nationalgridESO

Offshore Coordination project
Consultation feedback form

We launched our consultation on **30 September 2020,** and it closes on the **28 October 2020.**

Please use this form to send in your written feedback If you would like to feedback via this route. We are also working with stakeholders to receive verbal feedback. Please contact us if you would prefer to provide feedback verbally.

We would like to publish responses to our consultation following its closure. Please can you confirm whether you would like us to treat your response confidentially by selecting one of the options below: (delete those that do not apply)

- **Confidential – please do not share the feedback or company**
- **Confidential – you can publish the feedback without our name or sector included**
- **Confidential - you can publish the feedback without our name, but you are welcome to identify which sector we come from**
- **Non-confidential – you can publish the full response**

Throughout the consultation document we have asked some questions on our three reports that we would like your feedback on to shape our final documentation. These are below and do not need answering if you do not have views. If you would like to provide any other feedback, please feel free to do so.

Holistic Approach to Offshore Transmission Planning Report

Q1. Do you agree with our assessment of the key technology and system risk barriers coming from the Holistic Approach to Offshore Transmission Planning Report?

SuperNode welcomes this entire initiative and believes that the method of comparing the available grid technologies to be reasonable. Section 3 shows a good overview where the level of information is good and offers a broad overview of available HVAC, HVDC, and Low Frequency HVAC, however, there is no mention of other technologies which have been proven in an onshore environment and are under development for the offshore environment. This technology is further discussed in Q3 below.

With regards to considerations on the TRL of each technology, low frequency AC is considered, and detail provided on the TRL level even though it is at a relatively low level of TRL3.

As will be discussed in Q3, superconductors have been demonstrated and proven in the onshore environment in well-established grids such as Germany and South Korea. Best Paths has demonstrated a high capacity DC cable. Superconducting technology merits more recognition in this study while acknowledging that there is significant progress to be made for its use in the offshore environment.

SuperNode has achieved its statement of feasibility for a subsea superconducting transmission system.

Q2. Do you have any proposals on how to most effectively bring the technology to market for when needed?

One of the most important considerations during this process is to choose the most effective and efficient grid design without locking in/out a specific technology now. Designing tomorrow's grid using today's technology with an incremental approach is likely to result in a grid that is not fit for purpose in addressing the challenge. National Grid ESO should continue and indeed increase their emphasis on encouraging innovation in grid tech and not limit themselves with a premature selection of technology.

The report outlays a future where the design and voltage level are already chosen, with considerations for innovation made to suit the pre-set voltage levels. This does not facilitate disruptive or revolutionary innovation in grid technology. In **Section 5.2** of the report, superconductivity is classified as a "substitution" technology.

Superconductors offer the unique opportunity to maintain a more modest voltage level while facilitating the desired power transfer. Superconductivity by its very nature is revolutionary when compared to incumbent cable technologies. It can of course act as a substitute for a 525kV cable operating at 2kA (~1GW) however this is not how you take advantage of superconductors.

A better use of implementing a superconducting solution in the above example would be in implementing a 100kV - 200kV, 5kA - 10kA superconductor which operates at a much lower voltage but is capable of much higher currents.

Even in this scenario, the true benefits of superconductivity are not being taken advantage of because this example looks at substitution. The doubling of power capacity in copper cables results in a doubling of CAPEX, whereas a superconductor requires only an increase in the amount of superconducting tape. Building higher capacity lines will bring out the true advantages of superconductors.

Rather than having four or five 1GW HVDC lines back to shore from a development zone, a superconductor with 2 cables would export power back to shore, where the power can then be split up onshore into separate strands to connect into the grid. The environmental benefits both during installation but also with regards to footprint and public acceptability onshore are unignorable.

Q3. Do you have any additional evidence to inform the assessment we have made?

Key Point - SuperNode achieved a Statement of Feasibility from DNV GL in Q4 for an offshore superconducting based transmission system.

