Offshore grids: The energy transition’s next frontier
The European Union’s North Sea countries recently vowed to build more than half of the bloc’s needed offshore wind capacity by 2050 in order to help reach EU climate neutrality. At the heart of the ambition to turn the North Sea into a green energy powerhouse lies the idea that countries will collectively harvest the water’s windy resources and jointly reap the benefits of this interconnected clean electricity revolution. But such a complex network is yet to be designed and built, raising questions about how a meshed offshore grid could actually be implemented from a technical and economical point of view.

In this Perspectives, Sandy Mactaggart, Director of Offshore Delivery at SSEN Transmission, the electricity transmission network owner in the north of Scotland, and Niklas Persson, Managing Director of Grid Integration at Hitachi Energy, discuss the development of a meshed offshore grid based on hands-on experience gained whilst jointly developing one of Europe’s flagship HVDC (high-voltage direct current) multi-terminal projects in Scotland. They argue that offshore grids will be absolutely vital to unlock and harvest the best renewable energy resources and that a holistic planning approach involving all stakeholders as early as possible is the most efficient way forward. They also agree that a HVDC network stretching across several countries is technically feasible and that the entire energy transmission supply chain needs to tackle the risks surrounding current commodity price fluctuations and the availability of material.
A collective approach

Q: What are the benefits of strong relationships between project developers and technology providers when delivering energy transition projects?

Sandy Mactaggart (SM), SSEN Transmission: The key benefit of establishing long-term relationships with our supply chain and really understanding the collective approach is delivering on our plans by jointly managing the activities and risks. Specifically in the current climate we’re operating in, where resources and scheduling demands are very tight, we’re working as collaboratively as we can with our supply chain. It’s a kind of collaborative approach that focuses on how we can each play to our strengths and how we can reduce risks, while being productive on project development and future delivery.

Niklas Persson (NP), Hitachi Energy: I fully agree with what Sandy said and collaboration applies especially to HVDC technology. Its engineering processes are very specific compared to normal offshore AC substations where you have more standard interfaces that are well developed through many years of standardization. When it comes to HVDC we have a collaborative engineering process throughout the project. In our work with Sandy and his team we understand each other’s strengths and weaknesses. By discussing and agreeing on who is best suited to take on certain areas we eliminate risks throughout the execution process. This approach saves time, and time is a scarce resource if you consider the work we have to do as a society in order to drive forward the green energy transition. Collaboration is fundamental for us to be able to do more with the time that we have.

Q: How can project developers and technology providers best collaborate to deliver on plans, given the existing supply chain bottlenecks?

SM: As transmission operators we’re always working within tight timescales. I see great opportunity in a program approach rather than looking at individual projects, and in the UK we’re seeing this now with the publication of National Grid’s Holistic Network Design. It will certainly make it a lot easier by allowing us to organize activities in a way that encourages the most efficient delivery, while helping us avoid bottlenecks. Previously, we were often looking at individual projects as they came along with their own unique characteristics and timelines.

Specifically on the delivery of our second HVDC project, we found ways to improve efficiency when considering the timescales that were actually needed, without exposing either party to additional risks. The program approach certainly allows our management teams to learn from better planning and scheduling and to deploy lessons learnt on future projects.

NP: At Hitachi Energy, we have in the past been asked to do EPC (engineering, procurement and construction) work. Before, when the market was requiring only a couple of HVDC projects globally, we had the ability to either join forces with a partner or to carry out the construction work ourselves. But now that the market is requiring many more projects, we are looking at where can we scale best. That’s in our own factories where we make components like transformers, valves, control and protection, cooling systems etc., and it’s also in our engineering teams because we are a very attractive employer in this area.

Considering the scaling-up we are facing, we have adapted our approach to projects now through programs and more standardized interfaces, but also through each partner focusing on taking on the risks they can take on best and growing capacity to execute. This is key for us going forward.

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The Future is Offshore

Q: Are meshed offshore grids possible and if so, what would be the benefits?

SM: There will be a requirement for offshore grids, they’re absolutely necessary for the future of the green energy transition. We obviously need to look at the challenges associated with meshed offshore grids on a regulatory, technology and delivery basis. As a transmission operator, we are certainly taking very important steps towards an offshore grid. At the moment, we’re delivering the Shetland HVDC link project together with Hitachi Energy, that’s a multi-terminal project which will connect Shetland to the wider Great Britain’s grid for the very first time. Within Europe it’s certainly an important flagship project.

