TenneT: Offshore wind energy in North Sea to play key role in European energy

20/10/2018

Authors: Marco Kuijpers

Abstract

Authors

Marco Kuijpers

Metrics

Downloaded: 2
Viewed: 0
Size: 375.79 KB
La SEE (Société de l'Electricité, de l'Electronique et des Technologies de l'Information et de la Communication – Association reconnue d’utilité publique, régie par la loi du 1er juillet 1901) met à la disposition de ses adhérents et des abonnés à ses publications, un ensemble de documents numériques accessibles à partir de son portail des publications. Ces documents incluent notamment les articles des revues REE, 3 EI et e-STA disponibles sous forme numérique ainsi que des publications additionnelles regroupées dans l’espace eREE. Les présentes conditions précisent les conditions de diffusion et d’utilisation de ces documents et des informations qu’ils contiennent. L’accès à ces documents, qu’il se fasse de façon gratuite ou dans le cadre d’abonnements ou d’achats faits à titre onéreux, implique l’acceptation sans restriction de ces dispositions.

Droits de propriété et de diffusion des contenus téléchargés sur le portail des publications

Les contenus rendus accessibles sur le portail des publications sont, en règle générale, protégés par le droit d’auteur. En tant que producteur, et le cas échant d’auteur, des informations rassemblées dans les contenus accessibles par ce portail, SEE se réserve l’exclusivité des droits de copie et de diffusion de tout ou partie de ces contenus.

Les contenus sont rendus accessibles à titre individuel, pour les besoins de la personne en détenant des droits d’accès en cours de validité. Aussi, la modification, la reproduction et/ou la diffusion via Internet ou le Web, intranet, extranet ou toute autre forme numérique ou imprimée, de tout ou partie des contenus téléchargés sont interdites. Une tolérance est consentie quant à la reproduction d’extraits limités de ces contenus, dans le cadre de travaux ou d’activités auxquels ils sont utiles, à la condition que l’origine de ces reproductions partielles soit mentionnée de façon lisible et sans ambiguïté. Figeront en particulier : la REE (ou toute autre revue accessible sur le portail) en tant que la source, la référence de la publication et le nom de l’auteur (s’il figure dans la revue).

Ces dispositions s’appliquent également aux figures, illustrations, logos ou images.

Publication externe des contenus du portail des publications

Tout extrait des contenus du portail destiné à être utilisé dans des publicités, des communiqués de presse ou du matériel de promotion nécessite un accord préalable écrit de la SEE. Une version préliminaire du document proposé contenant ces extraits doit accompagner chacune de ces demandes. SEE se réserve le droit de refuser un tel usage externe pour quelque raison que ce soit.

Responsabilités

La SEE apporte tout le soin possible à la préparation des informations délivrées dans les contenus produits. Cependant elle ne peut être tenue pour responsable d’aucune perte ou frais qui pourrait
résulter d'imprécisions, d'inexactitudes, d'erreurs ou de possibles omissions portant sur des informations publiées, ni des résultats obtenus par l'utilisation et la pratique des informations délivrées.

Utilisation des informations recueillies lors du téléchargement de contenu

Le portail des publications est susceptible d'utiliser des « cookies » afin notamment de permettre l'utilisation de paniers d'achat et de personnaliser les parcours sur le site. SEE se réserve la possibilité d'utiliser les informations recueillies lors des téléchargements pour ses besoins internes et notamment pour l'amélioration de ses services, sans qu'elles puissent être cédées à des partenaires commerciaux. Conformément à la loi "informatique et libertés" du 6 janvier 1978, chaque utilisateur du portail dispose d'un droit d'accès et de rectification aux informations qui le concernent. Pour exercer ce droit, les utilisateurs doivent s'adresser à SEE – 17 rue de l'amiral Hamelin – 75783 Paris Cedex 16, par simple lettre ou en utilisant le formulaire de contact disponible sur son site.

