Dark fiber access, with three lines available, with low latency	Plans for dark fiber, N-2	8.3.2
3	Area size	>100.000 m² : 400.000-500.000 m²	>100.000 m² horizontal terrain	8.3.3
4	Infrastructure	Road access	2 lane road	8.3.4
5		Airport nearby	<1 hour	8.3.5
6		City center nearby	<40 minutes	8.3.6
7	First possible build start	When can an investor expect to start building	<1 year	8.3.7
8	Landowner	Professional attitude, enough financial capabilities, clear ambition, enough risk willingness	English speaking, enough resources to develop site	8.3.8
9	Regional cooperation	Municipality with positive attitude	English speaking key personnel	8.3.8
10	Land regulation	Preferably regulated as industrial area	Zoning application must have been sent	8.3.8
	Other physical criteria			
11	Local climate	Flood and other disaster probabilities		8.4.1
12	Topography	Horizontal topography is desired		8.4.2
13	Water for cooling	Enough water for water-cooling		8.4.3
14	Use of waste heat	Distance to district heating system		8.4.4

8.3 Evaluation of criteria

In the following section, the above mentioned criteria including minimum requirements are described. Locations described in appendix 3 are shown as examples.

8.3.1 GRID CONNECTION POINT

Stable connections of high voltage capacity are essential for DCEs. In this report, the minimum criterion for power access has been set at redundant high voltage grid close to the location (N-1) with a capacity of 132 kV or higher. 132 kV, 300 KV and 420 kV are common in Norway.

The process of building new high voltage capacity takes time; therefore locations with nearby access to high voltage grid will be an advantage.

The stability of the grid is often challenged when large consumers are connected, and detailed flow analysis should be carried out prior to the establishment, to evaluate the consequences on the operation of the grid. This aspect must be dealt with by the local and/or regional grid operator in cooperation with the TSO, Statnett.

It is also important to identify the distance from the location to the connecting high voltage grid, in order to estimate the cost of the connection. When new substations are needed, suitable locations must be found.

When developing a DCE location, one will in most cases, need a separate permit from Norwegian Water and Resources directorate, [NVE.](NVE)

Example: Redundant power supply in Eide site, near Molde.

The grid structure surrounding the location Eide in Molde Region, N-1 fulfilled. Supply lines are 132 KV (blue line) and one is 420 KV (red line) passing the site. There are two sites within the red circle, see fig 8-1, multiple mountain halls and one greenfield 188 000 m².

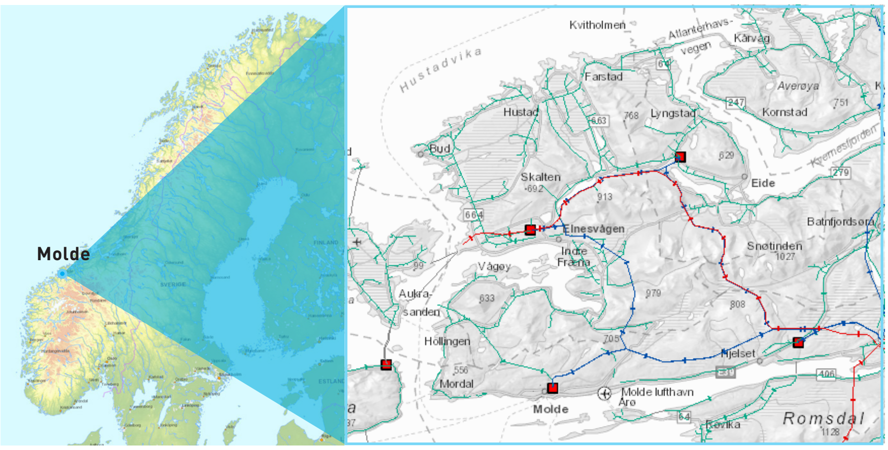


FIGURE 8-1
The grid structure surrounding the location Eide in Molde Region, N-1 fulfilled. Supply line are 132 KV (blue line) and one is 420 KV (red line) passing next to the site. There are two sites within the red circle. One multiple mountain halls and one greenfield option188 000 m²

Example: **Redundant power supply in Arctic Cloud Data Center in Mo i Rana.**

There is a significant power surplus in the Mo i Rana region. Whereas the annual production connected to the transmission grid is about 15 TWh per year, the regional consumption is about 10 TWh per year. There are several possible DCE locations; Location 1, in connection to Mo Industrial Park (MIP), has more than 500 MW available. Location 2 has 35 MW available, and can be upgraded to 100 MW within a year. Existing infrastructure offers high redundancy (N-1 criterion fulfilled) for additional delivery of power.

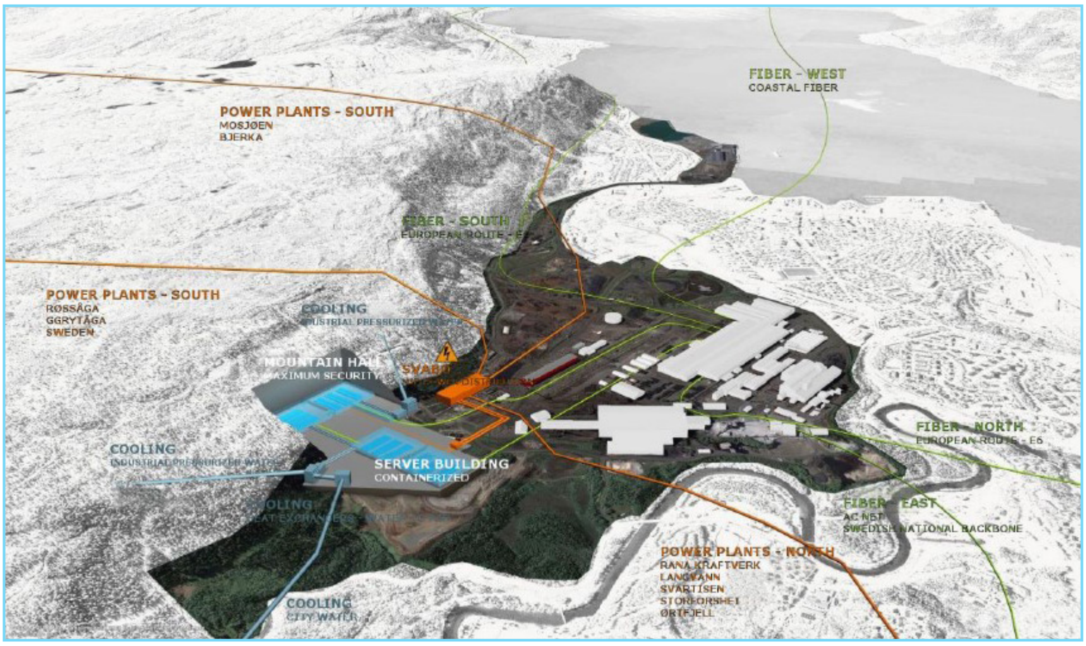


FIGURE 8-2
Location Arctic Cloud Data Center in Mo I Rana, N-1 fulfilled.

