One of the world’s most powerful interconnectors: NordLink – a glimpse into the future carbon-neutral energy system

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Delivering the energy transition requires groundbreaking electrical engineering feats. The newly opened 1,400 MW NordLink interconnector uniting Norway and Germany for the first time is one such achievement that celebrates a decades-old TSO partnership and underlines the need to cooperate across borders to deliver the energy transition. With the European Union (EU) target for cross-border interconnection capacity at 15 percent of peak demand by 2030, the continent requires huge investments in interconnector projects. This puts NordLink, the world’s most powerful VSC interconnector and cross-border HVDC electricity interconnector, at the forefront of an unprecedented engineering challenge that many can learn from.

We have invited two of the leaders behind the delivery of the 623-kilometer-long NordLink interconnector to share their experiences of bringing this pioneering project to life and to lay out their vision for Europe’s future carbon-neutral electricity grid. Tim Meyerjürgens, Chief Operating Officer of Dutch-German TSO TenneT, recounts the project’s complexity in how laying the cable across a Wadden Sea sandbank was dictated by the position of the moon, while Håkon Borgen, Executive Vice President of Technology and Development at Norwegian TSO Statnett, explains why building the NordLink cable was a bet on the energy transition that has already paid off.
How did NordLink come to fruition?

Håkon Borgen (H.B.), Statnett: “I must say, it’s been a long journey. We started thinking about connecting Norway and Germany as many as 25 years ago. The idea was really driven by the fact that we have a lot of renewable hydropower in Norway, whereas in countries like Germany there was mainly thermal power. The first concept of an interconnector to Germany was called the Viking Cable and we ended up using a lot of the engineering details from that time for NordLink.”

Tim Meyerjürgens (T.M.), TenneT: “In 1998 we had the change in European regulation with the liberalization of the energy markets. At that time the interconnector project was not really attractive anymore as the socio-economic benefit was at stake. H.B.: “But, together with TenneT, we still demonstrated that the technology works when we developed the interconnector project between Norway and the Netherlands. When NorNed was commissioned back in 2008 it was the longest interconnector in the world. That was a game changer because we proved that it’s possible to connect power systems over long distances. From that we developed the idea that it could be possible to build even more interconnectors from Norway. We [Statnett] held discussions with TenneT about reviving our old plans and that was the start of NordLink. TenneT and KfW are our partners in the project. We made this decision jointly because we knew that NorNed was functioning. And with the commissioning of the fourth cable between Norway and Denmark in 2014, using the VSC technology at 525 kV for the first time. The ministries in Germany and Norway then harmonized the licensing which enabled us to take a final investment decision in 2015.”

Håkon Borgen, EVP of Technology and Development, Statnett
How important was the TenneT-Statnett partnership to the NordLink project?

T.M.: “The key to such projects is to have one project team. For us the team did not only include Statnett and TenneT, but also our suppliers Hitachi ABB Power Grids, Nexans and NKT. You can only be successful if you deliver the project as one team. If you start fighting on these kinds of projects, you will get lost.

H.B.: “In the beginning we worked on the project culture in a very professional way. We spent a lot of time developing the one-team culture and we needed that because we did encounter challenges that we had to solve together. We couldn’t take a decision in Norway and then hear that in Germany they didn’t agree. We needed to tie the decision-making together and that worked amazingly well.

I remember when the Statnett board asked me about the risks involved with constructing the NordLink cable in the Wadden Sea. I said: ‘Well, we have a strong partner.’ Without TenneT on board, I don’t think it would have been easy for us to deliver the project. It’s fair to say that with TenneT we lifted the technology to the next level because together we were the first in the world to up the converter voltage level on an interconnector to 525 kV.

We also got our partner KfW on board because when you commit to such large investments you need to have strong partners. With KfW also involved, we had the financing and the building capability in place.

What were some of the biggest challenges you encountered when developing NordLink?

T.M.: “The size of the project in itself was one of the challenges. It’s currently the longest interconnector cable in the world and that also meant we had a lot of different environments to work in. We had to drill through the mountains on the Norwegian side, then we went into water that was up to 400 meters deep, and then we had the Wadden Sea which is on the one hand very sensitive and required innovative eco-friendly equipment and procedures but also had a sandbank which is so shallow that normal equipment can’t pass through. Even with special equipment, we could only pass once a month when the moon was in the right position and the tide was a little higher than usual.