Paris, le 28 avril 2013

Back to the future

It is the year 2050. At a central location in the North Sea, where the Exclusive Economic Zones of Denmark, Germany, the United Kingdom and the Netherlands meet, there is a brand-new artificial island measuring some eight square kilometers. It has a high-tech multifunctional maintenance and distribution centre, with its own hydrogen plant, and connects large-scale offshore wind energy capacity to direct-current electricity infrastructure and gas pipes. The artificial island is the result of an exceptional feat of engineering and international collaboration. At present this artificial far shore island exists only on paper, under the TenneT: Offshore wind energy in North Sea to play key role in European energy transition Marco Kuipers TenneT Senior Manager Offshore Netherlands TenneT is Europe's first cross-border Transmission System Operator (TSO) and manages the high-voltage electricity grid in the Netherlands and a large part of Germany. In both countries, the government has also designated TenneT as the developer and operator of the offshore grid. This paper describes the main offshore wind farm projects developed by TenneT, in the Netherlands and in Germany. It underlines the differences in technology. Finally, it gives a long term perspective of what the future may look like. ABSTRACT TenneT est le premier gestionnaire de réseau de transport (GRT) transfrontières européen. Il opère le réseau électrique des Pays-Bas et une grande partie du réseau allemand. Dans ces deux pays, les fournisseurs de réseau ont désigné TenneT comme développeur et opérateur du réseau électrique offshore. Cet article présente les principaux projets de fermes éoliennes offshore développés par TenneT aux Pays-Bas et en Allemagne. Il souligne les différences entre les technologies utilisées dans les deux pays. Enfin, il donne une vision prospective d'un projet d'avenir ambitieux prenant en compte l'éolien offshore. RÉSUMÉ Helwin 1 Offshore DC converter station. REE N°4/2018 Z 55 TenneT: Offshore wind energy in North Sea to play key role in European energy transition name North Sea Wind Power Hub (NSWPH). The ambitious plan is the brainchild of TenneT, Europe's first and largest cross-border Transmission System Operator (TSO) (see Box 1: TenneT's profile). The Dutch-German TSO has already formed a consortium with its Danish counterpart Energinet, Dutch gas grid operator Gasunie and the Port of Rotterdam Authority in order to explore the concept. According to TenneT, large-scale development of offshore wind energy is essential to ensure that the EU's CO2 emissions reduction objectives can be realized without sky-rocketing costs. Combining offshore wind energy with the development of "green hydrogen" and the electrification of industry completes TenneT's vision of the energy transition. The NSWPH can make an important contribution to the EU objectives for market integration and development of renewable energy sources. Thanks to this Power Hub, North Sea wind energy could meet the energy needs of 70 to 100 million people by 2050. This is not fiction, but a feasible plan. However, it does require a strong, joint and coordinated commitment from the partner countries, and places heavy demands on the offshore expertise of the collaborating TSOs and industries. Energy transition in Germany Although Germany and the Netherlands have both endorsed the Paris Agreement on climate change, the two countries have adopted very different sustainability roadmaps and timeframes. As early as 2010, the German government decided that by 2050 greenhouse gas emissions must be reduced by 80 to 95% compared to 1990 levels, and that renewable energy must account for at least 60% of the energy supply. In addition, increased use of these renewable sources must end Germany's dependence on nuclear power by as soon as 2022. The March 2011 disaster at the Fukushima nuclear power plant in Japan added further urgency to the achievement of this aim. Germany has become renowned for its focus and speed in implementing the Energiewende – the massive project aimed at shifting to a sustainable energy supply. In addition to solar energy, offshore wind is also a key pillar of that transition. Back in 2006, Germany already anticipated that by 2020 it would need a high-voltage electricity infrastructure with a large number of converter platforms in the North Sea, in order to "harvest" wind energy generated far out at sea and bring it to shore. In that year, the German government officially
distance, direct current results in fewer losses during transmission than alternating current. Consequently, DC technology is highly suitable for off-shore electricity over longer distances than a High-Voltage Alternating Current (HVAC) system, and requires two rather than three cables to do so. Depending on the compensated by the benefits and the resulting cost reduction. A High-Voltage Direct-Current (HVDC) system can transmit significantly larger quantities of formers are required at both ends of the cable to convert alternating current (AC) into direct current and vice versa. However, this drawback is more than more than 100 km The generated electricity enters the substation of the wind farm, and is transported via a 155 kV three-phase cable to the converter platform. Transformers increase the voltage level to that of the converter: 320 kV. The converter converts the three-phase alternating current to direct current, also at a voltage level of 320 kV. The two DC cables (positive and negative pole) run across the seabed from the platform to the landing point, i.e. the location where the cable comes ashore. From that point onward, underground cables transport the electricity to the onshore converter, where direct current is converted back into three-phase alternating current and transformed to the required voltage level. The electricity is then fed into TenneT’s 380 kV grid. Alternating current for wind farms located close to shore Three-phase alternating current is the most economically and technically efficient technology for transmitting electricity across short distances. The electricity is transported from the offshore substation across the seabed, and then via an onshore cable to a substation on land. At this substation, the power is transformed to the right voltage level (380 or 220 kV) and fed into TenneT’s high-voltage grid. HVDC system HVAC system 58 ZREEN N°4/2018 EOLIENNES OFFSHORE DOSSIER 1 Cost reduction of 40% Following its official designation as the Netherlands’ offshore grid opera- tor in 2016, TenneT has taken up the exciting challenge of designing and constructing a power grid at sea. One noteworthy “detail”: in 2013, the parties to the National Energy Agreement also committed to reducing the cost price of offshore wind energy by no less than 40% in ten years’ time, i.e. by 2023. This means that the costs of the off- shore grid under development must be reduced by a corresponding percentage. The tone has been set: the Agreement requires TenneT to apply its creativity and expertise to the fullest in designing and realizing the Dutch offshore grid. DC technology in Germany, AC technology in the Netherlands. In 2010, TenneT already demonstrated its ability to develop state-of-the-art technological solutions when the 200-km-long BorWin1 offshore grid connection was completed. Named af- ter the island of Borkum in the German sector of the North Sea, the BorWin1 project is the world’s first direct-current (DC) connection between an offshore wind farm (OWF) and the onshore high-voltage grid. DC electricity transmission has one disadvantage: massive transformers are required at both ends of the cable to convert alternating current (AC) into direct current and vice versa. However, this drawback is more than compensated by the benefits and the resulting cost reduction. A High-Voltage Direct-Current (HVDC) system can transmit significantly larger quantities of electricity over longer distances than a High-Voltage Alternating Current (HVAC) system, and requires two rather than three cables to do so. Depending on the distance, direct current results in fewer losses during transmission than alternating current. Consequently, DC tech- nology is highly suitable for off-shore