Point-to-point connections are becoming a challenge, certainly in the UK, in terms of achieving permissions and consents to build. That’s why we’re looking at the possibility of building a DC switching station in the Peterhead area of Aberdeenshire. We’re very confident in the multi-terminal technology that we’re deploying on the Shetland project which is an important foundations step for offshore grids. We need to address some of the challenges going forward but there’s no doubt that offshore grids will be needed.

NP: Agreeing on the design is the first thing that needs to happen. What will offshore meshed networks look like and what is the regulatory framework? How do you decide who receives the energy generated and when? How do project developers generate revenues? We need to address these questions before we can deploy the technology and decide how to collaborate among OEMs (original equipment manufacturers) to make sure that the various technologies actually integrate well. From a technical perspective, we are quite confident in offshore DC grids. Of course, they require more research and development but there aren’t any technical showstoppers.

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Niklas Persson
Q: What technical and other challenges need to be overcome in order to make the vision of a meshed offshore grid a reality?

SM: The growth of renewables but also the growth of the number of HVDC interconnectors provide significant challenges to the transmission system and its planning. Equally, it’s fair to say that the knowledge base and capabilities to design and deliver the network are growing all the time. Still, there’s another real challenge in terms of the availability of the resources. In order to actually work at the scale that we collectively have to reach between OEMs, operators and developers, everyone needs to grow their capabilities and the resources. I think that warrants some discussions about how we can work collectively on creating pipelines of resources into the industry.

NP: As a technology provider, we believe we have all the building blocks to create a meshed offshore grid. If we were to design one, it would be based on multi-purpose interconnectors with a few DC breakers. We need a multitude of these to make the grid happen and we need companies like us and other OEMs to collaborate in order to make it work technically. If we wait for standards to be implemented, it will take too long. I believe we need to identify a few pilot projects to move forward with. I am not afraid that the technology will not work but I am afraid of wasting time waiting for standardization. Creating offshore meshed grids needs a political force, it needs TSOs (transmission system operators) and project developers saying ‘let’s do it’. I am not afraid that the technology will not work but I am afraid of wasting time waiting for standardization. Creating offshore meshed grids needs a political force, it needs TSOs (transmission system operators) and project developers saying ‘let’s do it’.

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300,000
Number of workers needed by the wind sector

In terms of challenges, WindEurope estimates that in this industry - TSOs, regulatory bodies, OEMs, and developers – and within Europe we need at least 300,000 people to carry out the work required. We can attract people from oil and gas and other industries but there’s a lot of work to be done together to design training and to get universities on board to make our industry attractive. As an industry, we have a fantastic purpose and that’s quite unbeatable today. We have the chance to reposition our industry, but we need to get together on an EU and individual country level and see how we can put more effort into attracting more competence. This is a real challenge. I think if we want to scale up in a timely manner, we actually have to attract a lot of new talent.
HVDC at the core

Q: You have chosen to implement HVDC cables on the Caithness-Moray-Shetland (CMS) project. Why did you opt for this technology?

SM: It’s the distances and the energy transfer requirement. The publication of the ESO’s Holistic Network Design affirms the technology decision on CMS. Certainly for Shetland it absolutely makes sense because the benefits of the HVDC connection go beyond connecting Shetland to the UK mainland. It also provides additional fiber to the islands and improves their security of supply. These solutions were not available in the AC system. It really is a crucial project which is supporting Scotland and the UK’s transition to net-zero emissions; delivering the fantastic renewable resources that we have here in the north of Scotland and taking this clean electricity to demand centers all across Great Britain.

Q: What challenges do you see in connecting onshore renewables to the transmission grid?

SM: There’s unprecedented interest in available connections and it’s not just onshore and offshore wind. There’s tremendous growth in hydrogen, battery storage, and carbon capture, so there’s a number of strategically important projects all looking to construct infrastructure in similar areas. It’s going to become a very busy place in the foreseeable future. Some of the additional challenges are how the consenting authorities will be able to deal with the demand and how they can take holistic planning decisions in the absence of a full picture on when investment decisions will be taken. There’s a lot of pressure on them.

Scheduling is one of the most important elements of planning programs. To mention one example, our team on CMS worked closely with the SSE Renewable Energy team developing the Viking wind farm to coordinate logistics and transport on Shetland because we had around 400 staff between us on one small island. That was quite an impact in terms of accommodation and travel, so we worked together in our planning to minimize our impact on the local community.

Another challenge is power grid capacity, which needs to increase and become more flexible to integrate increasing amounts of renewables.

Niklas Persson

NP: The holistic network design is key. It’s usually easier to gain consent when building offshore compared to building onshore, so starting early on permitting and working with local authorities but also local people are really important. This is exactly what has now happened in the UK with the holistic network design and it’s a very good step forward. For us as a technology OEM, this kind of support is fundamental to our planning because we then know that we have a chance to be considered as a key partner and it encourages us to invest.