1. Superconducting Transmission Schemes

It is SuperNode's belief that these technologies are not properly considered when factoring in the timeframes discussed during this consultation. Superconductor based transmission lines should be included in this section describing the operational properties of a superconductor:

- **Zero Electrical Resistance** - When a superconducting material is cooled below its critical temperature, its electrical resistance reduces to zero.
- **High Power Density** – Superconductors can carry significantly higher levels of current and thus are capable of the transmission of higher power levels than copper

    - A lower voltage can be used to carry the same amount of power as a copper cable. Ie for 1GW: Superconducting cable (100kV, 10kA) vs Copper cable (500kV, 2kA)
- **Smaller Right of Way** – As superconducting cables has a smaller cross-section and the right of way required for their installation is much smaller than comparable copper cables.
    - The high-power capability means that a single link can replace a conventional solution with several links of greater footprint for bulk power transmission
- **Lower Cost -** For bulk power transmission applications, the cost of a superconducting system is cheaper than conventional technology.

The chief advantage of a superconductor-based system is its ability to transfer high capacities of power at lower voltage levels. The benefits of operating at this voltage level are truly seen when considering the implementation of a DC scheme for offshore wind farms, further discussed in question 3.

Superconductors have been proven in multiple onshore demonstration projects. The first demonstration of a superconductor for transmission is the Ampacity project in Essen, Germany. This project Implemented a 1km long, 10kV, 40MVA project using a three-phase superconducting cable with concentrically arranged phase conductors and a superconducting fault current limiter. This project was commissioned in 2014 and remains in operation. Further details can be found here

In 2011, KEPCO, LS Cable & System, and AMSC energised a 22.9 kV AC cable system at the I'cheon substation located near the city of Seoul. The cable successfully operated for two years. At the time of installation, it was the longest distribution voltage superconductor power cable in operation. KEPCO is also conducting type testing of a one km, 154kV AC cable system. In 2019, KEPCO (South Korean TSO) and LS Cables commissioned a 500m, 80kV superconducting line in South Korea. Further details here.

EU Horizon Project Best Paths was established to overcome the challenges of integrating renewable energies into Europe’s energy mix. It aimed to develop novel network technologies to increase the pan-European transmission network capacity and electricity system flexibility. One of the key parts of the project was to integrate superconducting high-power DC links within AC meshed network. This led to the design, manufacturing and testing of a 320kV, 10kA (3.2GW) superconducting cable. Gigawatt-scale superconducting cables have been investigated and shown to be technologically mature and cost-competitive for the transmission of large amounts of electricity. Thanks to their high efficiency, compact size, and reduced environmental impact, superconducting cables are likely to find higher public acceptance than overhead lines and conventional cables.’

This project was conducted by Nexans (Leader), CERN, Columbus Superconductors, ESPCI Paris, IASS Potsdam, Karlsruhe Institute of Technology (KIT), Ricerca sul Sistema Energetico (RSE), Réseau de Transport d’Électricité (RTE), Technische Universität Dresden, Universidad Politécnica de Madrid (UPM). Further details here.

Recently, NKT announced they are involved in the development of a 12km long superconducting project in Munich, Germany. This project will be the longest superconductor in operation and will operate at 110kV with an operational capacity of 500MW. The project is currently at preliminary stages of development. Further details here.

This abundance of onshore projects demonstrates the stage at which superconductors are currently performing at. The next step is to take this performance and demonstrate it in the offshore environment. This is the core focus of what SuperNode are currently working on. SuperNode are currently working on the development of a superconducting transmission line that can operate in the offshore environment. It builds on the experience and knowledge obtained to date from existing onshore projects and aims to further these developments through optimisation of the different sub systems.

It must be noted that superconductors have seen uses outside of transmission, with the most relevant being in the development of a superconducting generator used in the EcoSwing demonstration project in Denmark. This project saw an existing 3.6MW wind turbine have its generator replaced with a superconducting unit which reduced the overall weight and volume by 40% and 40% respectively. More Information here.