8.3.2 FIBER ACCESS AND CONNECTIVITY

For a data center site the connectivity to the European continent is of great importance. In order to meet the market demand, a DCE location should be able to offer at least three redundant fiber routes (N-2) from the location to various international fiber nodes, such as Stockholm, Rostock, Helsinki and Amsterdam.

By actual testing, developers should show route and the latency of the data transmission from the location to international nodes. Further, for the locations that wish to attract DCEs, dark fiber connections having the correct standard, should be in place within a maximum of 9-12 months.

Figure 8-3 shows all three types of Tier connections.

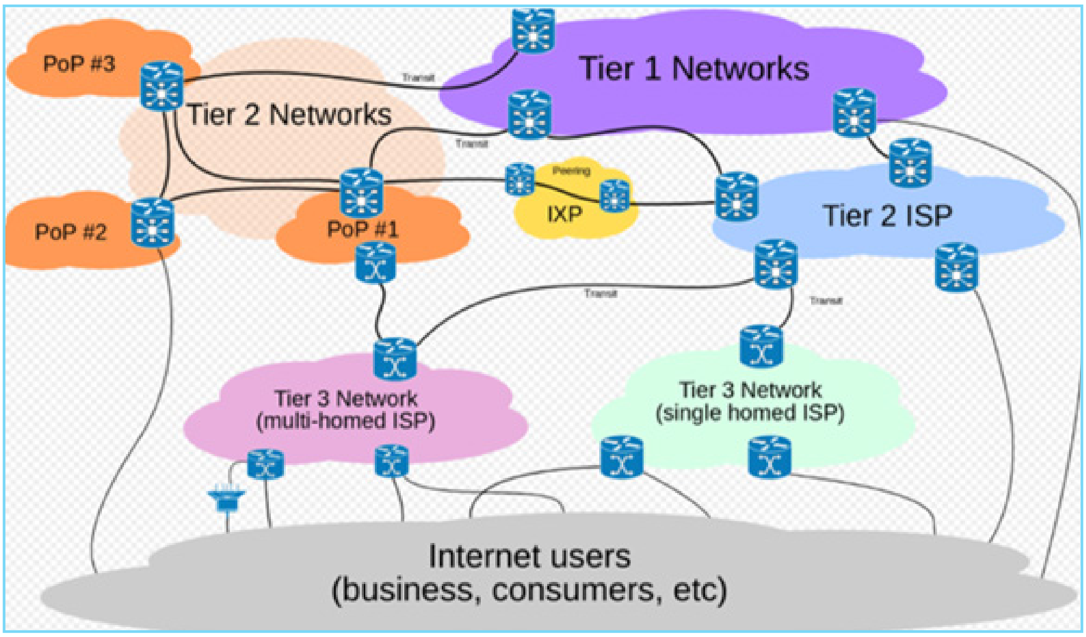


FIGURE 8-3
Three types of Tier network and how they operate. See explanations below.

Explanations, Metro/POP/Tier:

- Metro network (see figure 8.4) is a network that often covers a city. Large cities may have several Metro networks. The design is such that it has a ring structure for redundancy and diversified paths.
- Point of Presence (POP) is a physical location where technical equipment can be defined as a demarcation point or a location where network entities meet/connect.
- Tier 1, 2, 3 networks are defined from «size» of the network, and reach over the Internet. The Internet is built up from a large amount of separate networks that are «glued» together over among other things Internet Exchange points. At these locations there is an option to do peering with other networks. Some peering agreements are free, based on the size of the networks doing the agreement. Are they equal in size (value) no money is exchanged.

A Tier 1 network reaches all sides of the Internet without having to pay for capacity. Going downwards to Tier 2, they pay for 2 uplinks, etcetera.

For Tier 3 (reference https://en.wikipedia.org/wiki/Tier_1_network) the following applies

Definitions Tier 1:

- There is no authority that defines tiers of networks participating in the Internet. However, the most common definition of a tier 1 network is a network that can reach every other network on the Internet without purchasing IP transit or paying settlements.
- By this definition, a tier 1 network is a transit-free network that peers with every other tier 1 network. But not all transit-free networks are tier 1 networks. It is possible to become transit-free by paying for peering or agreeing to settlements.
- Common definitions of tier 2 and tier 3 networks:
- Tier 2 network: A network that peers with some networks, but still purchases IP transit or pays settlements to reach at least some portion of the Internet.
- Tier 3 network: A network that solely purchases transit from other networks to participate in the Internet.

Fiber is relatively easy to build, and often it is possible to build the necessary structures within the construction period of the data center (often one year). However, in order to gain the investors interest in the first place, existing connections should be identified and possible suppliers should be contacted and inquired about capacities and access to dark fiber.

Example: Three different fiber routes to international nodes

The N01 Campus location in Vennesla close to Kristiansand has identified three redundant fiber connections to Oslo, Denmark and London.

The first route is through the fiber on the Skagerak4 power cable via Denmark to Germany. The second route is from Vennesla to Oslo and via Sweden to Europe. The last option is through Lista – Valhall (offshore installation) – London that will be operational in near future.

The important part is to show that there are options, both on existing and future fiber routes.

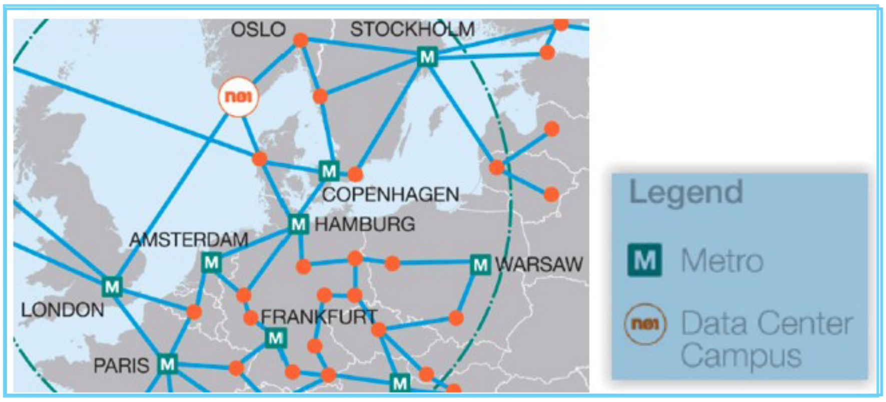


FIGURE 8-4
International routes from the N01 Campus in Vennesla, Kristiansand. Orange dots are POP nodes in preferred cities | Source: www.bulk.no

Example: Description of latency to international nodes

Lefdal Mine Datacenter can connect to London with 9 ms latency through Kårstø/Tampnet. The same route offers access to Iceland and the United States. The traffic to mainland Europe will be through several routes where major international service providers are present.

