INSIGHT BRIEF

How EU Contracts for Difference can support zero-emission fuels

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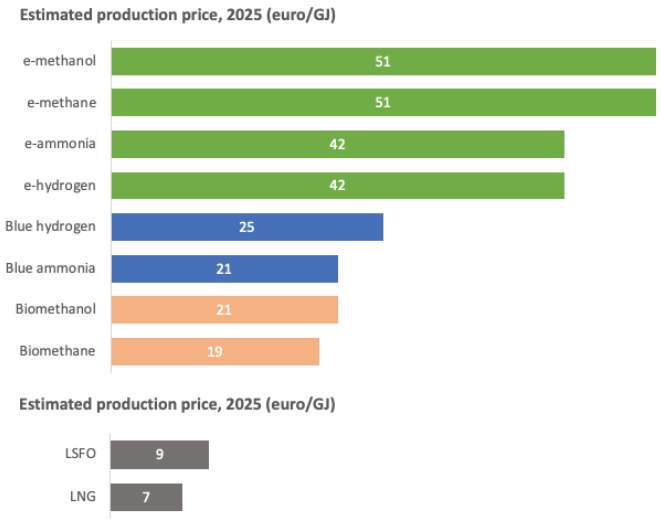
Introduction

The European Union (EU) is introducing new regulation to reduce GHG intensity and emissions from the shipping industry under the 'Fit for 55' package to achieve the decarbonization goals set out in the European Green Deal.

A previous Insight Brief[1] recommends that 'Fit for 55' should be designed and implemented with a target of having commercially viable zero-emission vessels operating along deep-sea trade routes by 2030, with at least five per cent scalable zero-emission fuels[2] (SZEFs) in international shipping, in line with the messages of the Call to Action for Shipping Decarbonization launched in the lead up to COP26.

A key barrier to achieving these targets is the significant competitiveness gap that exists between fossil fuels and zero-emission fuels (shown in Figure 1 below). The inclusion of shipping in the EU Emissions Trading System (ETS) will result in a reduction to the cost gap between SZEFs and fossil fuels. However, the expected ETS prices will be insufficient to create price parity with traditional fuels,[3] which means that a significant cost gap will remain due to SZEF production technologies still being in their emergence phase[4]. SZEFs are currently produced at low volumes and high costs, whereas fossil fuels have well-established technologies, supply chains and economies of scale which allow for low-cost production at high volumes.[5]

Figure 1: Fuel price estimates for common shipping fuels and zero-emission alternatives[6]



Source: *Adapted from the Mærsk Mc-Kinney Moller Center for Zero Carbon Shipping Industry Transition Strategy*

Therefore, in addition to putting a price on emissions from fossil fuels, the EU ETS should be complemented by support mechanisms that will reinvest a portion of shipping related ETS revenues into incentives for the production and use of SZEFs. This will drive down the cost of SZEFs, in a similar way to programs that supported renewable electricity such as wind and solar as explained by University of Oxford researchers in a June 2021 report.[7]

This Insight Brief outlines how the EU could use a portion of shipping related ETS revenues to fund a program of targeted Contracts for Difference (CfDs) to incentivize private investment into the production and use of SZEFs[8]. A CfD program that supports at least five per cent SZEFs in EU shipping would cost an estimated 1.2 billion euro annually.[9] This can comfortably be funded using shipping related ETS revenues which are estimated at 5 to 9 billion euro annually depending on the ETS price.[10] This strategy of carbon pricing combined with the reinvestment of revenues through CfDs could also provide a useful template for other regions and for eventual global action through the International Maritime Organization (IMO).

A CfD program should target different SZEFs in separation from each other to account for the fact that different fuels are at different stages of their development cycles. For example, hydrogen derived fuels currently have a cost disadvantage but have long-term scale advantages which are likely to make them the cheapest in the long-term. Moreover, upscaling hydrogen infrastructure may have benefits outside of the shipping sector which could improve energy security and ensure diversity of supply. Higher availability and lower costs for green hydrogen can also accelerate the decarbonization of other harder-to-abate sectors such as steel and aviation.

