Smart Ports Use Case

January 2021

Shore Power to support vessel operations

Developing UK ports as green energy hubs, moving towards Net Zero Carbon

Smarter UK Ports - Project Introduction

Smarter UK Ports is a series of five use cases for the use of technology in Smarter and Greener ports in the UK, developed and published by the Connected Places Catapult, in association with Royal HaskoningDHV UK.

The use cases are based on real-life challenges within many ports across the UK, co-created with five port authorities to give local context and relevance on how innovative technologies can be implemented to improve their business function, resilience, environmental impact and operational performance.

The five topics were selected together with the partner ports to give context and achievable, nearer-term initiatives that support the delivery of key Maritime 2050 themes. As challenges that exist at ports throughout the UK, these use cases present opportunities for collaboration and knowledge exchange to deploy and scale these potential solutions to realise wider sector impacts.

Meant as a snapshot of relevant challenges to port operators, these studies aim to inspire further discussion and collaboration, with clear next steps to make use of technology that deliver Smarter and Greener Ports

All of the Smart Port Use Cases in this series engage a range of existing or evolving technologies to bring improved digitalisation and business change in the multi-stakeholder environment that UK ports operate within.

We would like to thank our partner port authorities for their contributions and discussions and hope you find the series both enjoyable and informative. We would also welcome you to reach out directly to us with your own challenges and initiatives on our journey to Smarter and Greener UK Ports.

Henry Tse, Director of New Mobility Technologies, Connected Places Catapult

Topic	Supporting Port	Maritime 2050 Links
Connected Supply Chain – Virtual Pre-Gate for Ferry Operations	Portsmouth International Port	Trade Technology Environment
Automated Asset Inspection & Shared Port Insight	Shoreham Port	Infrastructure People
Green Energy – Shore Power for wind-farm Service Operation Vessels	Port of Tyne Authority	Environment Trade Infrastructure
Climate Resilient river operations in London by predictive level digital twin	Port of London Authority	Environment Trade Security & Resilience
Operational Resilience – Monitoring of marine assets in remote locations	Milford Haven Port Authority	Infrastructure Security & Resilience

1 The Challenge

Ports have an important role to play in the decarbonisation agenda, with vessels generating a large proportion of port emissions, yet there are still significant barriers to implementation of shore power in the UK.

The decarbonisation of UK ports is framed by key policies such as the Department for Transport's (DfT) Clean Maritime Plan and Maritime 2050. In 2019, the release of the DfT Port Air Quality Strategies policy included a requirement for ports in England with tonnage exceeding 1 million tonnes to produce and publish air quality strategies, identifying the measures they are taking to reduce emissions.

Many ports are already taking steps to tackle emissions from the activities under their direct control through the gradual electrification of port equipment. However, for many UK ports, the greatest source is the indirect emissions produced by the visiting vessels. Reduction of these emissions is a multi-stakeholder challenge that requires collaboration between the port, the port's users and shipbuilders.

Shore power, or cold ironing, is a widely recognised solution to the issue of in port vessel emissions and shore power solutions have existed for some vessels since the early 2000s. But to date, the uptake of shore power in the UK has been low, with some of the significant barriers to its implementation cited as the high capital costs, the lack of standardisation, cost of supplied electricity and uncertainty over demand from the port users.

Over the last 20 years, new market sectors have emerged for ports associated with the burgeoning offshore renewables market. With the ambitious targets set out in the government's recent Ten Point Plan for a Green Industrial Revolution (to produce 40GW of power from offshore wind by 2030), these markets look set to continue to expand.

With service lives of turbines in the order of 20 years, offshore wind farms require continued operations and maintenance (O&M) support from specially designed service operation vessels (SOVs). These vessels require dedicated shore bases to restock and enable the changeover of crew.

The Port of Tyne is one of the ports operating in this emergent sector, with plans underway to create a green energy park for the north east region. As part of this venture, Equinor has selected the port as the Operations & Maintenance (O&M) base for the new offshore wind farms at Dogger Bank, which collectively will form the world's largest offshore wind farm.