Additionally, the cable is so long that we needed two different manufacturers because one factory would have been overloaded with the amount of cable demand. This added another technical risk because we had to connect two different cables.

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Tim Meyerjürgens, COO, TenneT
At the open trench during the cable pull-in of NordLink in Warnemünde, Village, near Buesum, Germany
Source: TenneT

H.B.: “In the end we didn’t face problems in the Wadden Sea but on the mainland in Germany. The German licensing authorities had experienced a lot of challenges with wind projects and that turned into a change in attitude towards NordLink. We had to give very detailed specifications of the routing and as a result we had to shift the timeframe by around nine months. But otherwise we managed to really keep the project well within budget and time and it has been a great success.

We shouldn’t underestimate the high level of quality assurance we implemented on the project. Can you imagine laying a 525 kV cable under the sea? It’s not gas, it’s electricity. We monitored every single meter of the installation which meant that sometimes we had between 10-20 vessels offshore and we also had full control over the manufacturing process. All this we learnt from previous experiences.

Another challenge for Statnett was that we were developing the interconnector to the UK, North Sea Link, at the same time. The lengths of the NordLink and North Sea Link cables add up to 1,400 kilometers, which equals roughly 50 percent of the world’s cable production capacity. We had to be quite careful how we managed that, but we got all the suppliers on board and both Nexans and NKT delivered perfectly on time.

Our strong focus on HSE has played an important role in the project and should also be mentioned as one of the key contributions to a successful construction phase. The HSE mindset has been visible throughout the project and by all involved parties.

T.M.: “It was not only Statnett which had parallel projects, so did we. We were developing the offshore wind connections in Germany and required around 12 cables of 100-200 kilometers in length each. This means that almost the other half of the world’s manufacturing capacity was required by us to deliver also the offshore connections in time.

Source: TenneT

A vessel lays the first meters of the NordLink subsea cable in summer 2017
Source: TenneT

#Perspectives
Our investments in interconnectors are all driven by the fact that they bring value to the society because of the trade between our hydropower and the growing amounts of renewable power in continental Europe. The European energy system has shifted over the past 20 years from being a thermal power system to a green one.

Håkon Borgen

How is the NordLink interconnector performing today?

H.B.: “We successfully completed trial operations on 31 March. The energy availability was beyond the contractual value and that’s why we took it over. In that respect it was a success and we haven’t had any major issues.

We had some issues during commissioning and the link tripped. One trip at 1,400 MW, that impacted the power systems on both the Nordic and Continental sides. We made changes to the control system and now it is working well.

In the design phase we took the very wise decision to add fast DC breakers. These are installed to take in half the pole if we have a problem on only one of the converters. This ensures that we only lose half of the capacity when we have a failure.

T.M.: “When we took the final investment decision in 2015, NordLink was still a bet because renewables were already important but not in the same way as they are today. They are now also on the political agenda as the energy transition has really accelerated over the past years. Today, this kind of link is more important than ever. We are happy we took the decision to invest even before the energy transition had really started.

H.B.: “We had to bet on the renewable energy future and the price of CO₂. Back in 2015 we believed that the price of CO₂ would go up and that has now happened. Looking ahead, the business case will be even stronger because we’ll have maybe ten times as much wind and solar power in continental Europe, which Norway can use to regulate its hydropower. It will be a huge transformation of the whole European energy system and it feels good to be able to say that NordLink fits perfectly into that outlook.

Having said that, it’s important that the energy availability of the link is high and that the technology delivers these benefits.
What does the future hold for the Statnett-TenneT partnership?

T.M.: “We [TenneT] are taking all the knowledge and experience gained to serving the German and Dutch energy transition. We have chosen the 525 kV specification used on NordLink for the large onshore corridors we are building from the northern part of Germany to the south. We are also using 525 kV for the next generation of offshore wind connections. The North Sea will be the powerhouse of northwestern Europe and we need its offshore wind to serve our demand for energy.

We are now building connections that are what we call hub-ready. For the 2 GW offshore wind projects we are just preparing to connect, we are leaving space on the platforms to be able to integrate future DC breakers. This helps us avoid making investments now that are not future proof.