Other CfD programs provide useful lessons for overcoming the challenge of how to support technologies at different development stages. CfD programs often separate funding incentives into targeted groups of ‘established’ and ‘less-established’ technologies.[11]

Contracts for Difference can de-risk zero-emission shipping's first movers and lower costs for the shipping transition

Researchers from the University of Oxford have proposed a method through which CfDs can support shipping decarbonization, similar to how CfDs have been used by the UK and other governments to bring down the costs of renewable electricity generation. The main purpose of a CfD is to close the cost gap between an old technology and a high-potential new technology in the short term, until the new technology becomes competitive. Long-term competitiveness will be driven by technology learnings, scaling effects, and in the case of SZEFs the introduction of regulation to price externalities such as GHG emissions.

CONTRACTS FOR DIFFERENCE[12]

A CfD mitigates the market risks faced by suppliers of a new, high-cost commodity by paying the supplier the difference between a predetermined reference price reflecting the old technology (in this case, the cost of conventional shipping fuel) and a 'strike price' set at the value required for the new technology to be viable.

The strike price can be determined either administratively or through a competitive auction, in which bidders submit prices and the lowest bid(s) is awarded the contract, subject to meeting specified conditions. When the reference price is lower than the strike price, the supplier is paid the difference. This ensures that the supplier receives a guaranteed minimum price for the duration of the CfD. In most CfD mechanisms, if the reference price exceeds the strike price, the supplier repays the subsidy (support payment). (Clark, et al. 2021, p.39).

CfDs would allow the EU to subsidize the difference between what it costs to produce SZEFs (strike price) and the price at which SZEFs can be sold to energy users (reference price).

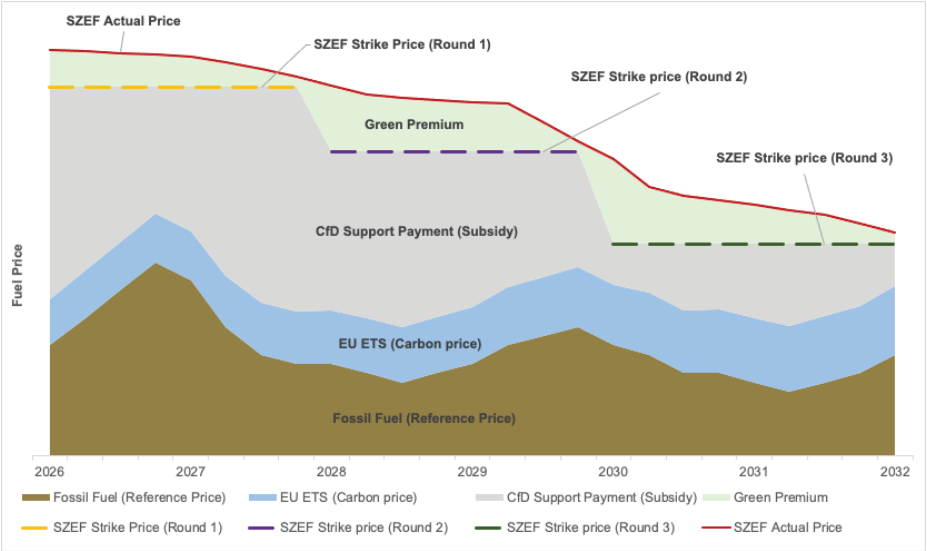
Since subsidies are only paid to the private sector when there is a difference between the strike price and the market reference price, the EU would not be required to pay subsidies if factors such as oil price volatility suddenly made SZEFs competitive with fossil fuels. In designing the CfD program, the EU could also put in place safeguards to limit the value of subsidies that can be paid if the reference price were to drop significantly.

Experience from renewable energy CfD programs suggests that to accommodate future price changes for fossil fuels and SZEFs, the CFD program should include multiple rounds staggered over several years. This would allow the EU to adjust the program as technologies develop, SZEF production costs come down and markets change.

