Call for evidence on shore power: response from Tyndall, Port of Aberdeen and Buro Happold

Department for Transport

Call for evidence on shore power: Implementing maritime commitments in the Transport Decarbonisation Plan, response form

Introduction

Thank you for responding. Your views will assist in gathering information on different aspects of supporting the deployment of shore power in the UK and will be used to inform future policy development.

Please fill in all relevant sections of this form, providing evidence where possible, and email it to: MaritimeTDPConsultation@dft.gov.uk.

Alternatively send by post to:

> Call for evidence on shore power
> Maritime Environment, Technology and International Division, Maritime Directorate,
> Department for Transport, Zone 1-5, Floor 4,
> Great Minster House,
> 33 Horseferry Road,
> London, SW1P 4DR

Closing date is 25 April 2022.

You

1. **Your contact details (used for contact purposes only):**

Simon Bullock, Tyndall Centre for Climate Change Research, simon.bullock@manchester.ac.uk

Marlene Mitchell, Aberdeen Harbour Board, m-mitchell@aberdeen-harbour.co.uk

Eliott Higgins, Buro Happold, eliott.higgins@burohappold.com

2. **Are you responding:**

This is a joint response from Aberdeen Harbour Board, Buro Happold and the Tyndall Centre for Climate Change Research at the University of Manchester, based on results from the Outline Business Case developed for a shore power demonstrator project at Aberdeen Harbour, funded via the Clean Maritime Demonstration Competition. The response does not cover all questions and focuses on questions where results from the Aberdeen case-study are most applicable. Non-response questions are marked "n/a".

Business Organisation

3. **What is the name of your organisation?**

- Aberdeen Harbour Board
- Buro Happold Ltd
- Tyndall Centre for Climate Change Research, University of Manchester

4. **How many people does your organisation represent?**

- Aberdeen Harbour Board – 50-249 people
- Buro Happold – 250 or more people
- Tyndall Centre – 50-249 people

5. **What industry or sector is your organisation from?**

- Aberdeen Harbour Board - Ports
- Buro Happold – Engineering Consultancy
- Tyndall Centre - Academia

6. **Where is your organisation based? (please specify town, region and country).**

- Aberdeen Harbour Board - Aberdeen
- Buro Happold - Bath, London, Leeds, Manchester, Edinburgh (Worldwide offices also)
- Tyndall Centre - Manchester

7. **What is your role in the organisation? (Please state your role).**

- Marlene Mitchell, Commercial Manager, Aberdeen Harbour Board
- Simon Bullock, Research Associate, Tyndall Manchester
- Eliott Higgins, Energy Engineer, Buro Happold

8. **Can you provide any evidence to quantify the current level of GHG and air pollutant emissions from vessels at berth in UK ports? Please disaggregate this information as much as possible (e.g. to cover different ports and vessel types and operational and idle vessels).**

   The recent Demonstrator project study for Aberdeen Harbour as part of the Clean Maritime Demonstration Competition found that 78% of the carbon dioxide (CO_2) emissions in Aberdeen Harbour came from vessels at berth (equivalent to electricity consumption of 53 GWh/yr), with vessels in transit within the port boundaries emitting 17%, and the port's own electricity and gas use just 3%.

9. **In your opinion, which technologies and fuels can contribute to reducing vessel emissions at berth and what are their costs, benefits and level of technology readiness? Please include both on-board and land side technologies (e.g. storage) where relevant.**

Shore power reduces local air pollution from vessels at berth to near-zero. Because the UK electricity grid carbon intensity is low, and the Scottish grid carbon intensity is very low, shore power in the UK/Scotland also offers major carbon dioxide (CO_2) reduction benefits compared with the use of ship's marine fuel oil to generate electricity. Shore power is also an option which is deployable now, unlike other potential options, for example the use of fuels such as hydrogen. Landside and on-board costs are bespoke to the size and context of port and vessel so cannot be easily normalised. A key variable will be any upstream grid reinforcement that may be needed but there are solutions to mitigate traditional grid reinforcement approaches, e.g. through the use of battery storage. There is an existing supply chain (with various suppliers) in the UK which offer a range of equipment which is at a high level of TRL.