wind farms (OWFs) located more than 100 km from the shore. The wind farms in the German sector of the North Sea are therefore mainly connected via subsea and onshore cables in a DC system. The first planned offshore wind farm zones in the Netherlands (Borssele, Holland Coast South and Holland Coast North) are located much closer to the coast, and can therefore be connected to the onshore grid using AC technology. The advantage is that costly AC-DC conversion is not required. Based in part on its offshore experiences in Germany, TenneT has designed a smart, scalable and future-proof offshore connection system based on standard components. In the aforementioned wind farm zones, five standard 700 MW offshore transformer platforms will be connected to the onshore grid via two cables per platform. If there are two platforms in a wind farm zone, these are also connected to each other to ensure optimal redundancy. The wind farms are directly connected to a platform and the realization of the offshore grid will be coordinated with the farms’ construction to ensure that the available capacity keeps pace with the demand. The OWFs in the next 7 GW phase (2023-2030) will be partially connected using TenneT’s standardized AC concept. However, it will be necessary to adopt DC technology for the Uumiden Ver wind farm zone (capacity: 4 GW), which is located so far from the coast that a DC system is the only feasible and cost-effective option. In a world first, TenneT’s standardized 700 MW AC concept will be based on 66 kV connections instead of the 33 kV connections that are commonly used for OWFs at present. A higher voltage level will result in lower losses during transmission, require fewer cable connections between wind farms and platforms, and will enable developers to connect wind turbines with greater capacity. A final noteworthy technical detail: TenneT continuously measures the temperature inside the cables. When the temperature permits, the transmission capacity can be increased from 350 MW to 380 MW. This also increases efficiency and thus helps to reduce costs. Rapid cost reduction In March 2016, the then-Minister of Economic Affairs announced that the world’s first non-subsidized OWFs off the Holland coast. Vattenfall was selected as the winning tenderer for the construction of two OWFs in the wind area called Hollandse Kust zuid (1,400 MW) which are scheduled to be taken into operation in 2021. These are the first wind farms in Europe to be realized without government subsidies. Market development and interconnectors Cost reduction through economies of scale and standardized technology is a good example of the way in which TenneT aims to develop the sustainable energy market in Europe. In conjunction with the tendering system adopted by the Dutch government, this approach REE N°4/2018 Z 59 TenneT: Offshore wind energy in North Sea to play key role in European energy transition ensures a level playing field for OWF operators and challenges them to develop increasingly effective installations. As a consequence, the costs for the development of offshore wind energy have decreased dramatically. Wind and solar energy are not continuous, easily controllable energy sources like conventional power plants. In addition, storage systems and load centres are not always located in areas with high average wind speeds. In order to utilize these geographical and meteo- logical differences as effectively as possible, it is therefore becoming increasingly important to exchange electricity over long distances and across national borders. Together with its European partners, TenneT is therefore constructing and operating so-called “interconnectors”: offshore and onshore electricity connections that link the high-voltage grids of different countries (see Box 5: Interconnectors). Level playing field Interconnectors offer a number of obvious advantages. They make it easier to exchange sustainably generated electricity between countries. This helps to improve the security of supply and makes it easier and less costly to maintain the balance between supply and demand on the grid. However, the secondary effects are just as important: an integrated grid ensures more uniform price levels for customers and suppliers. Internationally, this encourages the development of more effective and efficient solutions for the generation, consumption and storage of green electricity. This contributes to the energy transition and is good for society at large, because electricity is always made available at the lowest possible price. Coordinated collaboration Nevertheless, interconnectors are just the first step in the ongoing integration of energy systems. TenneT firmly believes that the success of the energy transition in Europe strongly depends on coordinated collaboration between the countries involved. The vision of a North Sea Wind Power Hub described at the start of this article is also based on international collaboration and a long-term perspective. The potential of offshore wind energy in the North Sea can be utilized more efficiently and cost-effectively, and in a shorter time frame, by collaborating regionally and ensuring the coordinated development of wind energy capacity and infrastructure in the North Sea, based on a shared vision of the future. An enormous potential is clear that offshore wind energy offers enormous potential. The commitment of the Netherland’s only offshore grid operator to the OWF concept – consisting of Danish TSO Energinet, Dutch gas grid operator Gasunie, the Port of Rotterdam Authority, TenneT Netherlands and TenneT Germany – has commissioned a study into the potential size of the total offshore wind energy capacity in North-West Europe. This re-sulted in an impressive total of 230 GW. Potential OWF locations include the Irish Sea, the Baltic Sea and the Atlantic coast of France. However, the lion’s share of the required capacity (approx. 180 GW) can be realized in the North Sea, according to the report (DC). If this is the case, the subsea high-voltage cable is used to exchange electricity between the Netherlands and the UK. BritNed is a joint venture of TenneT and National Grid, the UK’s Electricity System Operator (ESO). COBRACable The COBRACable is a 325-km-long HVDC interconnector with a transmission capacity of 700 MW. This interconnector between the Netherlands and Denmark is currently being constructed and will be operational in 2019. Particularly wind energy generated in Denmark will then become available to the European electricity market. COBRACable is a joint venture of TenneT and the Danish TSO Energinet. NordLink NordLink is a 623-km-long HVDC interconnector with a
transition. A scenario in which hydrogen is produced on a large scale for industry and the transport sector offers possibilities that radically change our current