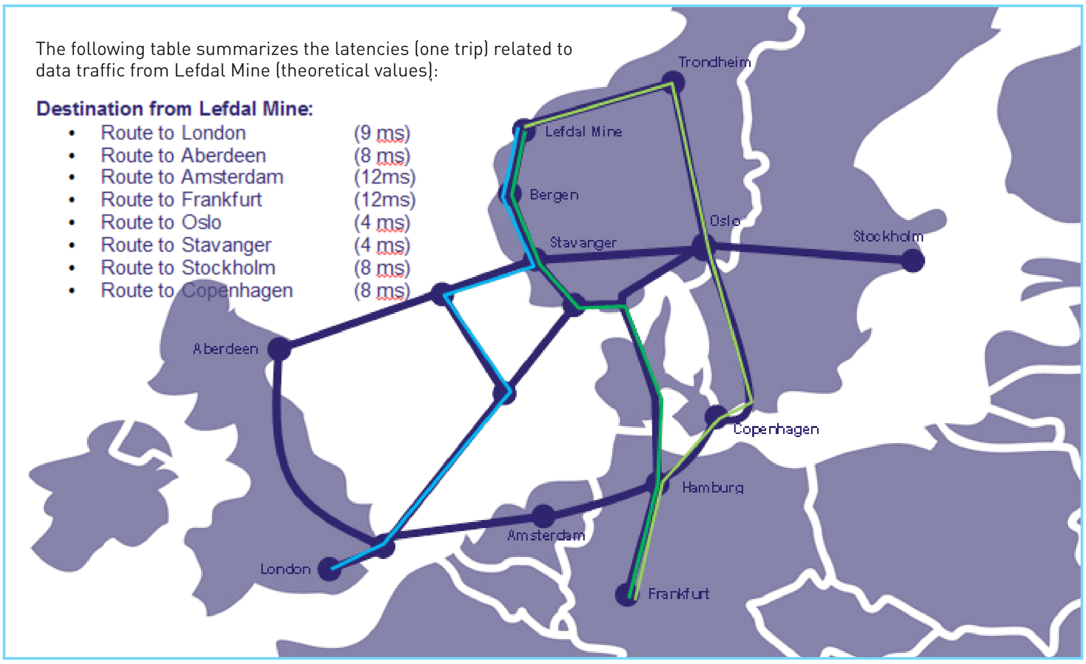


FIGURE 8-5
Latencies from Lefdal Mine Datasenter to national and international nodes. Source: | www.lefdalmine.no.

8.3.3 AREA SIZE

The minimum size of area should be 100 000 m², but often areas of 400 000 – 500 000 m² are preferred. Additional expansion possibilities in direct connection to the primary area are also an advantage. This criterion must be seen in connection with zoning status (chapter 7.3.7) and first possible build start. Many of the locations in appendix 3 are large enough, but may need more time than one year to complete the zoning process.

Example: Area size of the Rendalen and Notodden locations

An example is location Rendalen in Østerdalen with an available area of 902 000 m². Also the location Rossebu in Notodden, has an available area of 270 000 m² with possibilities of additional expansion of up to 700 000 m².

8.3.4 INFRASTRUCTURE: ROAD

Road connection of minimum standard is a necessity. The location must be able to provide paved, two lane road access to the location from the trunk road system ("stamveinettet"). The road must be suitable for large trailers and heavy vehicles that can transport containers.

The transport of people to a DCE can be divided into international travels from the international company and work travels for the local employees. Transportation of goods is needed to get access to building materials in the construction period, supply and replacement of server racks and operation and general maintenance of the center.

8.3.5 INFRASTRUCTURE: AIRPORT

The main background for the requirement for distance to airport, is that international staff easily can reach the location by air transportation, often from continental Europe and the United States. The site should ideally be located less than 60 minutes away from the airport. However, some of the international companies accept travel times up to 90 minutes or even 120 minutes depending on individual needs and the total set of qualities that the location can provide.

In Norway, Oslo international airport, Gardermoen is in a special position regarding the number of international flights. The nearby regional international airports at Moss, Rygge and Sandefjord, Torp make the greater Oslo area well connected.

Bergen, Stavanger and Trondheim can also provide regular flights to a number of international destinations. Also, some of the regional airports have international destinations that may fulfill this criterion.

Airport	International destinations pr. day (exclusive charter)	Destinations to Oslo pr. day (exclusive charter)	Type of airport
Oslo - Gardermoen - Rygge - Torp	129 83 26 20	-	Large airport
Bergen / Flesland	31	27	Large airport
Stavanger	29	25	Large airport
Trondheim	17	28	Large airport
Ålesund	7	11	Regional airport
Tromsø	5	14	Regional airport
Kristiansand / Kjevik	4	9	Regional airport
Bodø	1	11	Regional airport

TABLE 8.2
Airports and number of international flight pr day | Source: Avinor, Rygge Airport, Torp Airport.

Example: Infrastructure and logistics to location

The figure below shows the N01 Campus location in Vennesla municipality, and corresponding travel times from the site to Kristiansand city center, Kristiansand airport (Kjevik) nearest freight terminal (railroad) and nearest university (University of Agder).

The travel times for this location are within the minimum criteria set in this report.

Several of the other locations in annex 3 do not fulfill this criterion. However, it is important to realize that the actual requirements of the international DCE investors may be different from the criteria used here, and it is possible that locations situated on sites that do not comply with this criterion can be selected for other reasons.