Additional technologies and fuels that may be considered include:

- Hybrid / Battery Storage – installation of battery systems on ships to enable energy storage to reduce fuel costs, maintenance as well as emissions; Can remove need to run engines in port and can take advantage of grid renewable power, if available.

  Readiness Level: Available now

- Biofuels – alternative fuel source that is biodegradable, non-toxic and essentially free of sulphur and aromatics however there are barriers including feedstock availability and current costs for biofuels, and wider sustainability and carbon concerns.

- Hydrogen[1] – produced via electrolysis, hydrogen has the potential to be a readily available marine fuel, offsetting pollutants in port. Still significant knowledge gaps in terms of safety aspects associated with handling, storage and bunkering of hydrogen in ports.

  Readiness Level: Est. 5-10 years

- Grid Renewable Power – green grid power will offset pollutants from other fossil fuelled plant in ports, and can be utilised to support the introduction of other emissions reducing solutions such as shore power.

  Readiness Level: Available now

- LNG – alternative fuel source which supports NOx and SOx reductions, but LNG offers low CO_2 improvements at best and is still considered a high carbon fuel .

  Readiness Level: Available now

10. In your opinion, what impact would shore power have in reducing emissions at berth for (a) different vessel types and (b) different locations in the UK? Could shore power have any other positive or negative environmental impacts (e.g. any impacts on marine pollution)? Please quantify and disaggregate your responses as much as possible.

The biggest benefits from shore power are derived from frequent-visit vessels with high power demands and long stays. Berthing data analysis in Aberdeen suggests that the three categories of vessel which best fit this profile are Multi-Purpose Supply Vessels (MPSV), Dive Support Vessels, and passenger ferries. This picture will obviously vary greatly at other ports, where it is likely that other vessel types would be priorities, for example cruise or container vessels.

Shore power solutions result in cleaner air, lower CO_2 emissions and reduced noise pollution.

[1] And also hydrogen-based products such as ammonia and Liquid Organic Hydrogen Carriers (LOHCs)

11. **In your opinion, what are the key (a) barriers and (b) incentives for ship owner, ship operators and ports to invest in shore power?**

The key incentive for Aberdeen to invest in shore power is that it cuts CO_2 emissions, and reduces air and noise pollution in the harbour and surrounding city. Vessels at berth contribute 78% of the CO_2 emissions in the port, with vessels manoeuvring contributing 19%, and use of electricity and gas on the port estate just 3%. The societal cost of emissions from vessels at berth is £14m a year.

Addressing emissions at berth is therefore the priority focus for the port to contribute to Scottish and UK objectives on climate change and air quality. Shore power is the leading option to reduce emissions from vessels at berth. Providing shore power capability also futureproofs the port for likely increases in the use of hybrid or fully electric vessels in the medium-term; these vessels will require battery recharging.

The key barriers to shore power are economic. It is a well-established and technically feasible solution. But capital costs for ports are high. In a default position, these costs would need to be recouped through electricity sales. However, this is difficult because economic incentives are currently misaligned: less polluting grid electricity is highly taxed, very polluting marine fuel oils are untaxed. This means it is cheaper for ships to use oil on board to produce electricity than to be supplied from the grid, and consequently ports struggle to recover their capital costs through applying a premium on the electricity they sell to vessels. These problems are addressed in other countries by the provision of both capital funding from Government, and by addressing market failures through reducing taxation on grid electricity (see responses to question 26 and 27).

12. **Can you provide estimates of the costs and benefits for any current or future shore power projects in the UK, including emission savings, costs of infrastructure at ports and costs of any upgrades to existing network connections and any reinforcements required to the electricity network? If possible, please provide estimates of cost recovery periods for these projects and estimates of the associated increases in electricity demand?**

We stress that the numbers which follow, based on Aberdeen, should not be used to infer broader costs and benefits in the UK of a widespread roll-out of shore power. This is because projects in other locations will have markedly different circumstances, costs and benefits. This demonstrator project focuses on a specific location within Aberdeen Harbour, where a number of factors combine to suggest good potential viability for shore power. These include lack of requirement for major electricity grid reinforcements, high potential demand for electricity from frequent, long-stay vessels, and strong interest in shore power from vessel operators.