To support operations, Equinor's O&M base will comprise a 1.2 Ha site with parking, warehousing and office space adjacent to a deep-water quay. The quay will be suitable for berthing a range of different SOVs up to 85m in length.

With regular SOV visits to the port (every 4-5 days), reducing the emissions associated with a vessel fleet that will be servicing renewable energy developments for the next 2-3 decades, make SOVs a logical candidate for the application of shore power, to reduce the embedded carbon footprint of the windfarm operation.

> "Our partnership with the Port of Tyne will enable us to create a bespoke operations base for the new windfarm at Dogger Bank, with adoption of new technologies and infrastructure that will improve efficiency and reliability of our wind-farm service, as well as reducing the carbon footprint of the energy produced for decades into the future."

Luca Daniele, Marine and Logistic Leader, Equinor

2 The Solution

Shore power replaces the need for using vessel generators whilst in port, improving local air quality and long-term climate impact.

Shore power is the provision of electricity to vessels while they are berthed in port. Once vessels are connected to shore power, the vessels can switch off their engines that provide electrical power for the vessel crew and on-board systems. Once connected, the vessels no longer rely on their diesel engines which means local air particulate and carbon emissions, noise and vibrations from the vessel's engines are avoided for the duration of the visit.

For SOVs, there are some additional considerations: while offshore, SOVs rely on dynamic positioning (DP) technology, as used in many vessels in offshore industries from cable laying vessels to drilling units. This technology is used to maintain a fixed vessel position, without the need for anchoring, alongside the turbines; Equinor plan to use hybrid SOVs with onboard batteries (2-3 MW capacity) to power dynamic positioning while offshore to further reduce the use of fuel oil.

This means that the shore power provision at the O&M base at the port will need to support the onboard systems for the crew while simultaneously charging the SOV's batteries. This needs to be carried out within the relatively short period that the vessels are in port (around 6 hours).

A viable shore power solution for this operational context relies on overcoming several challenges:

Improved certainty in planning: There is a dilemma when it comes to the provision of the civil and electrical infrastructure to support shore power. Infrastructure takes time to plan and construct and before the port takes steps to invest and commit to specific infrastructure, some certainty over the vessels that will use the site is needed and guarantees over the future utilisation and income from the shore power infrastructure (e.g. the duration of the lease, the frequency and duration of vessels visits).

The solution to this is simple but can be easily overlooked. It relies on the right information being shared at the right time. This could be facilitated through early workshops between the potential vessel manufacturers, the operator Equinor and the Port of Tyne, something the Port of Tyne is well versed at facilitating through initiatives like the Innovation Hub.

Standardisation: Currently, there is only one worldwide standard (IEC80005-1) for high voltage shore power connections, which has been applied to define standardized connections for cruise ships and container vessels. The IEC80005-3 describes the requirements for low voltage shore power systems, but standard connection types for worldwide application have not yet been defined. In the UK, the power grid operates at 50 Hz, the onboard frequency of vessel systems can vary, some at 50Hz and others at 60Hz; in some cases, frequency converters may be required. Providing a system that is flexible to the requirements of multiple vessel specifications, quickly leads to substantial increases in capital costs.

At Port of Tyne, Equinor plan to utilise 4 to 5 SOVs, which may include models from different shipowners and manufacturers. Equinor has the benefit of being in the early stages of procurement, therefore, options exist for standardised requirements from different vessel manufacturers, in turn rationalising the costs of the supporting infrastructure.

Connection Options: In practise, shore power works like a scaled up version of a plug, cable and socket, with various connection options available. The first consideration is whether the cable is onboard the vessel or onshore (ship to shore versus shore to ship). This can impact who bears the majority of the capital cost, the port or the vessel owner.

For the level of power required for this scenario, around -500-700kW, another consideration is whether to opt for a low voltage or medium voltage connection. There is a trade-off between handling a multi-cable system (low voltage) or providing one cable and plug (medium voltage) with the requirement of an on-board transformer that takes up space onboard the vessel. Due to the relatively short turnaround time for the vessels and the manual handling implications of connecting multiple cables, a single cable, medium voltage solution is likely to be preferred.

