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REDUCING THE MARITIME SECTOR'S CONTRIBUTION TO CLIMATE CHANGE AND AIR POLLUTION

The Potential Role of Targets and Economic Instruments

A Report for the Department for Transport

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CONTENTS

EXECUTIVE SUMMARY

Aims of this report

Maritime 2050: Navigating the Future (Department for Transport, 2019) set out a number of recommendations aligned with the UK's ambition to achieve zero emission shipping by around the middle of the century. These included:

- "Government will consider the merits of introducing a medium term target for emissions of GHGs and air quality pollutants from UK shipping."
- "Government will consider the introduction of a target to reduce emissions of GHGs and air quality pollutants from UK shipping towards zero. Further details on the government's long term plans to reduce emissions from UK shipping will be set out in the Clean Maritime Plan, taking into account the IMO's 2050 GHG target."
- "Government will assess how economic instruments could support the transition to zero emission shipping in the medium to long term."
- "Government will consider whether and how the RTFO could be used to encourage the uptake of low carbon fuels in maritime, taking the availability of sustainable resources, competing uses and the international character of the maritime sector into consideration."

Each of these recommendations requires robust evidence in order to inform government's thinking about the extent to which there is a case for government intervention and if so, what form that intervention might take. This report aims to provide high-level analysis against each of these recommendations to inform the future direction of policy.

The analysis presented in this report draws on a combination of economic principles and a synthesis of publicly available data and evidence from shipping and other sectors and countries. It sets out the economic case for the UK introducing (a) targets to reduce emissions of greenhouse gases (GHGs) and emissions to air of pollutants from UK shipping; and, (b) economic instruments to support the transition to zero emission shipping. It then considers two relevant interventions that already exist with the aim of reducing emissions – the Nitrogen Oxides (NO_x) Fund in Norway and the Renewable Transport Fuel Obligation (RTFO) in the UK – and considers the pros and cons of those measures.

Key findings and conclusions

Emissions targets

Medium- and long-term targets can take a number of forms but share the common aim to ensure that a range of relevant parties take actions to achieve a specific future outcome by a particular date. The *collective* nature of this action is important in the context of environmental policy because both the problem of harmful emissions and the means to address it require many parties (such as

businesses and organisations across the economy, regulators, academics and individuals) working collaboratively and in a co-ordinated way.

The scale of the challenges posed by air pollution and climate change means that sustained changes in behaviour are needed. Targets can help to provide clarity over the scale and pace of required change, and to provide a goal with which behavioural changes, investment decisions and policies can be aligned.

The appropriate form of target will of course need to be context specific. It must be achievable, measurable and easy to understand. The target must also be accompanied by appropriate and credible commitments and mechanisms to ensure behaviours change to meet it, and to ensure proportionate monitoring and compliance measures are in place to facilitate progress towards it (with action triggered appropriately in the nearer term if emerging outcomes are not aligned with meeting the medium- or long-term target). In addition, attention must be paid to potential unintended outcomes, such as if the target provides an incentive to change behaviour in a way that creates other problems for the economy, environment or society, or worsens conditions against other important objectives, or if achievement of the target imposes unacceptable costs on some sub-sectors.

Targets can be considered from a number of perspectives such as the units they are measured in (output-based or input-based, absolute or relative) and whether they are mandatory or voluntary, short-term, medium-term or long-term, grounded in science or social welfare, owned by government or other organisations, or differentiated by geography or by sector.

There are a range of factors to consider when deciding on an appropriate target for a particular context: there is no 'one size fits all'. Relevant factors include:

- whether the target provides clarity on the expected emissions impact;
- whether the owner of a target can be held accountable for its delivery;
- whether the target would inadvertently encourage emissions leakage (the extent to which the target encourages firms to shift their emissions activities abroad to meet UK targets, rather than reducing emissions overall);
- whether the (domestic) target uses similar metrics to international targets or commonly accepted measures; and
- the ease of practical implementation, including monitoring and compliance costs.