The project focuses on provision of shore power at seven berths at the Albert and Mearns Quays on the Point Law Peninsula at Aberdeen Harbour. These berths are predominantly used by Multi-Purpose Supply Vessels (MPSVs) operated by Energy companies. These vessels typically use 250 kW of electricity at berth, with average stays of 12 hours.

The proposed project involves a centralised shore power system at 690V delivering power to seven quayside connection points, using mobile cable reels to minimise constraints on dockside crane operations. It involves frequency conversion, an 11kV to 690V transformer, and provision of a 3500kVA system overall.

The baseline capital cost estimates for the project are £8m. This cost is broken down in the table below:

Cost element	Detail	£k
Shore power unit	Centralised unit, outlet points, transformer, frequency converter, groundworks	2750
Cable management	7x cable reel systems	680
Port side connection	7x port side connection boxes	250
Low voltage network costs	Trenching, duct and cable work around quayside	1840
Network ancillary equipment	Cable protection systems	140
Cable storage building	8m by 8m steel structure with insulated cladding	1440
Electricals	Upgrade to existing DNO mains electrical system	200
Additional costs	Main contractor site set up and management, Main contractor overheads/profit, contingency, design fees	2000
Total		**8000**

Multiple sensitivities to these figures are set out in the detailed Outline Business Case (OBC) report which will be submitted to DfT as a core output to the CMDC.

Cost recovery for the port is via sales of electricity to ship operators, and is dependent on multiple factors, including the price of purchased electricity, the level of demand from ships, and the premium applied to grid electricity when sold to ship operators.

Assuming 50% Government grant funding, grid electricity at £150/MWh, a 20-year project lifetime, phased uptake of shore power by ship operators, a shore power premium of £114/MWh would deliver a total nominal equity IRR of 9%.

Varying the assumptions on grant funding and required IRR changes the required shore power premium. Ensuring this premium is not so high as to dissuade ship operators from using shore power is a critical issue for project viability and is covered in our response to question 27 below.

The project would reduce carbon dioxide emissions by on average 3,100 tonnes per year, and also reduce local air pollutants. Using Government values for CO_2 and air pollutant costs, the project provides a discounted social benefit of £20m over the project lifetime, more than double the project's estimated capex costs.

13. **Can you provide estimates of the total overall costs and benefits if shore power is taken-up commercially at scale across the UK, including the overall emission savings and electricity demand? Please disaggregate these estimates across different locations, if possible?**

- n/a

14. **Are you aware of any shore power installation projects underway in the UK? If so, please provide as much detail as possible?**

Port of Southampton has recently completed the installation of a shore power facility for cruise ships at the port's Horizon Cruise Terminal and Mayflower Cruise Terminal enabling zero emissions at berth. The project was completed at a cost of ~£9m, supported by a grant from the Solent Local Growth Deal which was arranged through the Solent Local Enterprise Partnership (LEP).

15. **Do you think Government coordinated guidance would be a helpful tool for ports and other operators to navigate the complexity of shore power projects? If so, which topics should be included to maximise the value of such a document?**

Given the global nature of the maritime sector, coordinated guidance at a regional, national, and international level would be the optimal way ahead, and would support ports and port users (ship owners/operators) in strategic decision making processes.

Currently there are a number of challenges: grid connectivity, frequency conversion, a lack of public funding, the uncertainty of utilisation and the price difference between marine fuels and electricity. These are compounded by varying circumstances across ports. Coordinated guidance is needed on how to address these challenges to implementation, with an aim of supporting a cohesive and consistent shore power network.