For the onshore infrastructure, consideration is needed over whether to opt for static pit based, static freestanding connection points or a mobile solution. The appropriate selection requires consideration of the quayside operations and whether the vessels have stern or mid-ship connection points. Cost is also an important factor, with mobile solutions costing significantly more.

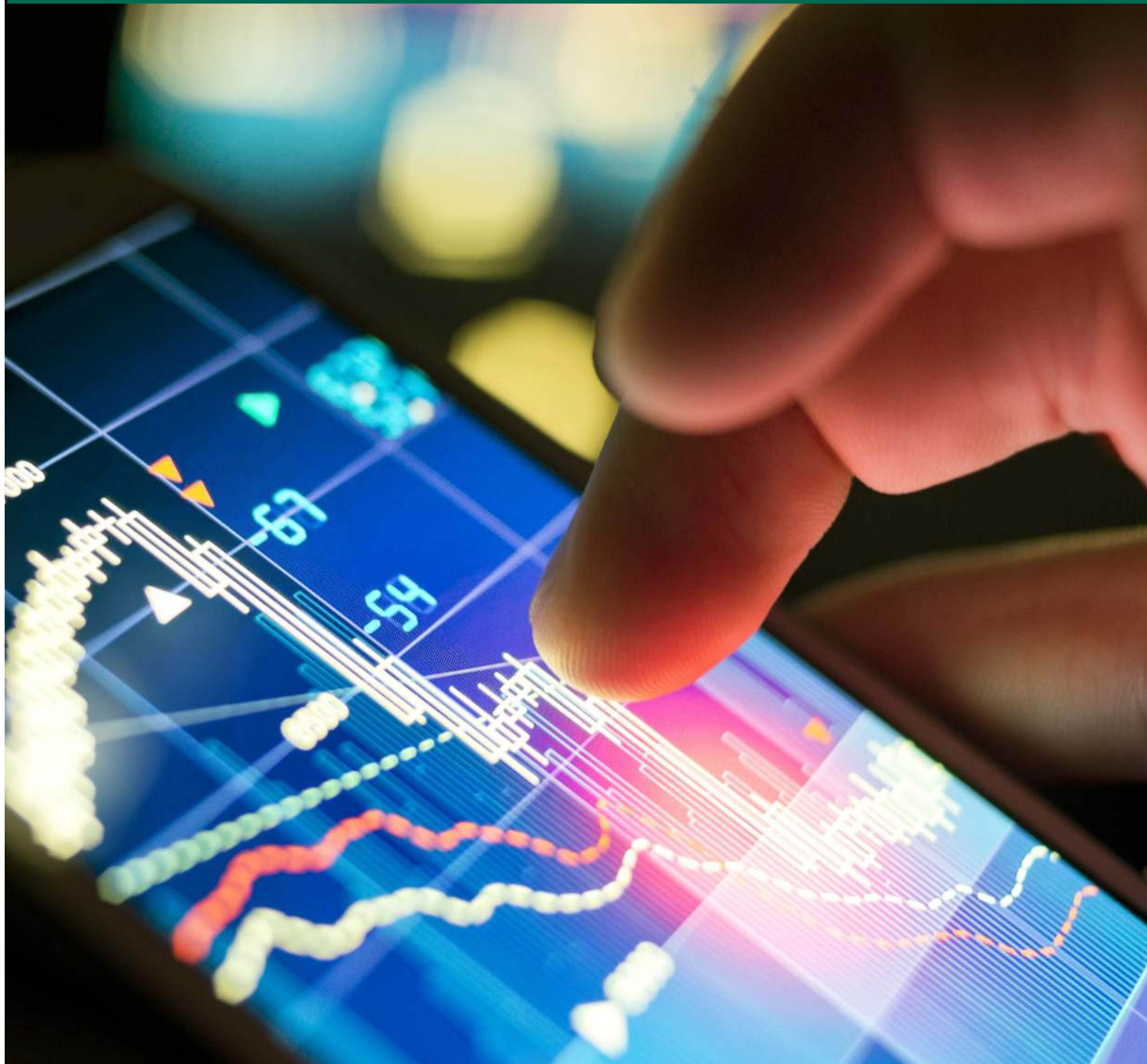
Power demand and management: Shore power is typically sourced from the national grid but demands from shore power can create a dilemma for both the port and the local energy network. The stress on the network for this isolated and occasional use of shore power would be in the order of - 500-700kW per connection. The local grid must therefore have the capacity to cope with this level of demand and the capital costs associated with remedying capacity issues (e.g. provision of a new substation) are typically high. From the perspective of the port, provision of shore power also risks an increase to the port's energy costs, due in part to the overall increase in energy consumption, but more importantly the peaks in demand caused by shore power connections.