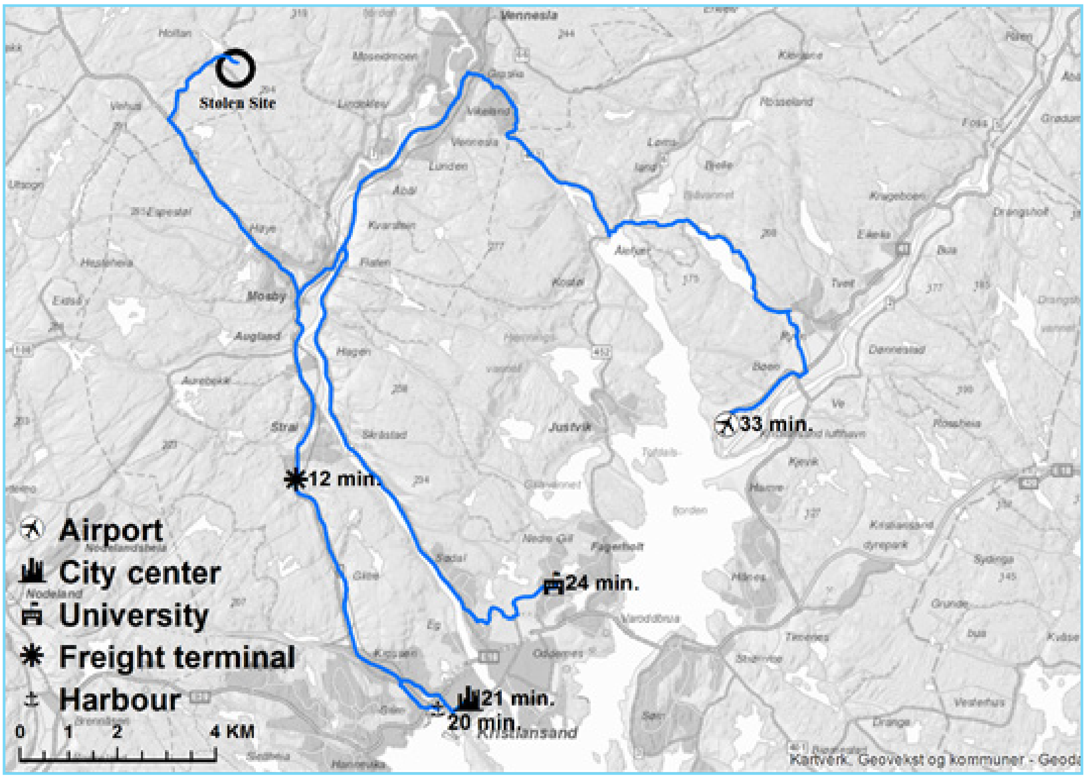


FIGURE 8-6
The N01 Campus location in Vennesla near Kristiansand (local name "Stølen"), distances to city center, airport, harbor, freight terminal and university.

8.3.6 CITY CENTER WITH UNIVERSITY

Most of the DCE operators choose locations that are situated within short distance of a city center, hosting a university or city college with relevant academic routes. Some of the potential DCE investors will require a maximum travel time of 40 minutes to a city center.

There are several reasons for this:

- Access to work force of sufficient academic level (necessary competence)
- Access to services for the data center.
- Access to medical services
- Access to urban qualities

Example: Industrial competence in the Notodden – Kongsberg hub

Industrial experience and networks in the area is also an advantage. An example is the industrial experience gathered in the region of Kongsberg/Notodden and the diversity of oil/gas-related companies, vendors and other industrial actors located here. The industrial cluster in Kongsberg consists today of companies like Kongsberg Gruppen, Dresser-Rand, FMC Technologies and GKN Aerospace. At Kongsberg, Buskerud and Vestfold University College offer studies, even some on PhD level, in systems engineering, advanced materials, system modelling and analysis etcetera. The University College works closely with the local industry within the fields of offshore- and subsea technology, materials- and production technology, defense and aerospace. Approximately 8 000 people in Kongsberg (population 25 000), work within the city's industrial cluster, which has formed NCE Systems Engineering Kongsberg, (NCE – Norwegian Centres of Expertise).

With only a 30 minute car-ride between, industrial actors in Notodden (population 12 500) work largely within the same fields as their colleagues in Kongsberg.

8.3.7 FIRST POSSIBLE BUILD START

This is an overarching criterion that depends on the outcome of many of the other criteria listed:

- Permission procedures to the municipality (zoning, grid etcetera)
- Building necessary new infrastructure (grid, roads, fiber etcetera)

To a DCE investor, it would be an advantage if maximum time to construction start up is less than one year. The overall readiness of a location can therefore be described when the location is identified and evaluated.

The importance of this criterion is to show that the more developed the location is, the lesser the risk that procedures and necessary preparations take more time than expected, resulting in delayed build start for the project.

To the DCE investor, it is important to have highest possible predictability in the planning of the data center, and it is an advantage if the developer can give a schedule for first possible build start, preferably within a year.

The area should preferably be zoned into an industrial area, as the investor prefers lowest possible risk with regard to zoning processes. As a minimum requirement, application for zoning to industrial area must have been sent to the municipality. For large industrial areas, the zoning plan may contain conditions regarding more detailed zoning before the area is ready for building.

8.3.8 LANDOWNER AND REGIONAL COOPERATION

In meeting with DCE investors and operators it is of great importance that the developer/owner has a proactive, positive attitude, and are capable of handling international customers in a professional way. Key personnel should be fluent in English language, with necessary business experience at an international level.

In order to attract foreign DCE investments, site developers may need to take both some costs and also risks by carrying out various planning and preparation work. This could for instance have to do with ownership (where ownership initially is spread on several actors), organization and management. It can also have to do with zoning processes, dialogue with grid owner(s), apply for permits etcetera. In some cases developers would even initiate and manage the initial construction work, as part of the site preparation.

To accommodate the DCE operators it is also important that involved actors on both local and regional levels are involved from early phases. This includes municipal governments capable to prepare for instance necessary infrastructure, process application for building permits, and actors like educational institutions, local constructors, suppliers, etcetera.

Based on the general development plans the municipalities normally have, one can often become aware of possible conflicts that may slow down, or even terminate, the zoning process, even if zoning application is not yet started. There are maps and registers of biological, cultural, agricultural and geological values and associated guidance as to how these are to be addressed in the zoning process.

There should be no special conditions following the final zoning plan, and necessary building heights could be as tall as 30-50 meters.

The ownership of the land must be clarified to make sure the land is actually available to development. This is normally part of the zoning process, but should be included in the description of the area. Simple ownership structures are preferred.

Example: Final zoning, available extension

The Rossebu site in Notodden municipality is located 6 km east of Notodden city centre, by highway E134. The site is also 25 km from Kongsberg and 110 km from Oslo. At the Rossebu site zoning of 270 000 m2 industrial area is already finalized. An extension of the area by approximately 430 da is available directly adjacent, and the potential for conflicts of interests in this area causing delays in the zoning process is considered being small.

The zoning for Rossebu states a maximum building height of 15 meters; however, since the area has no close neighbors, the municipality may be open to consider higher building heights if needed.