Figure 2 shows the components of a zero-emission shipping investment decision under a CfD program. When making a strike price bid, a shipping operator will calculate the cost of fossil fuel (brown area) plus the cost of the EU ETS carbon price (blue area). The

shipping operator will then compare this fossil fuel cost to the SZEF costs (the red line). Importantly, not all additional costs related to SZEFs will need to be covered by the CfD support payment (the grey area),[13] because a portion of additional costs can be passed through to customers as a green premium (the green area).[14] The example in Figure 2 shows three successive rounds of CfDs, with the SZEF strike price (yellow, purple and green dotted lines) decreasing with each CfD contract round.

Figure 2: Example of a fuel-only Contracts for Difference mechanism



A CfD model for the shipping industry would most likely focus on the cost of fuels,[15] with ship operators directly receiving government subsidies for the cost difference between the strike price for SZEFs and fossil fuels. In turn, ship operators would sign offtake agreements with fuel producers based on this fixed strike price.[16]

A fixed strike price means that fuel producer revenues would also be fixed (with the potential for some revenue enhancement through 'green premiums' paid by customers). Therefore, regardless of market dynamics, fuel producers will be driven to reduce costs to improve profits. This will likely result in a virtuous cycle, where optimisation drives fuel prices down, which in turn lowers the cost of the shipping industry's energy transition. Subsequent CfD rounds are likely to have lower support levels, as future CfD bidding will likely occur at lower strike prices.

This virtuous cycle was clearly demonstrated by three successive rounds of CfD auctions for offshore wind administered by the UK Government, which saw the strike price for offshore wind reduce to a third of its original value, ending at a price below that of baseload electricity (see Figure 3 below).

Figure 3: The UK Offshore Wind strike price from three successive rounds of CfD reverse auctions compared to the current baseload electricity price[17]

Contracts for Difference should target Green Corridor projects to leverage funds most effectively

Zero-emission shipping is currently in its 'emergence' phase, with over 200 projects[18] already underway across the globe demonstrating the technologies and business models needed to decarbonize the shipping industry. For zero-emission shipping to move into a 'diffusion' phase of rapid uptake, at least five per cent of the fuels used in international shipping must be SZEFs by 2030. In the EU context, this would require approximately 11 GW of electrolysis capacity[19] if it was based on green hydrogen and green hydrogen derived fuels alone.[20] This would save circa 2.7 million tonnes of Heavy Fuel Oil (HFO) per year by 2030.[21] The required electrolysis capacity can be achieved comfortably in the context of announced global capacity as of the second half of 2021[22] (see Table 1 below) and the EU Hydrogen Strategy which targets 40 GW of electrolysis capacity in Europe by 2030.[23]

Table 1: Electrolyzer capacity requirements and availability[24]

	2026	2027	2028	2029	2030
Electrolyzer capacity needed for EU Shipping (GWe)	2.2	4.4	6.6	8.8	11.0
Global electrolyzer capacity available (GWe)	22.2	30.8	38.3	45.0	61.9

Achieving this 2030 target and scaling the initial demonstration efforts into industry-wide solutions will be challenging due to the diverse and complex nature of the global shipping industry. This is where the establishment of Green Corridors to promote zero-emission shipping can play a role. A Green Corridor is a shipping route on which technological, economic, and regulatory feasibility of zero-emission shipping is supported by public and private actions. Several EU member states have already committed to support Green Corridors by signing the Clydebank Declaration.[25]

A CfD program aimed at supporting Green Corridors is an effective way to leverage ETS funding to maximize GHG emission reductions,

because the financial incentives provided by CfDs can be combined with targeted action across other barriers such as policy, regulation, safety measures, and infrastructure requirements. Targeted action that addresses each of the barriers to zero-emission shipping, can create a favourable ecosystem on a specific route, with the learnings from that route having beneficial spill over effects to the broader industry and in some cases to other harder-to-abate sectors. In this way the EU can use CfDs to accelerate shipping's broader energy transition through targeted funding support.