Another challenge is power grid capacity, which needs to increase and become more flexible to integrate increasing amounts of renewables. We can address these requirements by deploying modular and smart grid connections with standardized design, which can speedily scale up grid capacity without compromising on quality. For our part, power quality solutions can help strengthen the existing infrastructure without requiring more transmission lines, while a comprehensive portfolio of digital solutions, which combine advanced analytics, energy management software, and hardware systems with battery energy storage, can help manage volatile energy generation and consumption by consumers.
Q: Beyond the North Sea, where else could meshed offshore grids be developed?

NP: In the next ten years meshed grids will continue to grow in Europe. Europe is certainly more advanced when it comes to deploying DC technology and the North Sea is the cradle for developing meshed offshore grids. In other regions we see more radial interconnectors from generation to shore for now. If we look back at various plans to redraw the current power system, we have seen different proposals to use HVDC solutions to power Europe from Africa or Singapore from Australia. I am confident that we are at the very beginning of a new era of developing our sustainable power infrastructure and that HVDC technology will be at the heart of it.

Q: What role does HVDC play in integrating renewable energy?

NP: HVDC started with long-distance transmission and it has played a huge role in connecting far-away generation centers like hydropower to load centers. Then came offshore wind which really brought HVDC to the fore. HVDC not only connects larger amounts of renewable energy to the grid, but it also provides an enhanced power controllability. With capabilities for frequency and voltage regulation, black start and power quality enhancement, the value proposition of this technology evolves from the traditional bulk power transfer to the most flexible technology for managing power flows and power quality in a more complex energy system. Moreover, due to its scalability in power provided by the advancements in power electronics and modular design, and utilizing the multi-terminal concept, HVDC really accelerates the shift to renewable energy, making the integration of renewables a seamless task.

As a next step, we are looking at connecting load centers in megacities to generation sites outside of the demand center. The issue is that in large cities, it’s almost impossible to gain planning consents so running a cable from the load centers to, for example, solar farms outside of the city is a fantastic application for HVDC.

Perhaps one of the most important applications of HVDC when talking about the energy transition is connecting offshore oil and gas platforms to the shore in order to replace local generation on the platforms which is typically highly polluting. We have seen this happening in the Norwegian part of the North Sea, but we are also seeing more and more interest in this technology from elsewhere.

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Niklas Persson
Managing challenges ahead

Q: What concerns need to be overcome to ensure that project plans come to fruition?

SM: I think that one of the main challenges we are facing right now are the uncertainties we are currently living with and which we didn’t have 12 months ago. Normally, when we’re looking at risks we think about regulatory or political risks that we can often overcome through collaboration. But currently we are facing acute new issues such as commodity price uncertainty, the supply of materials, and the availability of labour. We have to be active in these issues and come up with ways to make sure they don’t become barriers to the delivery and scale that are needed in the energy transition.

NP: The challenge of speeding up the energy transition has changed fundamentally over the past 12 months. What concerns me most is the cost of commodities and materials. In our industry, it can take two to five years to get a project to execution stage and then it can take another five years to deliver it. How do we as an industry manage cost certainty over these long periods and work to reduce risks instead of pricing them into every single step? It’s a concern to me and we need to continue working together to avoid ‘greedflation’ where the whole supply chain starts putting prices up unnecessarily to take advantage of a scarcity of supply situation.

SM: I fully agree. The one thing that will benefit us is that we have long-term relationships across our supply chain where folks would like to continue doing business over the next five, ten or even 20 years. Some of the risks Niklas called out are very real. We need to find certainty and stability against a pricing environment that can potentially change quite drastically; just look at the oil price over the past year, for example. I think that some of the things we can do are ensuring we play to our strengths, reduce interface risks, and figure out how to address the risk of cost uncertainty.

Q: What is your personal motivation to work in the energy transition?

SM: It is a privilege to be involved in planning and delivering not just Scottish and British ambitions but global net-zero requirements. On a personal level, this is a fantastic opportunity to build a team that is working in such an innovative area. It’s hugely energizing and very rewarding to be part of something that requires a certain pace and to collectively challenge traditional thinking through strategic problem solving. It’s a real challenge but we also need to look back at what’s been achieved to give us that focus and the purpose to go forward.

NP: From a personal perspective, and as Sandy described, working collaboratively and trying to solve this energy transition is fabulous. There’s not been one boring day since I started and it’s getting even more and more exciting the longer I am in the industry.

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