

NorNed



Europe's link for the future



We take electricity for granted

in our everyday lives. Without thinking about it, we switch on the lights, leave the coffee maker on and turn the vacuum cleaner on to full power. However, these routine actions would not be possible without somebody to supply the power. In both the Netherlands and Norway we meet the demand for energy by means of an efficient electricity grid. TenneT and Statnett are responsible for the 'highways' in the electricity grid that connect all regional grids to each other and to the European grid.

As national grid administrators – also known as transmission system operators (TSOs) – of the grids in their respective countries, both TenneT and Statnett rapidly respond to developments in the energy market in North-western Europe. A connection between the Netherlands and Norway is in line with the European Union's policy of interconnecting markets and enhancing the free market system.



The cable

The longest submarine high voltage cable

In this brochure you can read all about **NorNed** - the extraordinary project to install a 580 kilometre cable along the seabed of the North Sea, between Norway and the Netherlands. A joint initiative of two TSO's Statnett and TenneT.

NorNed is a submarine high voltage cable which interconnects the Dutch and Norwegian electricity grids. The cable enables Statnett and TenneT to transmit electricity from the Netherlands to Norway and vice versa.

With a capacity of 700 megawatts (MW) – the cable can supply, half of Amsterdam or Oslo's demand of power.

Where is the cable located?

The high voltage interconnection is installed along the shortest possible route between the two countries. The connecting points are situated in Feda, on Norway's south coast, and Eemshaven in the very north of the Netherlands.

The TSOs are responsible for the connection between the cable and the national high voltage grid in both countries.

When did the project start?

The NorNed project has been hailed as a major success. The preparations started back in 1994, and the decision to build the interconnector was made at the end 2005. The cable was completed in May of 2008.

Why install a new interconnection?

The Dutch electricity grid already had interconnections to Germany and Belgium before the completion of the NorNed project, while Statnett had cables linked to Sweden, Finland, Denmark and Russia. As such, some of the power supplies of Norway and the Netherlands already originated from abroad.

The NorNed cable links the Dutch and Norwegian national grids to markets to which they were not previously connected. The cable contributes to the overall security of supply.



Converter station in Feda, Norway



The cable laying ship C/S Nexans Skagerrak



Converter station in Eemshaven, The Netherlands



Production of single core cable, Nexans Halden, Norway

Technique

580 kilometres and 47.000 tonnes in total

The NorNed cable is either buried in the seabed or covered by rock. It was installed with the help of a special cable ship. Converters on the mainland convert the cable's direct current to alternating current and vice versa.

The cable was rolled out in sections measuring 75 kilometres in length, except for the Waddenzee section, which is 47 kilometres long. The sections were connected to one another at sea. A considerable layer of sand and rock covers the cable in order to protect it. The cable could only be installed in favourable weather conditions, for example, when the sea was calm.

Facts and figures

Out of the 580 kilometres of cable, 420 kilometres lay in shallow water up to 50 metres deep. The remaining 160 kilometres of cable have been installed at a depth of up to 410 metres. The double core cable weighs around 85 kg per metre; the single core cable weighs 37,5 kg per metre. The cable has a total weight of 47.000 tonnes. It was manufactured at factories in Sweden and Norway. The first 270 kilometres of the route from Eemshaven to

Norway comprises a double core cable, partly for environmental reasons and partly because this has been agreed upon by the Dutch and German authorities. For the remainder of the route, two single cables have been opted for, mainly as these are easier to maintain.

Facts and figures

- Cable length: 580 km
- Cable capacity: 700 MW (megawatt)
- Total project costs: EUR 600 million, 495 for the cable it self
- 24 licences in four countries includes substations and connections to the mainland grid
- 22 agreements with existing cable and pipeline owners
- Converter stations in Feda (Norway) and Eemshaven (Netherlands)
- Weight: single-core cable: 37,5 kg per metre; two-core cable: 85 kg per metre
- Voltage level: +/- 450 kV (kilovolt)
- Maximum sea depth: 410 metres

From direct current to alternating current

The NorNed cable is a direct current connection. Due to energy losses, the use of alternating current is not efficient when transmitting power across a distance of several hundreds of kilometres. However, the mainland high voltage grids in