In fact, a program of CfDs to support the required amount of fuel to reach five per cent SZEFs by 2030 would cost around 1.2 billion euro per year,[26] which would easily be covered by shipping related ETS revenues. Based on the current proposal to include shipping in the EU ETS, the EU would generate 5 billion euro per year if carbon prices were kept at 50 euro per tonne and as much as 9 billion euro if the carbon price increases to 87 euro per tonne in 2030.[27]

THE EU SHOULD SELECT GREEN CORRIDORS BASED ON IMPACT AND FEASIBILITY

An overarching criterion for selecting a Green Corridor is that it provides sufficient scale and volume for impact: it must be large enough to include all the essential value-chain actors needed to scale zero-emission shipping, including fuel producers, vessel operators, cargo owners, and regulatory authorities. A Green Corridor must also have potential for large-scale GHG emission reductions, so that it generates real impact on the shipping sector's decarbonization goals. Moreover, a Green Corridor must also be feasible, which can be assessed based on the four critical building blocks described below:

1. Cross-value-chain collaboration: Stakeholders that are committed to decarbonization and are willing to explore new forms of cross-value-chain collaboration to enable zero-emission shipping from both the demand and supply side.

2. A viable fuel pathway: Availability of zero-emission fuels, along with bunkering infrastructure to service zero-emission vessels.

3. Customer demand: Conditions need to be in place to mobilize demand for green shipping and to scale zero-emission shipping on the corridor.

4. Policy and regulation: Policy incentives and regulations to narrow the cost gap and expedite safety measures.

The EU should target each segment of the shipping industry individually

In identifying Green Corridors, the EU should seek to target a diverse set of shipping segments including container ships, bulk carriers, tankers, international ferries, and cruise ships. The international shipping market is made up of several sub-markets, each with their own prices and economic incentives. Through specific Green

Corridors, CfDs can be designed to provide separate opportunities for major parts of the industry. Without separate CfD programs, shipping segments with high value cargo and ability to pass on a greater portion of extra costs to customers would benefit disproportionately more than others because they could bid at more competitive strike prices.

Different SZEFs, such as ammonia, hydrogen, methanol, and synthetic LNG, may also be more suitable for different segments of the shipping industry, which is another important factor to consider in designing a CfD program.

Cross-subsidization between segments of the shipping industry can also be avoided by the EU ensuring that CfDs in each shipping segment are funded in proportion to the ETS revenues received from that segment (i.e., so container ETS revenues fund container CfDs).

Regardless of the segmentation, supporting Green Corridor projects in specific shipping segments is also likely to result in spill-over benefits for other routes and segments from a fuel production, ship technology and infrastructure perspective. For example, a CfD that incentivizes the use of SZEFs on an international route, will create an opportunity for the development of bunkering infrastructure at large ports, such as storage tanks and vessels for refuelling purposes[28]. This bunkering infrastructure could then also be used for feeder container routes within the EU.

Examples of possible container, bulk carrier and regional ferry Green Corridors are described below. These examples were chosen to illustrate how this CfD program may work and are by no means an exhaustive or prioritized list. National and regional stakeholders will undoubtedly be able to identify other promising routes.

The Asia-Europe container route

The Getting to Zero Coalition report, The Next Wave: Green Corridors outlines results from a pre-feasibility study into the Asia-Europe container route (See Figure 4). This route possesses all the critical building blocks for a Green Corridor, starting with the fact that it currently generates approximately 22 million tonnes of CO2 emissions annually[29] – more than any other single global trading route.

Figure 4: The Asia-Europe container route

The analysis of the Asia-Europe container route also provides an indication of the potential funding levels required to decarbonize the route. There could be as many as 50 new-build zero-emission vessels deployed on the route by 2030,[30] which is roughly 17 per cent of container capacity.[31] While 12 billion euro in capital expenditure is required by 2030[32] on the route to support these vessels,[33] the total cost of ownership for a zero-emission vessel is expected to be only 25 per cent[34] more expensive than fossil fuel powered vessels once shipping has been integrated into the EU ETS.