16. **In your opinion, how could government's coordinating function be deployed to accelerate collaboration across the maritime sector to facilitate shore power projects? Can you please provide examples?**

- n/a

17. **In your opinion, does future revenue uncertainty represent a significant barrier to investment in infrastructure for shore power? Please explain your answer.**

Yes. The OBC for Aberdeen clearly highlights that demand for shore power is a critical determinant for the project's financial viability. If shore power is too expensive, ship operators will not use it, demand will fall, weakening overall project economics. See response to question 27 for further detail.

18. **Can you provide examples of innovative commercial finance models that might help de-risk port investment in shore power infrastructure? Please include as much detail as possible.**

Similar to any energy supply system, there are various commercial models which can be applied dependent on availability of capital, investment appetite, associated risk with long term energy supply and the ability and desire for different organisations/ stakeholders to procure, own, operate and maintain equipment, as well as administrating and billing for consumers. In the case of Aberdeen different models were assessed across a spectrum following some commercial models from other deregulated energy systems, e.g. district heating and private wire. More information is provided in the OBC.

Questions. Please provide evidence to support your response.

19. **Do you have any other views on the potential of Government's coordinating function in supporting the uptake of shore power?**

Given the ambitions of the Government as set out in the Clean Maritime Plan it is essential that there is a strong level of support and coordination from the UK Government. Shore power projects help the Government deliver on its air quality and climate change objectives.

Successful shore power projects in other countries have only been able to proceed with government support in the form of grants and/or subsidies for capital investment as well as reductions in electricity taxes to ensure shore power offers a clear economic and environmental solution for ports and vessel owners/operators alike.

Policy needs to ensure the correct framework is in place to enable the deployment of shore power solutions on a wider scale to reduce emissions in ports and support further greening of the maritime sector as a whole. And to maximise the opportunity, consideration should be given to harmonisation between EU and UK policy.

The Government's coordinating function in the short term should be to prioritise policy and funding support to enable strong shore power projects with high social benefits to become financially viable.

20. **Do you have any other views on the potential of Government's coordinating function in supporting the uptake of shore power?**

- n/a

21. **In your view, what would the impacts of a mandate on vessels to use shore power while at berth be on (a) ship owners (b) ship operators (c) UK ports and (d) the wider UK economy?**

- n/a

22. **Do you think that any mandate on vessels to use shore power while at berth in the UK should be accompanied by a mandate on ports to install the related shore power infrastructure? Please explain your answer.**

- n/a

23. **In your view, what would the impacts of a mandate on port operators to install shore power infrastructure be on (a) ship owners (b) ship operators (c) UK ports, (d) energy network operators, and (e) the wider UK economy?**

The costs of shore power provision will vary greatly between ports. Some ports would require considerable grid reinforcement, others very little. A mandate on ports is likely therefore to have very uneven effects. Without policy support on both provision of capital funding and on reducing taxation of electricity, a mandate on ports is likely to incur very large costs on some ports, which they have little chance of recouping. Our response recommends therefore that the Government focus in the short term is on policy instruments to reduce electricity taxation, and on provision of capital funding support – see response to questions 26 and 27. In the medium term, a form of mandate on ports and vessels, with very careful design, could complement these funding and tax measures to drive greater shore power deployment. Any such mandate should be based around zero emissions, rather than shore power specifically, to allow for the most cost-effective solutions to be deployed, depending on port and ship circumstances.

24. **In your view, what would the impacts of a mandate that all vessels are "shore power capable" by design be on (a) ship owners (b) ship operators (c) UK ports and (d) the wider UK economy?**

- n/a

25. **Do you have any other views on the potential implications of Government mandates, or any other regulatory intervention, to support the take-up of shore power? Please include evidence where possible, including references to international case studies where relevant.**

- n/a

26. **Are you aware of economic instruments deployed internationally to address emissions at berth? If so, please provide details, including their cost and environmental impacts.**

A rising carbon price applied to marine fuel oils would enable shore power to compete fairly against fossil fuels. But there has been little progress on putting a carbon price on marine fuels internationally in the last decade, and there is no guarantee progress will occur in the near future. Before then, and in the absence of carbon pricing, national policy change on electricity taxes and support on capital funding are both necessary for shore-power projects to be a viable business proposition in the UK, as is the case in other countries.