To serve the European energy transition we cannot wait with our investments and we are working with other TSOs and our suppliers on technical standardization. We are currently running an open technology cooperation program for all potential HVDC suppliers of our project to connect 2 GW of offshore wind farms. We want to standardize these platforms so that it doesn’t matter which supplier we choose. Interoperability is the next step.

H.B.: “The scale of new production offshore will affect the entire European energy system, Norway included. We see building meshed grids offshore as a big challenge ahead in order to connect all this wind to the European onshore grid. Future investments will be difficult unless we solve interoperability, unless we have control over this issue in order to reduce the risks. What we want to avoid is that each operator chooses their own voltage and their own design because that will not deliver connectivity in a viable way. We have to cooperate strongly in order to make it work. Statnett and TenneT are working on this together and more broadly within the ENTSO-E committees. There’s no doubt that time is pressing because the offshore grid in Europe will come.

T.M.: “We only get there if we all get there. The energy transition is such a huge challenge for all of us, we cannot do it alone and it’s also not a competition.

What will the future offshore grid look like?

H.B.: “If we look at NordLink we are looking into the future because it is likely that there will be an increasing number of these large components connecting to the AC grid. We need a deeper understanding of how to run this system and how to deal with the reserve strategy. What we will see in future is the offshore and onshore grids merging. At Statnett we believe that it is important to look at the grid in a holistic way instead of onshore/offshore in order to assess grid strengthening as a whole. When looking at the next ten years, we need a holistic view of the grid in order to understand how best to deliver the energy transition.

T.M.: “The ENTSO-E area was designed for a balancing power capacity of 3,000 MW in order to compensate the loss of two 1,500 MW nuclear plants at one location at the same time. But with our newest projects we’re using larger units than nuclear power plants. Our new offshore links and offshore connections will have a capacity of 2,000 MW each. We have to deal with this and find ways to keep the grid stable if something unforeseen happens.

Another challenge of collaboration is that we still have different market models in different countries. An offshore wind farm, for example, is very difficult to connect to an interconnector because there is uncertainty among governments over wind farm subsidies bringing unintended benefits on the other side of the cable. These are all subjects that are solvable but it takes time to harmonize the market models.

There’s no doubt that the electricity grid is the backbone of the energy transition and without it we will not be successful.

Tim Meyerjürgens
Where is the energy transition heading?

T.M.: “We are transforming the whole energy system in Europe from thermal-based power to renewables which brings completely new challenges as well as different needs for the grid. There’s no doubt that the electricity grid is the backbone of the energy transition and without it we will not be successful. If we are not successful as TSOs, Europe will not be successful with the energy transition. To me that’s really key and that’s why I’m working in this sector. It’s such a great challenge we are facing and what I like every day in my job is that you can really influence to meet best results.

One aspect that is often forgotten is that we in the power sector are quite advanced in the energy transition because we’ve been working on it for 20 years now and are reaching our goals. But now we are also seeing other sectors accelerating to decarbonize. Especially if you look at the chemical and steel industry, they are now going for electrification. That means that our electricity consumption will easily double in the next years. That’s our next challenge, but we are working already on the solutions together with our partners.

H.B.: “It’s not difficult to build a renewable energy system in itself but what is difficult is making it secure enough for the customers in Europe. The huge challenge is to deal with the intermittency of renewable energy. We need to work together because the challenges are too big, we can’t solve them alone anymore. We need cooperation and innovation in order to make this future system resilient. The goal of reaching zero emissions is an amazing task that is extremely motivating to work for. It’s bigger than the moon landing, it’s really something.

A final thought...

I would like to thank Tim and Håkon for their valuable and interesting insights into the history and development of Europe’s biggest renewable energy highway.

This is a benchmark project for the global power industry, which I’m convinced will inspire generations of engineers in years to come. It has enabled all partners to bring together their unique skills and experience to deliver a world-first project on time, in spite of the global pandemic.

I am immensely proud of my company’s contribution to NordLink. Our HVDC technologies and the expertise of our people in designing and delivering complex grid interconnections of this kind have contributed to the project’s success.

We have worked closely over many years with Statnett and TenneT on HVDC and other grid solutions. Together, we are enabling Europe to move toward a carbon-neutral energy system.

Niklas Persson, Managing Director, Grid Integration, Hitachi ABB Power Grids