	Description
Municipality:	Notodden
Zoning status:	Zoning plan – «Industriområde på Rossebu-sletta», accepted 2007.
Purpose:	Industrial area: 270 000 m²
Size of area:	700 000 m² (including planned extension area)
Building factor/height:	Max 70% BYA = 189 000 m² built area. Building height: 15 meters
Special conditions in zoning plan:	No
Owner:	Gnr/Bnr 42/643 Rossebu næringsområde AS
Potential of conflicts in development:	Small

TABLE 8-3
Evaluation of location Rossebu, Notodden.

Example: Local cooperation

In order to attract DCE investors to the locations at Alvdal, Tylldal and Rendalen, local actors have organized themselves through a separate development company. Behind this company one finds land owners, power suppliers (Eidsiva Energi and Nord-Østerdal kraftlag), fiber provider (Eidsiva Bredbånd) and the municipalities of Alvdal, Tynset and Rendalen.

For further information, see http://tynset.koyopa.com

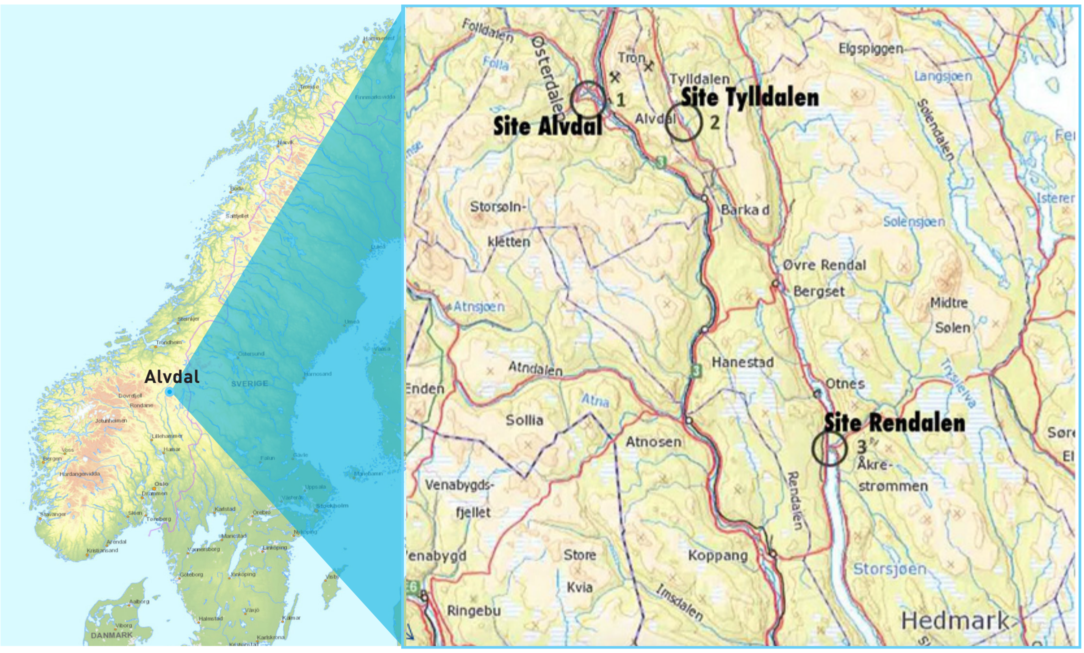


FIGURE 8-7
Map showing the Alvdal,Tylldalen and Rendalen sites.

8.4 Other physical criteria

In addition to major criteria listed in 8.3, there are a number of other physical concerns that constitute a number of criterions.

8.4.1 LOCAL CLIMATE

Probability of natural hazards such as earth quake, eruptions, hurricanes, flooding etcetera are considered by the investors when selecting locations. Norway is generally not exposed to the kind of natural disasters that can be fatal for a DCE.

Areas with low average air temperatures, are especially favorable for air cooling. Generally, the interior parts of Norway have lower annual mean temperatures compared to the coastal parts (Rendalen 0,8°C vs Kristiansand 3,7°C), which allows for air cooling all year. The inner parts of the country also have the lowest probability for strong gales and massive precipitation.

8.4.2 TOPOGRAPHY

Ideally, for a data center investor, the area would be flat and ready for construction.

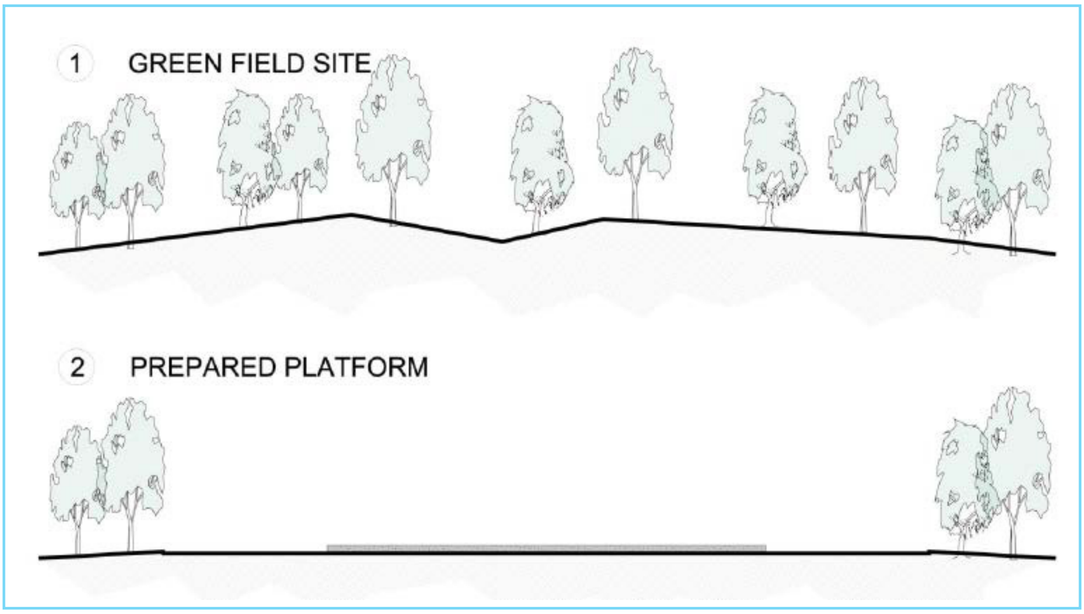


FIGURE 8-8
Flattening out the landscape, preparing for datacenter. | www.bulk.no.