Government may wish to consider several other factors too, such as the options available for meeting a target; the potential costs to business; the economic, environmental and social benefits from achieving a particular target; interactions with other policies or targets; and costs to the public purse of monitoring and enforcing the target, among other practical issues.

Analysis in this report suggests that mandatory, absolute targets set by the government (such as achieving a specified GHG and air pollutant emissions reduction relative to a historic[1] baseline by a specified date) can be the most appropriate and proportionate means for ensuring that environmental goals stated

[1] This means a baseline that has been observed from the past, as opposed to one that is projected to be a baseline in the future.

in *Maritime 2050* (Department for Transport, 2019) and the forthcoming Clean Maritime Plan are realised.

However, a single overarching target alone may not be sufficient and complementary targets may be useful. Targets set by industry offer the advantage of having industry commitment and co-ordination, and can be a valuable complement to more strategic targets set by government.

Importantly, medium- to long-term targets (say to 2050 or 2070) should be supported by short- and medium-term check-points to help monitor progress and ensure action can be taken to keep actions aligned with the longer-term target.

Data and monitoring mechanisms are an essential enabler of achieving the target in a proportionate way. In the context of UK shipping, this implies the need for a credible and verifiable, yet proportionate, way to measure shipping emissions.

Economic instruments

Economic instruments can play a valuable role in enabling the efficient achievement of targets and supporting the transition to zero emission shipping.

As with targets, there are a range of factors to consider when considering which type of instrument, or combination of instruments, could be most appropriate. These include whether the instrument:

- allows flexibility for businesses to choose the most cost-effective approach to reduce emissions;
- provides certainty of emissions reductions;
- encourages long-term efficiency improvements in the design, production and utilisation of emissions reduction technologies;
- has wider impacts beyond the primary objective of the economic instrument (for example, by impacting on other types of emissions that are not the focus of the instrument);
- minimises the extent to which firms shift their emissions activities abroad (which is known as 'emissions leakage', as noted above);
- is straightforward to implement because the data requirements, administrative processes and compliance mechanisms are proportionate; and
- is conducive to business planning by providing firms with sufficient foresight of the short- and long-term costs associated with the economic instrument.

Economic instruments are very context specific and there is no single design that can easily be replicated from one context to another. The outcomes and impacts of an economic instrument are very dependent on the design and context in which they are implemented, so careful analysis of options would be necessary to inform policy makers' decisions.

Importantly, when deciding on the most appropriate economic instruments and their more detailed design, a number of important and related issues will need to be considered. These include distributional issues in terms of differential impacts on sub-sectors within the shipping industry; potential costs to businesses; the economic, environmental and social benefits that could be achieved, including the opportunity to incentivise new low emission innovations; implications for trade-

flows and competitiveness effects; differences in impacts across geographies; the international context in which the domestic economic instrument is implemented; and the cost of the economic instrument to the public purse.

Furthermore, the design of the instrument should consider how to manage the following trade-offs:

- Encouraging behaviour to ensure short-term compliance as well as alignment with longer-term aims. The latter may involve encouraging near-term investment in R&D or the systems change needed to move to zero emissions shipping in the long run;
- Providing incentives to change behaviour to reduce emissions, while also being mindful of the cost implications for sub-sectors within the shipping or other industries and consumers; and
- Ensuring appropriate monitoring and compliance while also balancing data requirements and associated verification or administrative costs.

Example of an economic instrument: Renewable Transport Fuel Obligation (RTFO)

The RTFO is a current economic instrument for reducing GHG emissions from transport fuel. The RTFO obliges fuel suppliers to supply a minimum percentage of renewable fuel. Renewable Transport Fuel Certificates (RTFCs) are awarded to suppliers for each unit of renewable fuel they supply against their obligation. Suppliers can purchase RTFCs from other suppliers to meet their obligations, or they can sell them if they have met their obligations in terms of the fuel they supply. There is a maximum price (a 'buy-out' price) which offers suppliers the option of 'buying-out' of meeting their obligations. The current obligations cover suppliers of road and non-road mobile machinery (NRMM) fuel.