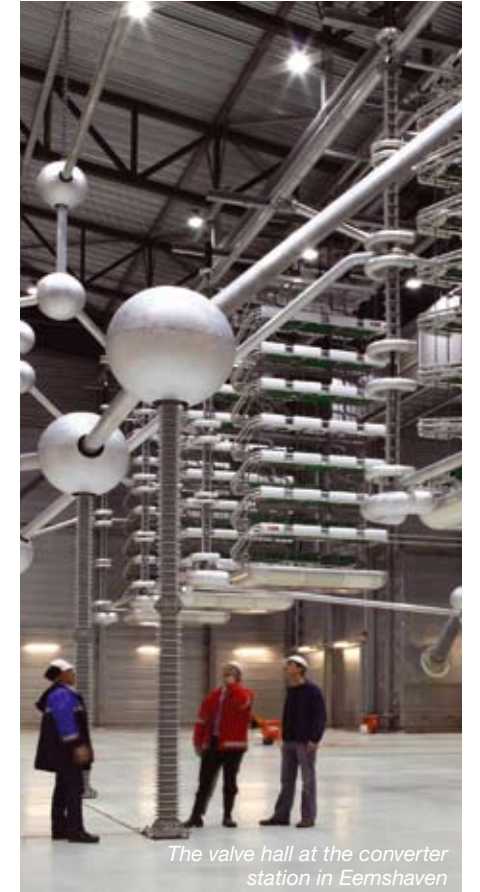
Norway and the Netherlands transmit alternating current.

As a consequence, large 'converters' are required to convert the alternating current into direct current. Both in Feda (Norway) and in Eemshaven (the Netherlands), these converters are set up as high voltage sub-stations or converter stations.

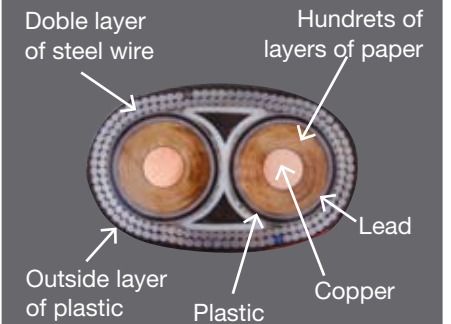
Each converter occupies a large area, about the size of three football pitches.

Because of the weather conditions in Eemshaven, it has been necessary to place the whole new station indoors, as salty wind and windblown sand may damage the equipment.

The converter in Feda is mainly set up outdoors, as Feda is located inland.



The valve hall at the converter station in Eemshaven



Two-core cable utilised at 270 km of the cable connection

Synergy

Water savings in Norway and green energy for the Netherlands

From the market's point of view, TenneT and Statnett are located at the edge of Europe. With the completion of the NorNed cable, both countries occupy a more central position within Europe. In effect, we are an 'electricity node' connected to other high voltage grids and electricity markets.

Norway and the Netherlands have different methods of generating electricity. In Norway, 99 percent of all electricity is generated through hydro-electric power, an environmentally friendly production method. Hydro-electric power plants convert the energy of falling water into renewable 'green electricity'.

In the Netherlands, electricity is mainly generated by means of fossil fuels such as natural gas and coal. Via the NorNed cable, Dutch market parties will be able to import renew-

able electricity. This will mainly be done during the day, when electricity consumption is at its peak.

Complementary

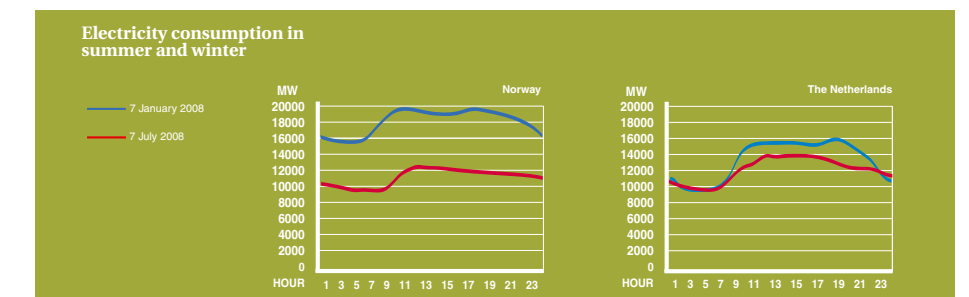
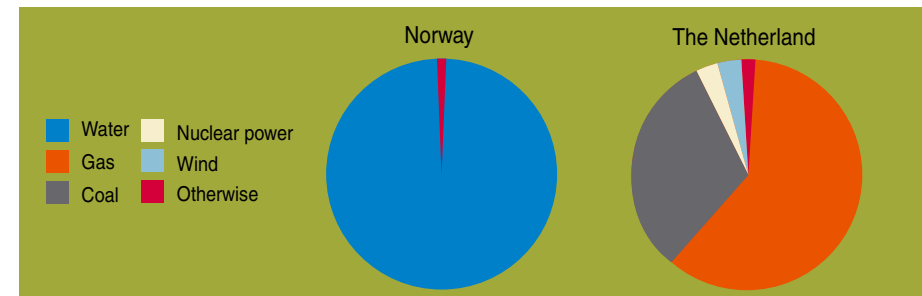
Norway and the Netherlands complement each other when it comes to the production and consumption of electricity. In the Netherlands, less electricity is consumed at night than during the day, while the energy consumption in Norway is relatively high during the night. The two countries also have different patterns of energy consumption:



Norway has an electric heating system, while the Netherlands uses gas heating. At night, Norway is self-sufficient in its electricity production. However, it prefers importing the cheaper electricity produced by the Netherlands during the night. This also allows Norway to save the limited water resources in its reservoirs for use during the day, so that it can in turn supply electricity to the Netherlands during expensive daytime peak hours.

Optimum use of production capacity

Because of the limited amount of electricity used in the Netherlands during the night, Dutch power plants are operated at a limited load during these night-time hours. Electricity cannot be stored, and the generators cannot be switched off because the power plants have to be ready in time for the daily morning peak in electricity consumption. Thanks to the NorNed cable, power plants in the Netherlands are able to make better use of their production capacity at night by exporting their electricity to Norway.



Trading

A strong European electricity market

The NorNed cable links the electricity grids of the Netherlands and Norway. In the near future, this submarine cable link will also make a significant contribution towards a robust European electricity market comprising central Western Europe and the Nordic countries.

This new 'electricity highway' allows exchange of electricity to and from Norway and the Netherlands. To begin with, allocation of capacity will be organised by an explicit, day-ahead auction. The explicit auction will later be replaced by an implicit auction.

Explicit auction links Norway and the Netherlands

The explicit auction implies that qualified market parties first purchase capacity on the NorNed connection (i.e. 'space on the highway') and thereafter electricity on the power exchanges. Market parties purchase capacity in an auction jointly organised by Statnett and TenneT: NorNed Auction.

All the 700 MW capacity of NorNed is available for the day-ahead explicit auction.

At the day-ahead auction, participants obtain capacity per hour for the next day. A day-ahead auction is electronic; bids come in through a special secured system. Statnett and TenneT inform the participating parties of the auction results and publish them on the website www.norned-auction.org.

Linking together Norway and the Netherlands is expected to ensure security of supply, make more efficient use of power systems and make prices converge. More avail-

able capacity and expanded trade between Norway and the Netherlands will not only influence prices on the APX (Dutch power exchange) and Nord Pool Spot (Norwegian power exchange), but will also positively influence the electricity prices in neighbouring countries. Almost 20 qualified market parties take part in the explicit auction; this ensures a good competition in the market.

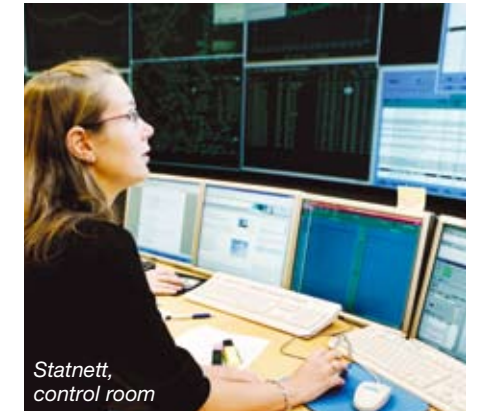
Towards market coupling

In June of 2007, responsible ministers, regulators, TSOs, power exchanges and industry associations in five European countries (Belgium, Germany, France, Luxembourg and the Netherlands) signed a joint memorandum of understanding (MOU). The MOU deals with the coupling of electricity markets and security of supply in Central Western Europe by means of an implicit market coupling. In an implicit auction, a market party simultaneously buys or sells

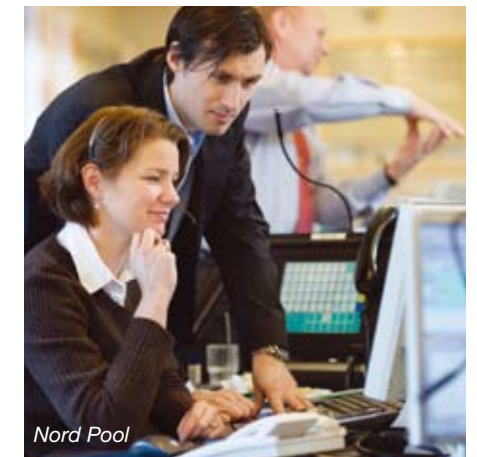
capacity and electricity in one of the electricity markets.