8.4.3 WATER FOR COOLING

Power consumption of >100 MW will result in large amounts of waste heat that needs to be removed from the DCE. In areas with low mean temperatures, air cooling may be suitable cooling solution. Water cooling may also be an option. Water has a much larger heat capacity than air, and the amount of air required greatly exceeds the amounts of water for the same cooling capacity. Cooling solutions must be evaluated for each site. In addition to investment and operation costs, possible utilization of low temperature (waste) heat ought to be investigated.

Given power consumption of approximately 100 MW, and a temperature difference of 20-25 degrees Celsius, the necessary flowrate will be in the order of 1-1,5 m3 /second. The water can be collected from a nearby lake or sea/fjord and distributed in pipes through the data center.

The efficiency of the cooling system based on free-cooling from adjacent sea or water basins (with constant temperature levels), will be roughly speaking ten times better than traditional cooling compressors. As cooling in traditional datasenters requires almost 50-60% of total (data)power consumption, this possibility could represent a significant differentiator. Goggle's datacenter in Hamina utilizes cooling from the sea.

Example: Lefdal Mine Data center, Nordfjord – water cooling, figure 8.10

In the Lefdal Mine Datacenter in Nordfjord cooling water is taken from the fjord lying next to the center. When taken from an appropriate depth, favorable water temperature can be held stable throughout the year. A similar cooling solution is chosen by Green Mountain data Center at Rennesøy near by Stavanger.

8.4.4 USE OF WASTE HEAT

The utilization of waste heat from the DCEs cooling system should be considered for each location. The temperature of the waste heat (air or water) is normally 20-22 degrees Celsius. The temperature level of the waste heat from the DCE is normally not high enough to provide any efficiency to district heating systems unless combined with heat pumps.

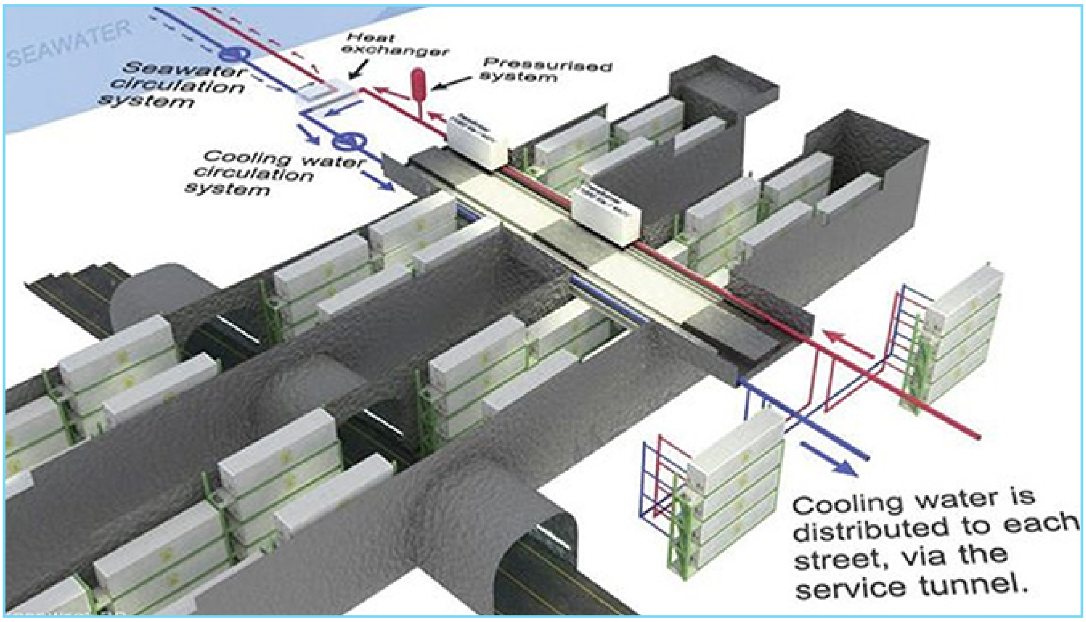


FIGURE 8-9
Water cooling system in Lefdal Mine Data center in Nordfjord, Norway. | Source: www.lefdalmine.no

9 APPENDIX

9.1 Appendix 1: Contact lists some regional grid companies

Grid company	County	web-adress
Agder Energi Nett AS	Agder	http://www.aenett.no/
EB Nett AS	Buskerud	https://www.eb-nett.no/
Ringeriks-Kraft Nett AS	Buskerud	http://www.ringeriks-kraft.no/
Varanger Kraftnett AS	Finnmark	http://varanger-kraftnett.no/
Eidsiva Nett AS	Hedmark and Oppland	https://www.eidsivanett.no/
BKK Nett AS	Hordaland	http://www.bkk.no/
SKL Nett AS	Hordaland	http://skl.as/
Istad Nett AS	Møre og Romsdal	http://www.istadnett.no/
MØRENETT AS	Møre og Romsdal	http://www.morenett.no/
Nordmøre Energiverk AS	Møre og Romsdal	http://neas.mr.no/
Nordvest Nett AS	Møre og Romsdal	http://www.nvn.no/
HelgelandsKraft AS	Nordland	http://www.helgelandskraft.no/
Nordkraft	Nordland	http://www.narvikenerginett.no
Nordlandsnett AS	Nordland	http://www.nordlandsnett.no
Nord-Salten Kraft AS	Nordland	http://www.nordsaltenkraft.no/
Nord-Trøndelag Elektrisitetsverk	Nord-Trøndelag	http://www.nte.no
Hafslund Nett AS	Oslo, Akershus, Østfold	https://www.hafslundnett.no/
Haugaland Kraft AS	Rogaland	http://www.haugaland-nett.no/
Lyse Elnett AS	Rogaland	http://www.lysenett.no/
SFE Nett AS	Sogn og Fjordane	http://sfe.no/
Sognekraft AS	Sogn og Fjordane	http://www.sognekraft.no/
Sunnfjord Energi AS	Sogn og Fjordane	http://www.sunnfjordenergi.no/
TrønderEnergi Nett AS	Sør-Trøndelag	https://tronderenerginett.no/
Skagerak Nett AS	Telemark, Vestfold	http://www.skagerakenergi.no
Troms Kraft Nett AS	Troms	http://www.tromskraft.no

9.2 Appendix 2: Fiber / connectivity

9.2.1 SUPPLIERS OF CONNECTIVITY IN NORWAY

The table below lists the most relevant suppliers of fiber capacity in Norway.