The RTFO could be rolled out to the maritime sector in three ways:

1a. Marine fuel could be included within the current RTFO without obligating marine fuel suppliers. Suppliers of renewable fuel to the maritime sector could benefit because they would generate RTFCs which could be sold to other suppliers who could use them to meet their obligations. In this case, suppliers of fossil marine fuels would not have an obligation, and so would not incur the costs associated with meeting an obligation with respect to marine fuels, but would have the incentive to provide renewable fuels because of the potential RTFC revenues.

1b. Suppliers of marine fuel could be obligated under the existing RTFO. Suppliers of renewable fuel to ships could benefit from RTFCs if they exceeded their obligations, although suppliers of fossil marine fuel would incur the costs associated with blending the required volume of renewable fuel or purchasing an equivalent number of RTFCs in order to meet their obligation.

2. A separate maritime RTFO (mRTFO) could place a blending obligation (or GHG reduction requirement) on fuel used in the maritime sector, separate to the obligations based on road and NRMM fuel suppliers under the RTFO.

Options 1a and 1b would provide an incentive for suppliers to increase the renewable fuels they provide to maritime. However, they do not guarantee that any

renewable fuel is actually supplied into the maritime sector. This is because, even if the suppliers of fossil fuel for shipping were obligated (option 1b), they could purchase RTFCs from suppliers of renewable fuel in other sectors, such as road transport, if this was cheaper than supplying it directly to the maritime sector, or they could buy out. Option 2 ensures renewable fuel is supplied into the maritime sector (unless the buy-out price is paid), therefore building up renewable marine fuel supply chains and potentially supporting innovation in its production. A marine RTFO could be designed to provide wider benefits, such as benefits related to air quality that may not necessarily result from renewable fuel obligations. For example, RTFCs could be restricted to fuels that meet minimum standards regarding sulphur or nitrogen content.

Example of an economic instrument: the Norwegian NO_x Fund

The Norwegian NO_x Fund is a combination of an emissions fee and a subsidy. It involves firms paying an amount of money to the fund, based on their NO_x emissions, the revenues from which can be used to finance NO_x reduction measures. The Norwegian Fund is open to oil and gas, mining, railways, aviation and shipping sectors. Firms that join the fund pay emissions fees per unit of NO_x and benefit from subsidies when purchasing technologies to reduce their emissions. The fund provides up to 80% of the investment cost of NO_x reduction measures that would otherwise not be viable.

Although there are many advantages of the Norwegian NO_x Fund, a major challenge is that in focusing on NO_x only, it leaves open the possibility of investments being made to reduce NO_x emissions at the expense of GHG emissions or other air pollutants, or missing opportunities to invest in different abatement options to reduce those wider emissions alongside NO_x.

A fund which considers air pollutants and GHGs as a package could be more effective in avoiding unintended adverse outcomes on other emissions.

The Norwegian fund shows that the key issues for successful implementation were:

- **Clarity over the charge base and scope:** Defining which ships or shipping activity would be subject to the levy (or charge). This took into account practical issues (such as what information would be required from which ships and in what format); enforcement issues (such as what would happen if a shipping firm did not pay the required levy or did not report emissions); the potential for competitive distortions; and the extent to which funds were distributed to foreign shipping firms.
- **Interaction with existing policies:** Consideration of the Fund interacts with other policies such as the Emissions Control Areas (ECAs), in which there are already constraints applied to shipping within defined areas. .
- **Responsibility for the fund:** Defined structures for who is responsible for the implementation of the levy; who is responsible for enforcement; and who is responsible for distribution of the revenues.
- **Costs and benefits of the intervention:** The responsiveness of different parts of the shipping industry to the implementation of a levy; the likely cost burden

on industry; the level of revenue generated; the level of emissions reduction that could be delivered (whether through behavioural change to reduce emissions so that the levy burden is lower; or through the reduction in emissions if the revenues can be used to fund emissions-reducing investments); and any potential unintended consequences.