To address the issue of peaks in demand, consideration should also be given to a power management system (PMS) to electronically monitor and control the shore power system and electrical distribution network. A PMS provides a comprehensive overview of the system at the port, monitoring operations centrally to provide both operational efficiency savings by distributing power to equipment as needed to reduce the electrical peak demand and maintenance savings by allowing the maintenance team to prioritise and schedule regular preventative maintenance activities.

There are also alternatives to sourcing energy from the grid, such as locally embedded generation through off-grid energy sources (e.g. an onsite wind turbine or solar panels). Energy generated locally can be stored and distributed when required using a micro grid. A micro grid solution such as this could be combined with other electrical infrastructure onsite such as charging points for landside equipment such as forklift trucks and could also be used to assist with 'peak shaving' to reduce the port's energy costs.

3 How it Could Work

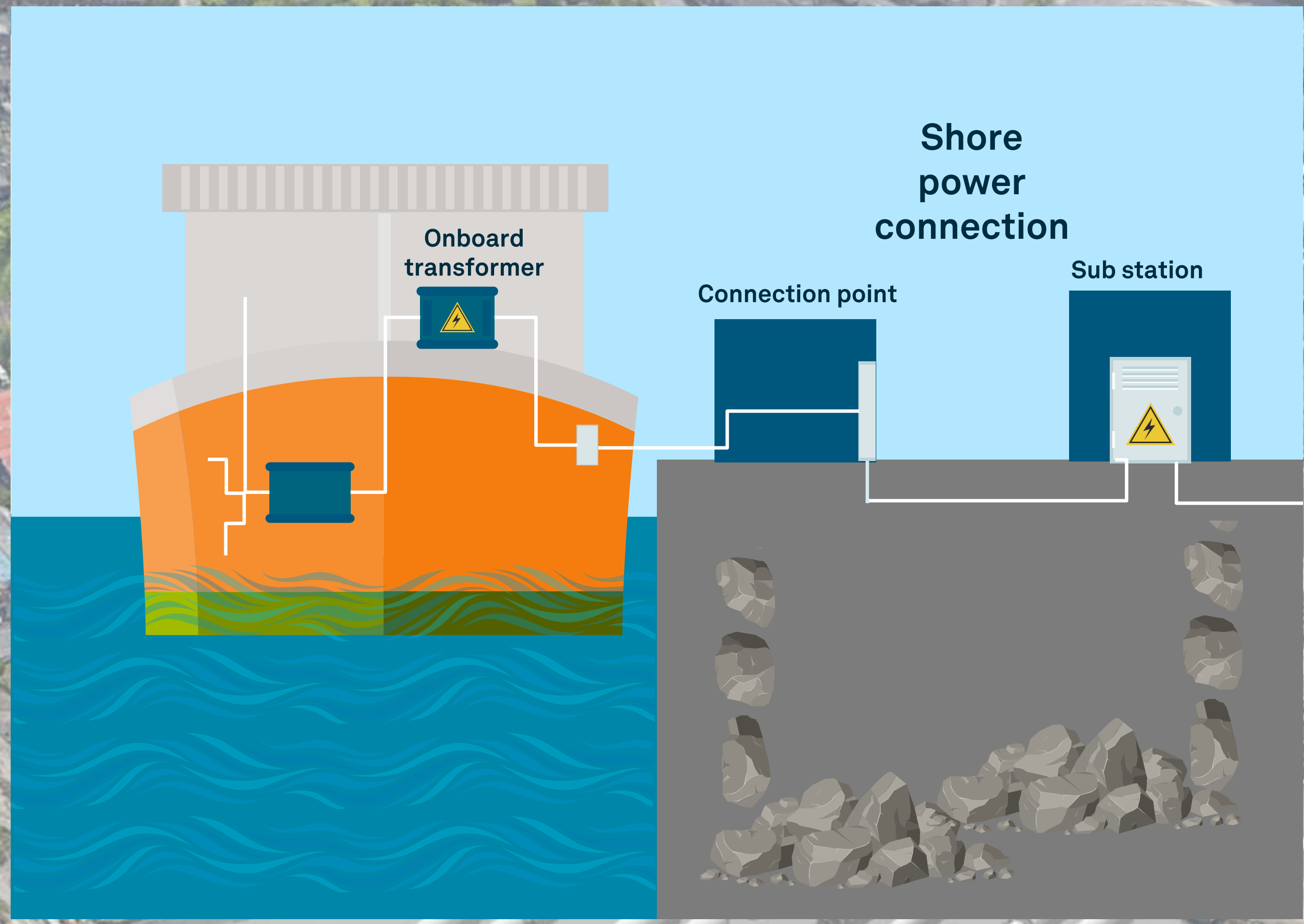
For the indicative power and turnaround time of SOVs, a medium voltage shore power solution with a single cable and plug and a transformer located onboard the SOV is likely to be the preferred solution. A static onshore connection would be more cost effective. A PMS could be used to smooth peaks in energy demand.