Provider	Area	Contact
Telenor	National	wholesale@telenor.no / http://www.telenorwholesale.no
Broadnet	National	wholesale@broadnet.no
Kysttele	Trondheim – Narvik (coastline)	http://kysttele.no/English
Stamnett fiber	Trondheim – Narvik (on land)	http://stamfiber.no/kart.html
Bredbåndsfylket Troms	Troms County	http://www.bredbandsfylket.no/home.30224.en.html
Ishavslink	Finmark County	http://www.ishavslink.no/
Eidsiva Fiber	Oslo – Trondheim and regionally, to Sweden	http://www.eidsiva.net/bedrift/datakommunikasjon/mork-fiber
BKK	Regionally	www.bkkfiber.no
Lyse	Regionally	http://www.lyse.no/?lang=en_GB
Bulk AS	Oslo - Kristiansand	www.bulk.no
TeliaSonera		http://www.teliasoneraicmap.com
RIKS	Trondheim-Ålesund	www.riks.no
Tampnet	South west Norway	www.tampnet.com

9.2.2 CONNECTIVITY WITHIN NORWAY

One of the national providers of connectivity (Telenor) has a network map like the one below and mapping this with the other national operator will give connectivity to most parts of Norway. The main challenge is access to transport fiber between cities and not as much in city connectivity.

FIGURE 9-1
Telenor fiber grid in Norway.

FIGURE 9-2
Broadnet fiber grid in Norway.

Eastern part of Norway

Eidsiva provides one of the largest regional fiber networks in Eastern Norway, with approx. 6000km of fiber routes. With several existing border crossings to Sweden, with additional planned, Eidsiva provides 24 and 48 pair access to Swedish fiber network. Through partneres in Easyfibre, Eidsiva offers continuous fiber routes from eastern Norway to Northern Germany.

FIGURE 9-3
Eidsiva fiber network.

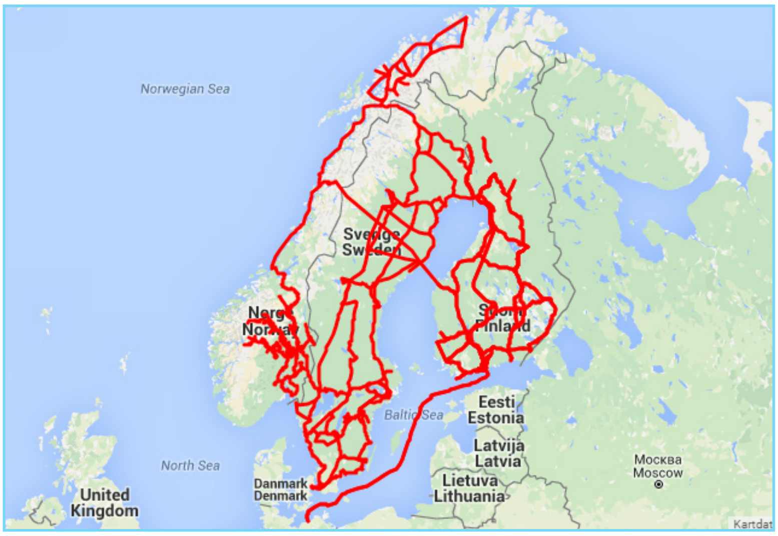


FIGURE 9-4
Easyfibre network (beta map, not complete)

Southern part of Norway

Bulk Infrastructure connects internationally with carrier networks in Oslo via Sweden, or Oslo to Kristiansand and then subsea cable to Denmark and to the European Continent.

From Stavanger there are options via Kårstø to United Kingdom today. There are free fibers that are controlled by TeliaSonera International Carrier on the same cable as Tampnet operate. The fiber system has 15 more years in operations and offers open access.

From Stavanger to Bergen there are openings for fiber even if the networks are not optimal. There are plans to look into this important connection for a later state to connect Bergen direct to Oslo. This is initiated as a project and there are works going on to get more sponsors.

Working along these thoughts and plans will help any initiatives in this "circle" to connect to the International markets.

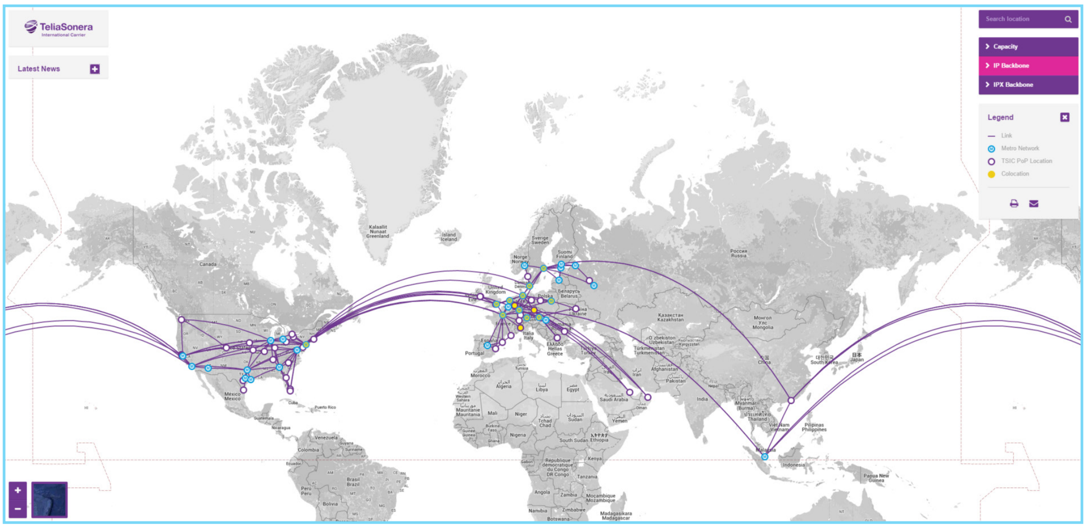


FIGURE 9-5
Telia Sonera is an International Carrier, the one of four European Telecom Companies delivering Tier 1 level.
http://www.teliasoneraicmap.com/

Central Norway

The Trondheim region has several options and can support most initiatives. Going north (Nord Trøndelag county), the NTE region will be able to help and there are also ongoing an existing transport fiber routes to Nordland County. The new initiatives together with existing coverage can connect most locations in the Northern Norway. Redundancy via Sweden can be setup across several options on this path going north.(Mo i Rana - Luleå and Narvik - Kiruna)

The Northern part of Norway

In the Northern part of Norway there are several operators with business products that may support the DCES both on capacity and dark fiber products. These are Telenor, Ishavslink and Varanger bynett.

KystTele was founded in 2005 and is owned by three of the largest electric utilities in Northern Norway. KystTele builds, operates and maintains the only open neutral fiber optic infrastructure between Northern and Southern Norway. The company is competition-neutral and provides a network that is open to all players on equal terms.

