

NorNed

Europe's link
for the future



We take electricity

for granted in our everyday lives.

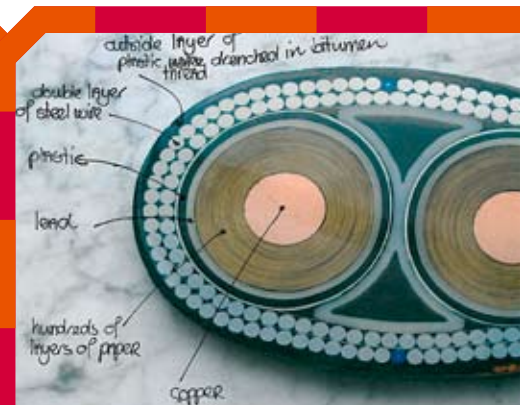
Without thinking about it, we switch on the lights, leave the coffee maker on and turn the vacuum cleaner on to full power. However, these routine actions would not be possible without somebody to supply the power. In both the Netherlands and Norway we meet the demand for energy by means of an efficient 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 Northwestern 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.

Feda - Norway



Illustration: ABB



The cable

The longest submarine high voltage cable in the world

Statnett and TenneT have installed a 580-kilometre cable along the seabed of the North Sea between Norway and the Netherlands. In this brochure, you can read all about this extraordinary project.

Statnett and TenneT are the managers of the national high voltage grid in their respective countries, also known as transmission system operators (TSOs). Statnett administers the national high voltage grid in Norway, while TenneT is the TSO in the Netherlands. Both organisations take care of the transmission of electricity in their countries, from the companies that generate the electricity (the producers) to the customers (regional grid administrators). The NorNed project is a joint initiative of the two TSOs.

WHAT IS NORNED?

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 total length of 580 kilometres, the NorNed cable has a capacity of 700 megawatts (MW) - enough to supply power to half of Amsterdam or Oslo.

WHERE IS THE CABLE LOCATED?

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

Eemshaven - The Netherlands



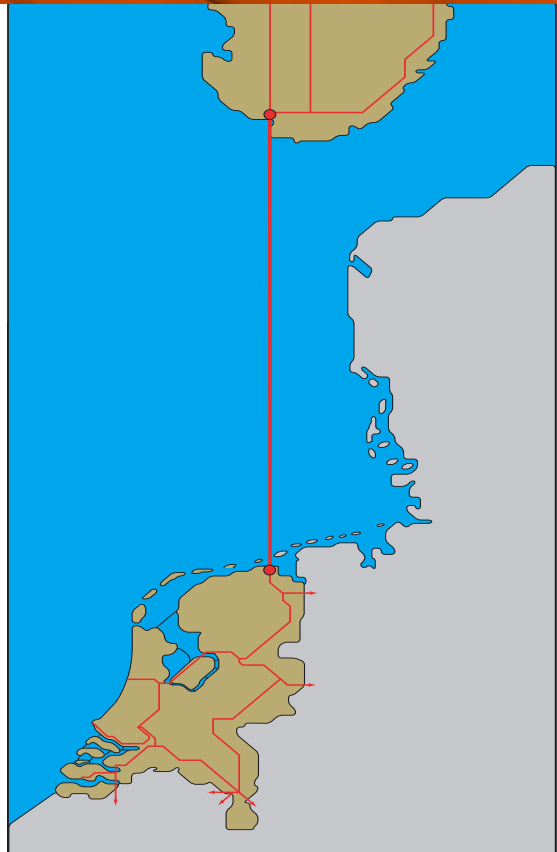
are responsible for the connection between the cable and the national high voltage grid in both countries.

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 of 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.



FACTS AND FIGURES

Cable length: 580 km

Cable capacity: 700 MW (megawatt)

Total project costs: EUR 600 million

24 licences in four countries

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



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

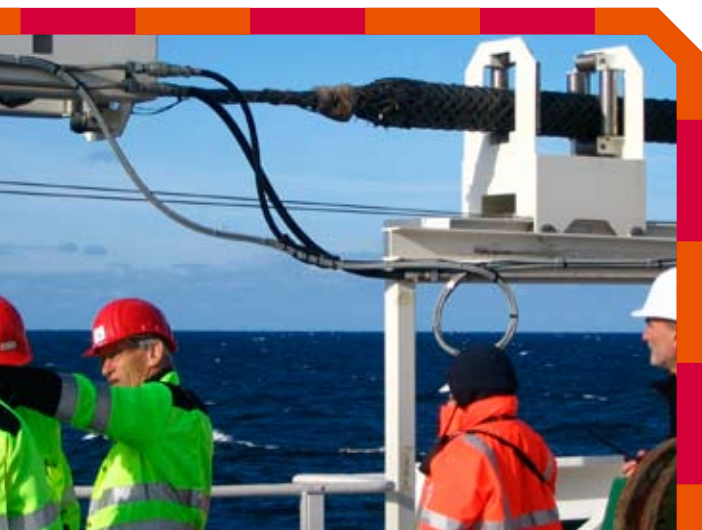
Out of the 580 kilometres of cable, 420 kilo-

metres 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 in 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 because these are easier to maintain.

FROM DIRECT CURRENT TO ALTERNATING CURRENT

The NorNed cable is a direct current connection. Due to energy losses, the use of alternat-



ing 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 at high voltage substations or converter stations. Each converter occupies a large area, about the size of three football pitches.