Industry Example

Shore power provision in Seaport Ijmuiden
Large fish trawlers require 250kW (@400V), which is most likely comparable to the power demand of SOVs. The images below are from the Port of Ijmuiden, a large fishing port in the Netherlands. Some of the key motivations for this project were the benefits it offered in terms of reduce noise and energy costs. The solution was a flexible installation embedded in static pits that enabled supply to vessels at both 50/60Hz.

Source: Royal HaskoningDHV, 2015



4 Wider Impacts

Reduced air pollution and emissions from vessels in ports is critical to the UK's climate obligations; electric power to visiting ships can become a key mitigation tool.

The use case for shore power to support a regular fleet of SOVs visiting the Port of Tyne to support the windfarm has a number of elements that work in its favour. In particular:

- That the quay at the Tyne Clean Energy Park will be predominantly used by a known fleet of vessels.
- The site is currently being redeveloped and therefore installation of the shoreside infrastructure is timely.
- The lead-time before procurement and vessel build allows collaboration to standardise the requirements for the vessels.
- There are other regional developments along the River Tyne in the pipeline, such as vessel replacement for the ferry terminal in the north port and the redevelopment of the Swan Hunter site where lessons could be easily shared.

This situation is not directly comparable with some other port sectors, where ports are contending with operational, multi-user quays that handle a range of vessels at different stages in their design lives, with a wide-range of power demands, frequency and connectivity requirements.

However, across the UK, there are many other examples of port-specific vessel traffic where similarities do exist. These include vessels used in the fishing industry and for offshore decommissioning and support activities. There are also ports with point-to-point visits from a small number of vessels, or examples of vessels that shuttle goods along inland waterways such as the Manchester Ship Canal or the Thames where the provision of shore power to enable hybrid vessel systems could help to reduce emissions from vessels within populous areas. Many UK ports are bordered by residential properties, like the site in the Port of Tyne. Shore power solutions also have the potential to benefit residents through reductions in noise pollution.