using the existing gas infrastructure. Hydrogen can also potentially be stored in the earth’s salt deposits, which are located relatively close to the surface in

be possible to produce hydrogen in large quantities and at low cost by means of water electrolysis using renewable electricity. It can be stored and transported

a very useful and sustainable alternative to oil and gas, which are currently used as raw materials and fuel by the energy-intensive industry. In the future, it will

Dutch aviation, shipping, steel and (petro)chemical industries collectively consume five times more electricity than all Dutch households combined. Hydrogen is

industry and the transport sector. In order to achieve rapid and cost-effective growth, the Coalition advocates an approach similar to the one applied to offshore

develop and implement green hydrogen technology, in order to create long-term energy storage solutions and pro- mote the sustainable development of

Project director from 2012 to 2014 and managing partner at Twynstra Gudde from 2000 to 2014. He holds degrees from Insead, Rotterdam University of

will actually be built, but the ongoing feasi- bility studies will nevertheless produce valuable knowledge and insights for a larger island further out in the North

infrastructure as the originally envisio- ned North Sea Wind Power Hub, but on a smaller scale. It is currently uncertain if this island in the IJmuiden Ver zone

involved have now asked TenneT to investigate the possibilities for an artifi- cial island in this zone. This island would have roughly the same multifunctional

further deve- lopment of offshore wind farm zones in the Dutch sector of the North Sea in the period until 2030. The proposed IJmuiden Ver wind farm zone is

or – for the Eurosceptics among us – as an entirely unrealistic plan? Certainly not. In March of this year, the Dutch government pre- sented its roadmap for the

Offshore wind energy in North Sea to play key role in European energy transition Regardless of the findings concerning the technical and economic potential of

analyses will be performed focusing on technical, mar- ket-related and environmental aspects. Photo 1 : NSWPH beach view. REE N°4/2018 Z 61 TenneT:

tomorrow, or the day after tomorrow. The five consortium partners have agreed to investigate the pos- sibilities offered by this concept until mid-2019. Concrete

deve- loping an integrated sustainable energy system. Political support It will come as no surprise that a power hub in the North Sea will not be realized

as both an energy carrier and as a raw material for industry. Consequently, electrolysis is expected to develop into a mature and economically viable

over long distances more cost-effectively than electricity. The existing gas infrastructure in the North Sea could be used for this purpose. Importantly, that

it possible to absorb peaks in wind energy production on-site, so that losses during transmission can be minimized. Moreover, hydrogen can be transported

characterized by high average wind speeds, and this will of course contribute to a higher wind farm output. The pro- posed location of the NSWPH is also in

port and maintenance facilities on the island, the generally complex off- shore logistics can be organized more efficiently and effectively. The anticipated area