This has led to the investigation of superconducting based wind turbines in the US where the Department of Energy has provided support to GE and AMSC based designs with the core aim of developing next generation turbine drivetrain technology. Details here.

2. DC schemes

There is brief discussion on the opportunity presented in the use of DC Turbines and DC array cable designs. The referenced paper in the report dates to 2010. Since then significant work has been done into the potential for the implementation of DC wind farms. MVDC (Medium Voltage Direct Current) wind turbine drivetrains and DC array collection systems have been assessed for their feasibility and value proposition (one such publication). Carbon Trust have carried out two projects researching the opportunity (details here).

This study considered the use of 80kV MVDC array cables back to land and the potential cost savings compared to current HVDC and HVAC designs. This study did however find that there are limitations to current MVDC cables available when considered with future turbine capacities in mind. +/- 80kV strings would be limited to ~300MW capacities and the volume of cables back to landfall would increase.

This is where the true potential of DC schemes will be unlocked through higher capacity array cables. The Horizon Promotion project examined meshed offshore DC grid requirements and addressed associated technology integration challenges to conclude that meshed offshore HVDC Grids could make a significant contribution to a Low Carbon future across Europe. The ability of a superconducting cable to take higher levels of current while maintaining the same voltage level means that MVDC schemes can be used instead of HVDC, whereby offshore array cables "merge" at an offshore busbar and superconducting MVDC export cable brings the power back to land via two cables.

Separately SuperNode are currently studying the feasibility, and the operational and techno-economic benefits of a DC superconducting offshore grid in collaboration with academic researchers in the UK.

3. Grid benefit assessment

The UK has a clear target to take advantage of the vast offshore resource available in the North Sea. The development of 32GW of offshore wind off the east coast (figure 4-20) highlights the vast opportunity, however, this opportunity should be viewed in a more opportunistic and integrated manner. The report does discuss interconnection with neighbouring grids (27GW by 2050) but the opportunity to truly take advantage of the offshore resource and deliver this power in an effective and efficient manner has been overlooked.

Europe has a target of 450GW by 2050. This is a target that will not be reached in a nationalistic way. The development of a meshed offshore grid is vital to achieving this target and presents an opportunity for the UK to partake as a net exporter of power. The Promotion project, which recently ended, pointed to the deployment of a meshed grid in the North Seas. This type of development requires strategic long-term planning and cooperation between all nations involved.

The UK has a vast offshore resource which with the appropriate grid design and implementation, can be exploited in the most efficient manner with deeper interconnection to neighbouring grids.

Even without consideration of a larger grid development in the North Sea, higher levels of interconnection with neighbouring grids should be considered in the scenarios. The 30GW of interconnection envisaged for 2050 is a conservative target which only increases interconnector capacity by 8GW vs 2030.

Q4. Do you have any further feedback on the report?

Changes to largest single infeed

We welcome the recognition that redundancy in HVDC configuration has value and merits investigation in the same way that bootstraps are considered not to be largest single infeed. This points towards the merits of a meshed offshore arrangement that can handle larger amounts of electricity without compromise. Two of the most valuable advantages of superconductivity are described in the report where it is stated that "superconducting HVDC cables which offer higher capacities and occupy less space can be used to HVDC cable, if they become available on commercial terms and are cost competitive across the timescales under consideration. However, the maximum power capacity of any single offshore transmission circuit will depend on the SQSS requirements that can ensure onshore security of supply." Per Promotion the conclusion is that higher capacity cables are more valuable within the context of integrated / meshed grids.

Superconductivity offers the opportunity to have significantly higher capacities of power carried on a single line, which can then be "split" 3/4/5 ways meaning that the points of connection with the onshore grid could be smaller in capacity.

Cost-benefit Analysis Report

Q1. Do you agree with our assessment of the costs and benefits?

The approach taken is a good step in defining the costs and benefits of such a large and costly system. As noted in the report, there are further areas of research which could take place. The potential of superconducting meshed grid technology for instance could be explored to compare the high-power transmission advantages of this technology to the current ‘counterfactual’ and potential future ‘integrated’ systems to reduce environmental and social impacts further.