"The Tyne Clean Energy Park is a vital development to support the UK's goal for renewable energy and offshore wind in particular; we are proud to be a key part of this strategy and our development work will bring the best of technology and infrastructure innovations to future-proof operations here for a reduced climate footprint from our energy demands"

The offshore wind sector is a growing sector and there are other nascent offshore sectors such as floating offshore wind and carbon capture and storage (CCS) on the horizon. The legacy of these offshore developments is that ongoing O&M will be required over their service life in addition to eventual decommissioning. Facilities like the Tyne Clean Energy Park will be needed around the UK to support the government's ambitions of 40 GWs of offshore power by 2030. There is strategic value in creating a benchmark for a low-emission supply chain to support these industries.

An interesting potential future synergy for these two sectors, is the opportunity that offshore renewables present for the generation of zero emission fuels like green hydrogen, as one option in the ongoing race for the green transport fuel of the future. The power generated from offshore wind is intermittent and being able to store the excess energy by generating hydrogen through electrolysis is a concept that is being explored through several projects such as the Gigastack, HyChain and Energy Kingdom projects. Developing these key cross sector relationships (offshore renewables and ports) through smaller scale opportunities for collaboration to prove viability, paves the way for future collaboration on the nation's journey towards Net Zero Carbon. As an island nation, our ports are the critical interfaces between land and sea. This unique position means that ports have the potential to act as hubs for green energy and to unlock decarbonisation across other sectors, for example transportation by heavy goods vehicles.

5 Implementation Route

Shore Power requires support to create a viable business case and propagate adoption across the port sector.

The use of shore power in ports is not a new concept. However, the uptake of shore power for commercial vessels (that require more than a low voltage connection) is uncommon, particularly in the context of the commercially focused privatised UK port sector. This is due to a combination of significant barriers, including:

- High capital costs with limited access to public funding support,
- A prohibitive system for upgrading the energy network near to ports that penalises increased demand on the national grid,
- Uncertainty over demand for shore power from port users, compounded by high costs of electricity in the UK, relative to common vessel fuels such as heavy fuel oil.

One of the key advantages of using shore power to support the ongoing maintenance of the offshore wind sector includes the nature of the vessel traffic (a small number of vessels that will use this dedicated support base over an extended timeframe). Therefore, the starting point for implementing a cost-effective shore power solution for this use case is standardising elements of the specifications for the vessels that will use the site and designing the aligning support infrastructure.

The costs associated with installing shore power facilities are significant and public funding would help during the feasibility stage to progress the technical requirements for a shore power solution and to evolve a workable long-term business case.

The business case for shore power projects is often challenging due to those high upfront costs and long pay back periods, particularly when the benefits accrued are linked to public goods (e.g. improved air quality) rather than purely financial. Providing support to the port and operators to implement this infrastructure or any required vessel adaptions could help overcome this barrier. This could be facilitated by government, by creating a standardised approach for ports and operators to apply for funding (for elements of the vessels or infrastructure respectively) by demonstrating the carbon emissions reduction or wider benefits to society from improved air quality and reduce climate impact as part of the application.

The topic of developing zero emission berth standards is something that is being widely discussed in the port sector through forums such as the British Ports Association. It is important that knowledge from all sectors of the port, transport and offshore energy industries contributes to the development of wider industry guidance and standards. Government bodies such as BEIS have a role to play in facilitating cross sector knowledge sharing.

Next steps

- Develop a standard specification for 'shore power ready' SOV vessels to be used in the growing offshore renewables sector.
- Fund a demonstrator project for shore power at the Port of Tyne with lessons learnt to be shared with other comparable sectors.
- Develop a zero emission berth standard for the UK port sector.
- Provide ports with early funding support to undertake technical feasibility studies to assess infrastructure and cargo specific requirements for the provision of zero emission berths.
- Develop a funding framework for ports and operators for vessel berth related emissions reduction, that takes account of the wider benefits to society.

Thomas White
Solutions Architect,
New Mobility Technologies

cp.catapult.org.uk

Follow us on Twitter
@CPCatapult

Email us
info-mk@cp.catapult.org.uk

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