A CfD program covering the fuel cost difference for 50 zero-emission vessels by 2030 is estimated to require funding of 420 to 600 million euro annually.[35] This cost would be more than covered by the carbon revenues generated through the EU ETS on just this route – calculated to be in the range of 1.5 to 2.1 billion euro annually.[36]

South Africa-Europe- bulk carrier route

A bulk carrier route to be considered for CfD support could be the South Africa to Europe iron-ore route. In 2020, approximately 12.1 million tonnes of iron ore were exported from South Africa to Europe, with the majority being imported by The Netherlands (4.9 million tonnes) and Germany (4 million tonnes).[37]

Despite the route requiring multiple stops at different ports, a green corridor can be created with fuel infrastructure in South Africa and policy/regulatory measures coordinated between South Africa and the EU. Indeed, the relationship built between the EU (and especially Germany) and South Africa through the Just Energy Transition Partnership[38] could serve as the foundation for establishing a Green Corridor backed by CfDs. Support for zero-emission shipping in countries outside of the EU would also be a fair reflection of the fact that part of the revenues received under the proposed EU ETS would come from extra European Economic Area shipping activity, therefore CfD support outside of Europe would not represent EU tax leakage.

The investment requirements for the route would be less than the Asia-Europe corridor. Approximately 15 zero-emission vessels would be needed to fully service the route each year, with a corresponding capital expenditure requirement of circa 1.2 billion euro to support these vessels.[39] Implementing a CfD to cover the fuel cost difference for 15 zero-emission vessels on the route would cost between 110 to 140 million euro annually.[40]

European regional ferry routes

An EU CfD program could also target long-distance[41] regional ferries and cruise ships such as those that travel between the EU countries in the Baltic Sea region, from France and Spain to Ireland or those operating in the Mediterranean. These routes are an important segment of the EU shipping industry and have the added benefit of helping to raise awareness of the potential for green shipping in the general population since they provide passenger services. For example, decarbonizing the Baltic ferry routes could result in CO2 emission savings of more than 600,000 tonnes annually[42].

The decarbonization of ferries may require a specialized type of CfD program compared to other shipping segments. In some respects, the decarbonization of regional ferries is an easier undertaking than for intercontinental cargo routes. The relatively shorter journeys taken by ferries mean a wider range of zero-emission technologies are available, while the higher margins and proximity to the end-customer mean more costs can be passed through as green premiums. Despite these lower operational costs (OPEX), in switching to SZEFs, ferries are expected to face higher capital costs (CAPEX) as a proportion of total switching costs. Therefore, ferries may need a CfD program based on total cost of ownership rather than fuel costs alone.

Contracts for Difference could be administered by the EU and member states

Given that an EU CfD program would ideally target both long-distance international routes, as well as some regional routes, CfDs could be administered by both the EU and member states.

Long-distance international routes, such as the Asia to Europe container route and South Africa to Europe iron ore route involve numerous EU member states and will require collaboration with countries outside of the EU. So, for this type of route, the EU would be best placed to fund and administer a CfD program.

On intra-EU routes such as those taken by regional ferries, it may be more appropriate for CfDs to be administered at the country level with a partnership formed between two member states.

Conclusion

The inclusion of shipping into the EU ETS will make a small contribution to reducing the cost gap between SZEFs and fossil

fuels. However, a large cost gap will remain unless SZEF production technologies can be further refined and scaled to compete with well-established fossil fuels.

To refine SZEF technologies and to achieve the high production volumes required to bring prices down, incentive systems must be implemented to encourage demand and stimulate private investment. The EU can provide these incentives through a program of CfDs targeted at different segments of the shipping sector and a range of SZEFs.

Moreover, an EU CfD program should focus on potential green corridors that have high potential for emission reductions, combined with favourable characteristics such as cross value chain collaboration, customer demand, viable fuel pathways, and favourable policy/regulatory environments. Focusing on these corridors provides an effective way of leveraging EU funds to rapidly refine SZEF technologies, while also scaling production and use.

This CfD strategy would support the Getting to Zero Coalition goal of at least five per cent SZEFs in EU shipping by 2030 at an estimated cost of 1.2 billion euro annually.[43] Significantly, this sum could be funded with just a portion of shipping related ETS revenues, which are estimated at 5 to 9 billion euro annually depending on the ETS price.[44] The three Green Corridor CfD programs highlighted above would cover about half of the programs needed to ensure that the EU can lead international shipping's decarbonization transition.