An implicit auction implies harmonisation of Gate Closure Times (GCTs), which is a precondition to the market. The GCT is the 'deadline' for submitting bids on the day-ahead market.

Market coupling between the Central Western European market and the Northern European spot market can be realised once the Central West European regional market has been established.



Statnett, control room



Nord Pool

Steps in the explicit day-ahead NorNed Auction

Qualified participant in the Dutch and/or Norwegian electricity market



Participant acquires cable capacity, through the NorNed Auction



TSOs inform participants and publish auction results on website



Participant purchases or sells power at APX and Nord Pool Spot



TSOs schedule next day electricity flow programs



TSOs manage transmission of electricity, day after trading

Benefits

Ensuring reliable supply of electricity and stable prices

The NorNed cable has not only created a physical connection between the Netherlands and Norway, it also has great benefits for 'all of us'.

The great advantage of the NorNed cable for Norway and the Netherlands is that the cable enhances security of supply of electricity.



Eight transformers have been produced for the NorNed project each weighing about 250 tonnes

The cable has also strengthened TenneT's and Statnett's positions as transmission system operators (TSOs) in the Norwest European electricity market and the Nordic region.

Benefits for the market

Thanks to the NorNed cable, more international trading can take place. The NorNed cable will introduce more traders and competition to the market places and as such contribute to enhanced liquidity.

As a result of NorNed, the electricity prices determined on an hourly basis by APX and Nord Pool Spot is expected to fluctuate less. This will in turn result in a more stable overall electricity price.

Benefits for end users

In Norway, the prices are expected to become more stable between

the seasons: higher prices during the summer and lower prices during winter. Whilst in the Netherlands prices in general are expected to come down.

In The Netherlands, this will be most noticeable on peak consumption hours during the day, while in Norway during the winter.

Additionally, in Norway, profits on NorNed will provide end users with reduced tariffs.

Benefits for the society

Dutch production plants are as a result of how the cable's operation is planned, able to make better and more efficient use of their production capacity during the night. This can reduce CO2 emissions from power production.

Environment

Responsibility towards society

During the installation of the NorNed cable, Statnett and TenneT have been taking careful account of the vulnerable natural environment in which the submarine high voltage cable is being laid, for instance with regard to the plant and animal life in the Waddenzee area.

TenneT and Statnett are aware of their responsibility towards society. All new high voltage lines and cables have been integrated into their environment as well as possible. When installing the NorNed cable, they took into account the wishes of government bodies, interest groups, businesses and local residents.

Preconditions

The route and location of the NorNed cable depended on various aspects:

- Environmental planning/preconditions: environmental considerations, locations of nature reserves, shipping routes
- Electrical/technical preconditions: strength of the magnetic field, soil condition
- Organisational preconditions: costs, timeline
- Policy frameworks defined by the government: spatial planning, legislation

Consultation

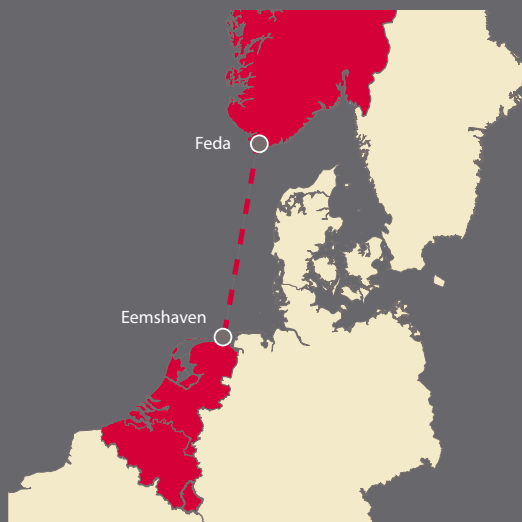
Part of the NorNed cable runs through Waddenzee. This is a marine area where plant and animal life receive a great deal of attention.

The exact route of the submarine high voltage cable is determined in consultation with government bodies and interested parties.



Laying of the first 45 km of the cable outside Eemshaven, the Netherlands





For more information about NorNed



www.statnett.no

Statnett SF

P.O. Box 5192 Majorstuen

NO-0302 Oslo, Norway

T: +47 22 52 70 00

F: +47 22 52 70 01

firmapost@statnett.no