ADAPTING EXISTING SUBSTATIONS

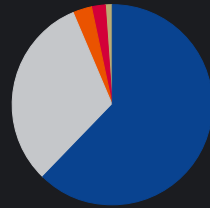
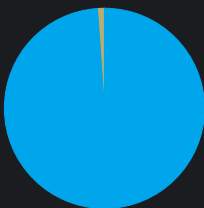
TenneT and Statnett have modified the existing high voltage substations at Eemshaven in the Netherlands and Feda in Norway: a separate connection has been installed, as well as an additional transformer and a converter building. Because of the weather conditions in Eemshaven, it is necessary to place the converter 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, by a fiord.



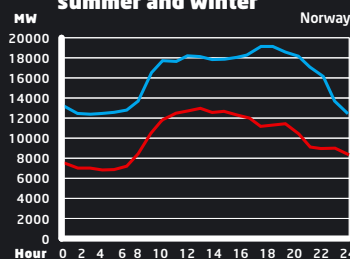
Electricity production NORWAY

THE NETHERLANDS

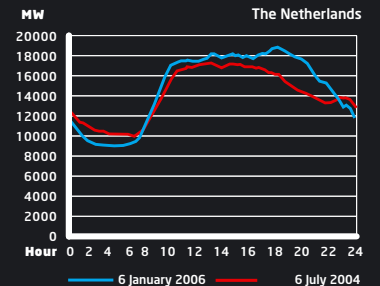
- Water
- Gas
- Coal
- Nuclear power
- Wind
- Otherwise



Electricity consumption in summer and winter



The Netherlands



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 renewable 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.

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. Allocation of capacity will be organised by an explicit, electronic day-ahead auction.

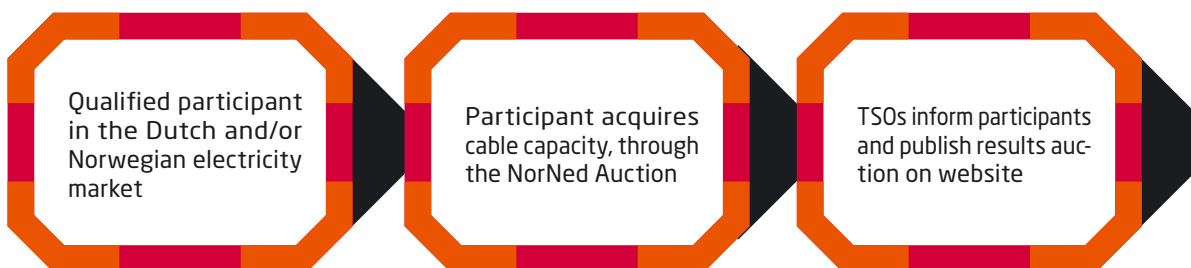
EXPLICIT AUCTION LINKS NORWAY AND THE NETHERLANDS

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 auction, participants obtain capacity per hour for the next day. In the nearby future an intraday auction will also be possible, using unused capacity of the day-ahead auction. 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, particularly due to reduced Dutch power prices. More available capacity and expanded trade between Norway and the Netherlands will not only influence prices on the APX (Dutch power

Steps in the explicit day ahead NorNed Auction



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 market system.

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 submit-

ting next-day bids on the day-ahead market. At the moment, the GCT of the involved European exchanges still differ from one another.

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.

Photo: Trond Isaksen



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'.

BENEFITS FOR THE TSOS

The great advantage of the NorNed cable for TenneT and Statnett is the fact that the cable enhances the security of supply of electricity in the Netherlands and Norway. This has strengthened TenneT's position in the Northwestern European electricity market and Statnett's position in Scandinavia.

In addition, Dutch production plants are able to make better use of their production capacity during the night, as a result of how the cable's operation is planned.

BENEFITS FOR THE MARKET

Purchasing electricity will become cheaper for market parties in the Netherlands as electricity prices are expected to converge. The supply has increased while the demand for energy has remained the same. Basic economic principles have dictated that prices will drop in such a situation.

BENEFITS FOR SOCIETY

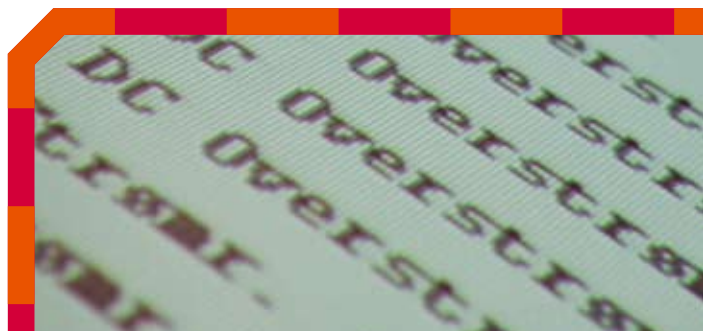
Thanks to the NorNed cable, more international trading takes place. The NorNed cable contributes

to more stable electricity prices in Northwestern Europe, because the electricity prices in Norway and the Netherlands are expected to converge. The electricity prices determined on an hourly basis by APX and Nord Pool Spot 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 during the seasons: lower prices during the summer and higher prices during winter. The purchase price of electricity in the Netherlands is expected to drop slightly. End users such as consumers and businesses will eventually profit from this development because they will be charged a lower price for each kilowatt-hour of electricity.

Photo: Erik Thallaug



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.

Eemshaven - The Netherlands





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