The EU has a unique opportunity to catalyze the decarbonization of international shipping. To seize this opportunity, European policy makers should use the 'Fit for 55' package to stimulate the production and uptake of SZEFs by reinvesting a portion of shipping related ETS revenues into zero-emission shipping. This strategy could also provide a useful template for other regions and for eventual global action through the IMO. In this way, the EU can lead the transition to zero-emission shipping while positioning itself and its companies as the leaders of the hydrogen economy of the future.

Endnotes

1 Global Maritime Forum, *Insight Brief: How the EU can catalyze the global transition to zero-emission shipping and the green hydrogen economy*, March 2022

2 Scalable zero-emission fuels include hydrogen and hydrogen-derived fuels such as ammonia, e-methanol, and synthetic hydrocarbon fuels.

3 Parker, S., Shaw, A., Rojon, I., Smith, T. *Harnessing the EU ETS to reduce international shipping emissions: assessing the effectiveness of the proposed policy inclusion of shipping in the EU ETS to reduce international shipping emissions*, Environmental Defense Fund Europe, London, December 2021.

4 The SZEF emergence phase is characterized by a relatively high Technology Readiness Level (TRL) for most SZEFs, but Investment Readiness Levels (IRL) that are still in early stages. Detailed assessments of TRL and IRL have been completed by Lloyd's Register. Lloyd's Register, *Zero-Carbon Fuel Monitor Dashboard*, (accessed on 6 May 2022).

5 Sustainable biofuels also have the potential to significantly reduce the GHG emissions from shipping. As biofuels are more mature and are already in use as a marine fuel, the cost gap will be significantly smaller. Biofuels however are very unlikely to be available in sufficient quantities to cover the full fuel need of international shipping, which means SZEFs will be needed to decarbonize shipping. Further analysis can be found in (Energy Transitions Commission, *Bioresources Within a Net-Zero Emissions Economy: Making a Sustainable Approach Possible*, July 2021)

6 Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, *Industry Transition Strategy*, October 2021, p. 16 (Currency conversion from USD to euro is at 2021 average of 1 euro = 1.18 USD).

7 Oxford Smith School of Enterprise and the Environment, *Zero-Emissions Shipping: Contracts-for-difference as incentives for the decarbonisation of international shipping*, June 2021.

8 Funding for CfDs could also come from other sources such as the EU Innovation Fund. This may be of particular relevance if the EU intended to commence a CfD programme prior to ETS revenues from shipping being collected.

9 Energy Transitions Commission calculations. Assumptions include HFO Price of US$450/t and SZEF price of US$1300/tHFOe. See appendix for complete list of *assumptions*.

10 Parker, S., Shaw, A., Rojon, I., Smith, T. *Harnessing the EU ETS to reduce international shipping emissions: assessing the effectiveness of the proposed policy inclusion of shipping in the EU ETS to reduce international shipping emissions*, p. 31, Environmental Defense Fund Europe, London, December 2021.

11 Global Infrastructure Hub, *Case Study: Contracts for Difference (CfD) to accelerate electricity market reform and launch auctions for renewable energy*, November 2021.

12 Oxford Smith School of Enterprise and the Environment, *Zero-Emissions Shipping: Contracts-for-difference as incentives for the decarbonisation of international shipping*, p. 39, June 2021

13 When first examining the chart, readers may notice that the CfD Support Payment (grey area) is much larger than the EU ETS (blue area). This may lead to the conclusion that EU ETS revenues will be insufficient to cover payments under a CfD program. However, this is not the case since the chart demonstrates fuel prices rather than total costs or total revenue. Moreover, the CfD program only has to support five percent of fuels used in shipping, not the entire industry meaning that shipping related EU ETS revenues will be more than enough to cover payments under a CfD program.

14 Mærsk's Eco Delivery model is an example of how a green premium might be passed through to customers. *Mærsk Eco Delivery* is a carbon reduction add-on sold by Mærsk on all trades for all or a portion of containers shipped.

15 In switching to SZEFs, capital expenditure is expected to make up a large proportion of total switching costs for ferries. Therefore, a total cost of ownership CfD program may be more appropriate for the ferry segment, rather than the fuel only CfD approach suggested for other shipping segments.