No shore power project has proceeded globally without national or regional government funding. Research by the British Ports Association has compiled funding details for around 100 shore-power projects globally – the overwhelming majority have received between 50% and 80% funding support.

On taxation, between 2014 and 2021, Germany, France, Denmark, Italy, Sweden and The Netherlands have successfully applied to the EU for exemptions to the Energy Tax Directive, to allow shore power taxation to be reduced to the lowest level (0.5 Euros/MWh). The most recent EU Parliament text for amendments to the Energy Tax Directive looks likely to make these exemptions permanent, and extend them to all EU member states - it contains the provision that member states "*shall exempt electricity directly supplied to vessels berthed in ports*". In contrast, UK shore power electricity faces environmental taxation of around £50/MWh, despite it being far less polluting than electricity from its untaxed competitor – marine fuel oils.

27. **In your view, how could similar economic instruments be used in the UK to address emissions at berth? What would the impacts be on (a) ship owners (b) ship operators (c) UK ports and (d) the wider UK economy?**

Ports need to apply a premium to the price of the grid electricity they purchase from the grid, so as to recoup their capital and operational costs. The required level of this premium depends on multiple factors, the main ones being the required Internal Rate of Return (IRR), capital costs, the % of capital funding provided by Government or other outside entities, and the number of MWh of electricity sold.

This section provides quantitative data regarding these factors, from the business case developed for Aberdeen's Clean Maritime Demonstration Competition demonstrator project. It is split into two parts – first, the level of premium required to be charged to the ship operator by the port operator, on top of the price the port operator pays for grid electricity. Second, what level of shore power price might be acceptable for the ship operator to pay?

1. *Required premium for port operators*

Using data from the demonstrator project, we present ranges of the necessary premium on top of the grid electricity price, to deliver a given IRR for the port, under different assumptions for the % capital funding provided by Government:

Premium in £/MWh	% Government grant funding			
	25%	50%	75%	100%
6% IRR	123	92	61	29
9% IRR	156	114	72	30
12% IRR	194	139	85	32

From the above table, if the grid electricity price to the port was £150/MWh, the price to the ship operator for a 9% IRR with 50% grant funding would be £150+£114 = £264/MWh.

2. *The level of shore power price acceptable to ship operators*

The premium, and therefore the total price to ship operators, cannot be too high, or ship operators would simply not use shore power, and rely on cheaper electricity produced from ship's fuel.

A critical issue therefore is the interplay between three prices: grid electricity, the port's required premium, and the cost of marine fuel oil (the latter determining the cost of electricity supplied by the ship's engines). This interplay is made more complex by the highly volatile nature of marine fuel oil prices, and to a lesser extent the volatility in grid electricity prices. For example, marine fuel oil has seen a nine-fold variation in price in the last two years[2], with a high of $1647/t and a low of $176/t.

Despite this volatility, there is consistency in that in the last two years marine fuel oil has been consistently cheaper than UK grid electricity, in the range of £40-90/MWh[3]. So, at present, from the ship operator perspective, it would not be attractive to pay a large premium on top of shore power already being more expensive than electricity from its own fuel oils. And if ship operators baulk at high prices and do not use shore power, then demand falls, which further weakens project economics, raising the required premium further, making the project even less attractive to the ship operator – a vicious circle. Sensitivity analysis for the project highlights that high consumer demand is crucial to project economics: decreasing power demand by 30% increases the required premium by a further £43/MWh (40%).

To make projects viable therefore requires action to reduce the required premium, reduce the price of grid electricity, and/or increase the price of marine fuel oils. The latter is not a feasible short-term option, given that such matters are decided at the international level, and the prospect of a carbon price sufficient to make a material difference to project economics here seems many years away.

However, the Government can act on the other two factors.

First, grant funding is essential to reduce the level of required premium, as per the table above.