- **Monitoring and evaluation:** For the Norwegian NOx Fund to be effective, it needed to be appropriately monitored to ensure that the desired outcomes were being achieved, at the anticipated cost, and that unintended impacts were identified and managed. Learning and adapting the intervention is important to ensure it remains effective and least cost over time.

1 INTRODUCTION

Maritime 2050: Navigating the Future (Department for Transport, 2019) set out a number of recommendations aligned with the UK's ambition to achieve zero emission shipping by around the middle of the century. These included:

- "Government will consider the merits of introducing a medium term target for emissions of GHGs and air quality pollutants from UK shipping."
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- "Government will assess how economic instruments could support the transition to zero emission shipping in the medium to long term."
- "Government will consider whether and how the RTFO could be used to encourage the uptake of low carbon fuels in maritime, taking the availability of sustainable resources, competing uses and the international character of the maritime sector into consideration."

Each of these recommendations requires robust evidence in order to inform government's thinking about the extent to which there is a case for government intervention and if so, what form that intervention might take. This report aims to provide high-level analysis against each of these recommendations to inform the future direction of policy.

The analysis presented in this report draws on a combination of economic principles and a synthesis of publicly available data and evidence from shipping and other sectors and countries. It sets out the economic case for the UK introducing (a) targets to reduce emissions of greenhouse gases (GHGs) and emissions to air of pollutants from UK shipping and (b) economic instruments to support the transition to zero emission shipping. It then considers two relevant interventions that already exist with the aim of reducing emissions – the NO_x Fund in Norway and the RTFO – and considers the pros and cons of applying those measures to UK shipping.

This report is structured as follows:

Section 2 defines what a 'target' means and the economic rationale for setting targets. It sets out a typology of targets that could be implemented to reduce UK shipping emissions, along with criteria to assess those options at a high level. A qualitative assessment of each target option against those criteria is then provided, drawing on published evidence, complemented with expert judgement where required. The section concludes with some key observations relevant to policy makers.

Section 3 looks at the economic rationale for using economic instruments to support the transition to zero emissions shipping.

Sections 4 and 5 consider two policy examples, the UK RTFO (Section 4) and the Norwegian NO_x Fund (Section 5). The sections conclude by summarising key insights for policy makers.

2 MEDIUM- AND LONG-TERM TARGETS

Maritime 2050: Navigating the Future (Department for Transport, 2019) made two recommendations in relation to medium- and long-term emissions targets. These were:

- "Government will consider the merits of introducing a medium term target for emissions of GHGs and air quality pollutants from UK shipping."
- "Government will consider the introduction of a target to reduce emissions of GHGs and air quality pollutants from UK shipping towards zero. Further details on the government's long term plans to reduce emissions from UK shipping, will be set out in the Clean Maritime Plan, taking into account the IMO's 2050 GHG target."

This section provides analysis relevant to these recommendations. It first describes the economic rationale for setting targets, then sets out a typology of targets that could be considered to reduce UK shipping emissions, along with criteria for comparatively assessing those options in a high-level way. A qualitative assessment of the target options against those criteria is then provided, drawing on published evidence, complemented with expert judgement where required. The section concludes with some observations relevant to policy makers.

2.1 Economic rationale for targets

2.1.1 Definition of targets

A target represents a promise to achieve a determinable end-state by some certain time (Ehrenfeld & Howard, 1996) and is therefore the means for providing verifiable evidence that objectives have been met. The focus of this report is targets relating to the reduction of shipping emissions, both in terms of GHGs and emissions to air of pollutants.

In practice, experience suggests that they are often used to:

- provide clarity and transparency about what needs to be achieved at some future date in terms of measurable outcomes;
- create a shared understanding for all relevant parties who may need to take action to achieve the target;
- provide clarity on the direction of policy aligned with the target, and hence provide greater incentive to invest, aligned with the target; and
- provide a means for accountability for the target setter (from external stakeholders e.g. the public) and those that must meet the target.