FIGURE 9-6
Kysttele fiber Trondheim – Narvik.

FIGURE 9-7
Map showing Telenor fiber in eastern Finmark.

The International duct systems

The largest nodes of fiber traffic in Europe are London, Frankfurt and Amsterdam. Oslo is primarily connected to continental Europe via Sweden. In addition, there are other routes as explained below:

Tampnet is a Norwegian based actor that operates in the market space of selling capacity products out of Norway via their optical systems across the North sea, Figure 9-8. Capacities can be leased to Scotland and to UK. Still this is a working solution and a network optimal route given the planned DCE is located in South West of Norway.

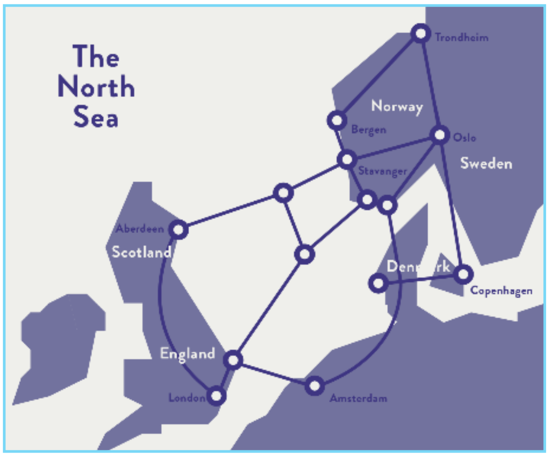


FIGURE 9-8
Tampnet fiber grid.

Figure 9-9 shows the Skagerak 4 cable system connecting Norway and Denmark and where it actually lands in Denmark. This is a cable that has 24 pairs of fiber. A few are used by Statnett to manage the power cable but the rest is open to lease for the commercial market.

FIGURE 9-9
Fiber connection Skagerak 4.

When arriving in Denmark there are multiple vendors that can bring traffic to and from DCEs.

Links:

http://www.netnod.se

https://en.wikipedia.org/wiki/List_of_Internet_exchange_points_by_size

http://www.ip-only.com/platforms/fiber-network/ terminates in Oslo with a data center.

http://maps.level3.com/default/

http://www.teliasoneraicmap.com

http://map.tatacommunications.com/#/ connected via other providers into Oslo.

http://www.cogentco.com/files/images/network/network_map/networkmap_global_large.png

http://www.globalconnect.dk/produkter/fiber-netvaerk/fibernet-daekningskort

http://www.ishavslink.no

http://www.tampnet.com/

9.3 Appendix 3: Locations

The table is a list of the locations identified during the project period and is not ranked. The number of possible locations / DCE sites is increasing, and the list is therefore not complete.

	Location	Municipality	Contact	Email	Website
1	Alvdal	Alvdal	Arild Løvik	arild.lovik@hedmark.org	http://www.tynset.koyopa.com/
2	Tylldalen	Tynset	Arild Løvik	arild.lovik@hedmark.org	http://www.tynset.koyopa.com/
3	Rendalen	Rendalen	Arild Løvik	arild.lovik@hedmark.org	http://www.tynset.koyopa.com/
4	Aurland	Aurland	Aurland Kommune	post@aurland.kommune.no	http://www.aurlanddatacenter.com/
5	Bodø	Bodø	Odd Emil Ingebrigsen	odd.emil@gmail.com	http://www.arcticnorwaydatacenter.no/
6	Eide, Greenfield	Eide	Lars Naas	lars@trollhousing.no	http://www.trollhousing.no/
7	Eide, Mountain Hall	Eide	Lars Naas	lars@trollhousing.no	http://www.trollhousing.no/
8	Flå	Flå		post@norsevalley.no	http://norsevalley.nxtfiles.com/
9	Kristiansand	Kristiansand	Peder Nærbø	pn@bulk.no	http://bulk.no/real-estate-data-center/locations/12
10	Lefdal	Eid	Mats Andersson	mats.andersson@lefdalmine.com	http://www.lefdalmine.com/
11	Luster	Luster	Edvin Brun	edvin@bluefjords.com	
12	Mo i Rana 1	Rana	Jan Erik Svensson	jan.erik@inkubatorhelgeland.no	http://www.arcticcircledatacenter.com/locations/
13	Mo i Rana 2	Rana	Jan Erik Svensson	jan.erik@inkubatorhelgeland.no	http://www.arcticcircledatacenter.com/locations/
14	Mo i Rana 3	Rana	Jan Erik Svensson	jan.erik@inkubatorhelgeland.no	http://www.arcticcircledatacenter.com/locations/
15	Narvik	Narvik			http://www.narvik.koyopa.com/
16	Notodden	Notodden	John Terje Veseth	john.terje.veseth@nuas.no	http://nuinvest.no/
17	Rjukan	Rjukan	Espen Remman	espen.remman@gmail.com	http://tynset.koyopa.com/rendalen-location
18	Varanger, Vardø	Vardø	Ingela Mästerbo	ingela@naeringssenter.no	http://www.invinor.no/no/Industries/Green-IT/Varanger/
19	Varanger, Vadsø	Vadsø	Ingela Mästerbo	ingela@naeringssenter.no	http://www.invinor.no/no/Industries/Green-IT/Varanger/
20	Varanger, Nesseby	Nesseby	Ingela Mästerbo	ingela@naeringssenter.no	http://www.invinor.no/no/Industries/Green-IT/Varanger/
21	Ørje	Ørje			http://www.orje.koyopa.com/
22	Brokke	Valle	Bjørgulv N. Berg	bnberg@online.no	
23	Hestesprangdalen	Kvinesdal	Thovald Reiersen	t-re@online.no	
24	Opofte - Lista Næringspark	Kvinesdal	Liv Øyulvstad	liv.oyulvstad@kvinesdal.kommune.no	
25	Lindalen	Flekkefjord	Rolf Terje Klungeland	rtk@flekkefjord.kommune.no	
26	Drangeid/Aarnes Eiendom	Flekkefjord	Andreas Møller		
27	Jåddan	Hægebostad	Arnt Nøkland	arnt.nokland@haegebostad.kommune.no	
28	Kjerlingland	Lillesand	Egil-Andre Mortensen	eam@jbu.no	
29	Ertsmyra	Sirdal	Jørgen Tjørhom	jorgen.tjorhom@sirdal.kommune.no	
30	Eiken Næringspark	Hægebostad	Arnt Nøkland	arnt.nokland@haegebostad.kommune.no	
31	Lista Fly og Næringspark	Farsund	Jørgen Tjørhom	jorgen.tjorhom@sirdal.kommune.no	

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