Germany and Denmark. As a result, the efficiency of these connec- tions will increase significantly from 40% to approx. 80%. With personnel, spare parts, a

countries would be able to connect large wind farms to the infras- tructure on the island. The island’s DC transmission cable to the onshore grid will fulfi a
dual purpose. They will also be used as interconnectors and thus facilitate international electricity trading between the Netherlands, Belgium, the UK, Norway,

is characterized by high average wind speeds, and this will of course contribute to a higher wind farm output. The pro- posed location of the NSWPH is also in

relatively shallow part of the North Sea, reducing the costs of constructing the island and the wind farms. If those combined advantages we- ren’t enough,

the parties involved are exploring one further option: producing green hydrogen on the island using elec- tricity generated by the wind farms. This would make

technology by approx. 2030. If the energy-intensive industry switches to hydrogen, (excess) electricity produced by offshore wind farms can also be used for

production (see Box 6: Hydrogen and offshore wind energy). Hydrogen tech- nology provides a further reason for coordinated collaboration aimed at deve-

ning to the security of supply in both countries, and is a joint venture of TenneT and Statnett. 60 ZREE N°4/2018 EOLIENNES OFFSHORE DOSSIER 1 ding to the study, Europe must utilize that potential to achieve its CO2

etrical balance, the actual realization of this vision requires broad political support in the participating countries. One step closer… Does all this mean that the North Sea Wind Power Hub should be regarded as a vision for the distant future, or – for the Eurosceptics among us – as an entirely unrealistic plan? Certainly not. In March of this year, the Dutch government pre-

sent its roadmap for the further deve- lopment of offshore wind energy zones in the Dutch sector of the North Sea in the period until 2030. The proposed IJmuiden Ver wind farm zone is located far from the coast, as its name implies (“ver” means “far” in Dutch). It will have to be connected to the onshore grid using DC technology. The ministries involved have now asked TenneT to investigate the possibilities for an artifi- cial island in this zone. This island would have roughly the same multifunctional infrastructure as the originally envisio-

ned North Sea Wind Power Hub, but on a smaller scale. It is currently uncertain if this island in the IJmuiden Ver zone will actually be built, but the ongoing feasi-

bility studies will nevertheless produce valuable knowledge and insights for a larger island further out in the North Sea. Box 6: Hydrogen and offshore wind energy. THE AUTHOR Marco Kuijpers is Senior manager TenneT Offshore Nederland since 2014. He was Eeneco

Project director from 2012 to 2014 and managing partner at Twynstra Gudde from 2000 to 2014. He holds degrees from Insead, Rotterdam University of

Applied Sciences and Fontys. B 6 H d d f h i d In the Netherlands, the Hydrogen Coalition (an alliance of 23 parties) has called on the government to further
develop and implement green hydrogen technology, in order to create long-term energy storage solutions and pro- mote the sustainable development of

industry and the transport sector. In order to achieve rapid and cost-effective growth, the Coalition advocates an approach similar to the one applied to offshore

wind energy. Large industrial consumers play a key role in designing the electricity sys- tems of the future and developing the required storage capacity. The

Dutch aviation, shipping, steel and (petro)chemical industries collectively consume five times more electricity than all Dutch households combined. Hydrogen is

a very useful and sustainable alternative to oil and gas, which are currently used as raw materials and fuel by the energy-intensive industry. In the future, it will

be possible to produce hydrogen in large quantities and at low cost by means of water electrolysis using renewable electricity. It can be stored and transported

using the existing gas infrastructure. Hydrogen can also potentially be stored in the earth’s salt deposits, which are located relatively close to the surface in

the Netherlands, Germany and Poland. In the light of these considerations, the Hydrogen Coalition regards the combination of hydrogen (which enables the

‘greening’ of industry and offers storage solu- tions) and offshore wind energy (offering large-scale production capacity) as a solid foundation for the energy

transition. A scenario in which hydrogen is produced on a large scale for industry and the transport sector offers possibilities that radically change our current
perception of the energy transition. Hydrogen can be converted to methane and stored in or transported by the existing natural gas infrastructure in the Netherlands and Germany. It can then be used to heat residential and non-residential buildings, but also to produce electricity in a controllable manner.

https://www.see.asso.fr/en/node/23831/landing