Q2. Do you have any other evidence to support or challenge the assessment made?

As was discussed during the questions for Annex 1, the lack of consideration of superconductivity should be reconsidered. it is true that it its currently more challenging to forecast the costs of the future, but this does not mean costs are not available. Even with conservative costs, superconductors present a large economic benefit in reducing the total system cost while also reducing the losses of the transmission system.

Q3. What do you see as the potential impact on the environment of these proposals, particularly the reduction in the number of assets and landing points?

Reduction of the number of assets and landing points can overall only be a good thing. Both construction and ongoing maintenance time and resource requirements would be reduced, therefore reducing the carbon footprint of the projects with fewer assets and landing points.

Environmentally, the impact from the projects would be reduced due to potentially shorter construction period, in less locations, with a significantly smaller footprint. this is both positive for the surrounding environment, but also in achieving public acceptance.

From a maintenance perspective, there are less points of failure with a lower asset count. Ongoing maintenance requirements in both time and personnel requirements would therefore be lower, requiring less boat trips relative to other the alternative.

Inclusion of superconducting mesh grid cable arrays would reduce this impact further due to the higher power density of the technology, allowing higher power levels in the cables, further reduction construction time, environmental impact, impact on local communities and project footprint.

Q4. Do you have any further evidence on the potential social and community impacts of these proposals? We would particularly welcome responses from local authorities on this question.

Again, inclusion of superconducting technology would further reduce social and community impacts with the reduced project footprint both in construction and operational phases.

It is known that the development of grid assets is an arduous process with overhead lines being near impossible to build now due to lack of public support. In offshore schemes, cable landing points present challenges with consenting an appropriate cable route back to the onshore substation. Reducing the number of cables landing onshore would reduce these challenges.

Having a significantly smaller footprint results in requiring a much smaller Right of Way (RoW) on land. Presenting a smaller cable corridor to landowners and stakeholders should be viewed more positively than the current regime.

Q5. Where do you see value for further work to build on and test these findings? Either from the proposed list or beyond?

There are multiple points noted throughout the report. There needs to be inclusion of superconductors in the CBA before it is taken further and scrutinised. There is an opportunity to investigate a technology that could vastly reduce overall system costs, reduce environmental impact, reduce system losses, and improve system stability. Superconductivity is the technology of bulk power transfer, so any discussion on grids of the future must involve it.

Offshore Connections Review Report

Q1. Do you think that if the areas we are highlighting were improved, that the ability to coordinate projects would be significantly increased?

The CION process is a process which requires urgent review and refreshing. It requires review with consideration of a more coordinated approach that includes a more regional view to connection. The review of the CION process, and indeed this consultation, must look beyond the current pace of development and look beyond to the future at the most efficient and effective option. This should result in existing projects development maintaining its current approach while reforming the process for the future grid architecture.

Q2. Do you think we have missed anything in our offshore connections review that would add value and increase coordination?

"Coordination across several projects is challenging, as the CION process only considers the most economic and efficient way to connect sole applications, without consideration of coordination with other applications, or the potential for further generation in the future."

The above is listed under "concerns and issues with current approach," but there does not seem to be a mention of how potential for further future generation from a site will be considered in the review of the process.

Do you have any other feedback, if so, please add below. Many thanks for taking the time to provide written feedback. When we publish our final documentation, we will let you know what we have done with the feedback and how it has shaped our work.

The development of a coordinated grid requires long term planning of both the grid assets but also the generation assets. It is vital that the work being carried out by the ESO on planning include input from leasing stakeholders (the Crown Estate, and Crown Estate Scotland). Without their involvement, the most optimal grid design will not be achieved. Building the most effective and efficient grid is intimately linked to the location of the renewable resource.

For this reason, it is vital that the offshore grid be considered, and coordinated, with all onshore grid processes and that the NOA process be expanded to include offshore in its scope.