Second, the current tax treatment for the different sources of electricity used by ships is highly perverse, and is in urgent need of reform. Grid electricity faces taxes of around £50/MWh (Contracts of Difference, Renewables Obligation, Feed-in tariff and Climate Change Levy), and is very low carbon. Electricity from ship's marine diesel oil is untaxed by global convention, is very high carbon, and pollutes the local environment. These incentives are the wrong way round. The UK can start to address this market failure by removing environmental taxes from grid electricity used by ships, as

[2] https://shipandbunker.com/prices/emea/nwe/nl-rtm-rotterdam#_MGO
3 See https://www.gov.uk/government/statistical-data-sets/gas-and-electricity-prices-in-the-non-domestic-sector for grid electricity prices, shipandbunker.com for ship fuel prices, with standard conversion factors.

other countries have done. We note that a precedent exists for this in the UK – the exemption for Energy Intensive Industries from 85% of their Contracts for Difference, Renewables Obligation and Feed-in-tariff costs[4].

With tax exemptions for shore-power to reduce the gap between grid electricity and ship' fuel electricity, and capital grant funding, the overall price to ship operators can become viable.

As an example, assuming grid electricity prices of £150/MWh, and ship electricity prices of £110/MWh, then with Government funding of 75%, and a 9% IRR - requiring a premium of £72/MWh - and a removal of £50/MWh of taxes/charges related to environmental and social policies[5], Aberdeen could provide shore-power at (150-50+72)= £172/MWh. This is higher than the assumed price for ship grid electricity, but within the range that vessels have been paying for ship-provided electricity in recent months.

9% IRR is lower than is standard for port infrastructure projects in the UK. Consequently, we note that such an approach or similar involves a stake from all main stakeholders - port, ship operator and Government. Ports are taking lower IRR, ships are paying a greater price, Government is providing financial and policy support. This collaborative approach would unlock the high net societal benefits that this shore power project can deliver.

Overall, we believe that in time shore power projects will become financially viable, if the international community introduces a strong global carbon price in the maritime sector. However, it is not acceptable to wait for international carbon pricing to make shore power project economics viable – these projects can deliver net societal benefits now. Ports and ship operators can work together to improve project economics, but this on its own is not enough. Government policy support on both capital funding and tax is essential to unlock shore power's benefits.

Wider questions. Please provide evidence to support your response.

28. **In your view, which alternative levers, including economic instruments, would support the commercial take-up of shore power in the UK? Please provide as much detail as possible, including on potential impacts.**

As set out in response to questions 26 and 27, we believe that Government capital funding support, and action to reduce electricity taxation, are the priority interventions to increase deployment of shore power in the UK.

29. **In your opinion, what uptake of shore power do you expect in the UK between now and 2050, in the absence of further Government intervention?**

Without funding support and action to correct market failures, uptake of shore power in the UK will be very limited.

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4 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/942616/CFD_RO_FIT_Exemption_Guidance_Revised_December_2020.pdf

5 Medium industrial electricity consumer (2,000-19,999 MWh/yr), value includes any taxes or charges relating to environmental or social policies but excludes VAT. BEIS https://www.gov.uk/government/statistical-data-sets/international-industrial-energy-prices, table 5.4.1 and 5.4.2, difference = £52/MWh, June-Dec 2021, latest data available as of April 2022.

30. **Do you have any other information or evidence that you would like to submit as part of your consultation response?**

- n/a

Final Comments

Any other comments?

Deployment of shore power would help the Government meet its air quality and climate change objectives. The outline business case for shore power at Aberdeen demonstrates clear societal benefits. But because of high capital costs, and market distortions in the way high carbon and low carbon electricity are currently taxed, shore power projects will struggle to be financially viable. In the short-term, strong shore power projects can be delivered if there is government support on funding, combined with via exemptions from taxes on electricity, as in other countries. In the medium term, action on carbon pricing for marine fuel oils, and carefully designed mandates on zero emissions standards in berths and ports, could drive wider deployment.