16 Other policy designs that can achieve the same effect are also possible, for instance providing the subsidies to the fuel producer, which then sells the fuel at a lower cost to the ship

operator.

17 Oxford Smith School of Enterprise and the Environment, *Zero-Emissions Shipping: Contracts-for-difference as incentives for the decarbonisation of international shipping*, p. 6, June 2021

18 Getting to Zero Coalition, *Mapping of Zero-Emission Pilots and Demonstration Projects, Third Edition*, March 2021.

19 Energy Transitions Commission calculations. See appendix for *assumptions*.

20 Hydrogen derived fuels can also be produced using blue hydrogen based on natural gas combined with carbon capture and sequestration.

21 Energy Transitions Commission calculations. See appendix for *assumptions*.

22 Based on Hydrogen Council aggregated numbers. Further research published by the Hydrogen Council indicates even larger amounts of total electrolysis capacity available by 2030.

23 European Commission, *A hydrogen strategy for a climate-neutral Europe*, p.3, July 2020.

24 Energy Transitions Commission calculations. See appendix for *assumptions*.

25 The Clydebank Declaration was launched at the COP26 meeting in Glasgow in November 2021. The Declaration has 22 signatories, including the following EU member states: Belgium, Denmark, Finland, France, Germany, Ireland, Italy, The Netherlands, Spain, and Sweden.

26 Energy Transitions Commission calculations. See the appendix for *assumptions* and *Table A2*.

27 Parker, S., Shaw, A., Rojon, I., Smith, T. *Harnessing the EU ETS to reduce international shipping emissions: assessing the effectiveness of the proposed policy inclusion of shipping in the EU ETS to reduce international shipping emissions*, p. 31. Environmental Defense Fund Europe, London, December 2021.

28 Pre-feasibility studies conducted on several routes for The Next Wave: Green Corridors report show that the capital expenditure requirements for bunkering infrastructure are relatively small compared to the investment needs for fuel production. The required capital expenditure for bunkering would add only a small amount to the cost of fuel and as more vessels switch to SZEFs the cost of bunkering on a per tonne basis would reduce. (Getting to Zero Coalition, *The Next Wave: Green Corridors*, November 2021, p. 30)

29 Getting to Zero Coalition, *The Next Wave: Green Corridors*, November 2021

30 Getting to Zero Coalition, *The Next Wave: Green Corridors*, November 2021, p. 42

31 Getting to Zero Coalition, *The Next Wave: Green Corridors*, November 2021, p. 41

32 Capital expenditure includes shipping related electrolysis, hydrogen storage, ammonia production and investment costs for renewable energy production.

33 Getting to Zero Coalition, *The Next Wave: Green Corridors*, November 2021, p. 43 (currency conversion made at 2021 average of 1 euro = 1.18 USD).

34 Getting to Zero Coalition, *The Next Wave: Green Corridors*, November 2021, p. 45

35 Getting to Zero Coalition, *The Next Wave: Green Corridors*, November 2021, p. 49 (currency conversion made at 2021 average of 1 euro = 1.18 USD).

36 Energy Transitions Commission calculations. See appendix for *assumptions*.

37 Chatham House (2021), *resourcetrade.earth*.

38 European Commission, *France, Germany, UK, US, and EU launch ground-breaking International Just Energy Transition Partnership with South Africa*, November 2021.

39 Energy Transitions Commission calculations. See appendix for *assumptions*.

40 Energy Transitions Commission calculations. See appendix for *assumptions*.

41 Short-distance ferries should be considered out of scope for the purposes of this CfD program since the decarbonization pathway for most of these vessels will be through electrification rather than using zero-emission fuels.

42 EU MRV Data from 14 long-distance regional ferries in the Baltic Sea region.

43 Energy Transitions Commission calculations. Assumptions include HFO Price of US$450/t and SZEF price of US$1300/tHFOe. See appendix for complete *list of assumptions*.

44 Parker, S., Shaw, A., Rojon, I., Smith, T. *Harnessing the EU ETS to reduce international shipping emissions: assessing the effectiveness of the proposed policy inclusion of shipping in the EU ETS to reduce international shipping emissions*, p. 31, Environmental Defense Fund Europe, London, December 2021.