2.1.2 Stages in formulation of a target

The United Nations Environment Commission for Europe (UNECE, 2010) sets out a proposed approach to defining targets. This approach is shown in Figure 1.

Figure 1 Stages in formulation of a target

Source: Union of the Baltic Cities (2010)

1. **Vision.** A vision is an aspirational description of what an organisation or government would like to achieve or accomplish in the long-term future. It is intended to serve as a clear guide for choosing current and future courses of action. For example, *Maritime 2050* sets out clearly that the UK's vision is to be a leader in zero emissions shipping and play a "proactive role in driving the transition to zero-emission shipping in UK waters and [be] seen globally as a role model in this field, moving faster than other countries and faster than international standards" (Department for Transport, 2019).
2. **Objectives.** Objectives are smaller, tangible and more easily accessible aspects of the vision, sometimes referred to as strategic goals. For example, chapter 8 of *Maritime 2050* sets out several objectives relating to the UK's vision, including having the "UK flag as the flag of first choice for vessels adopting low or zero emission technologies" and for the "UK to be seen in 2050 as a role model in the field of zero emission shipping, having moved faster than other countries, and having captured a significant share of the economic benefits of the transition" (Department for Transport, 2019).
3. **Indicators.** Indicators are the aspects of the objectives that can be assessed in order to measure success or underpin targets. Indicators are an essential part in the formulation of targets (Union of the Baltic Cities, 2010). Based on indicators, measurable and quantified targets for priority areas can be agreed. Stakeholder participation to develop indicators can be helpful (UNECE, 2010). Based on the vision and objectives of *Maritime 2050*, potential indicators could include both direct and indirect indicators.

   Direct indicators focus on the desired outcome, regardless of the solutions/technologies deployed, e.g. reductions in GHG emissions and air pollutant emissions. Indirect indicators focus on actions that are intended to help reach the desired outcome, e.g. number of ports with onshore power supply, or the number of ships with a particular technology. Indicators which are direct are generally more desirable in policy making as they direct effort towards meeting the desired objectives as well as being solution and technology agnostic and avoiding unintended consequences (Baresic, Raucci, & Narula, 2018). [2]
4. **Targets.** As noted above, a target represents a promise to achieve a determinable end-state by some certain time (Ehrenfeld & Howard, 1996). Once indicators have been selected, the next stage is to define the desired value of the indicator at the end of the time frame: in other words, to set the

[2] To date, it is estimated that over $500 million has been invested in the EU through TEN-T and CEF funding for marine bunkering liquid natural gas (LNG) projects, supported by Directive 2014/94/EU, mainly for the purpose of improving air quality. However, it is clearly shown that there is no significant CO_2 equivalent reduction achieved through the use of LNG as marine fuel relative to the reduction required to achieve the IMO's 2050 objectives (Baresic et al., 2018).

target. Targets are therefore the means for providing verifiable evidence that objectives have been met (Condon, 2012). The indicator is what is measured to check whether the target is reached.

2.1.3 Economic rationale for medium- and long-term targets

A large body of literature in organisational and psychological research shows the positive relationship between goal setting (or targets) and performance (Locke, 2004; Locke & Latham, 2006). Studies have shown that specific, ambitious targets lead to a higher level of performance than do unambitious or vague targets (Locke & Latham, New Directions in Goal-Setting Theory, 2006).

Such target setting in relation to climate change has been embraced by the UK in legislation through the Climate Change Act 2008, which sets the UK a target of achieving at least an 80% reduction in GHG emissions, relative to a 1990 baseline, by 2050. Consistent with this longer-term target, the UK has 5-yearly legally-binding carbon budgets which are intended to ensure the UK is on course to achieve the longer-term target by monitoring the UK's emissions trajectory. Significant progress has been made against the longer-term target, more so in some sectors than others. The Committee on Climate Change (CCC) has therefore advised the government to set stretching targets where progress has been low, especially in the transport sector (Committee on Climate Change, 2018).

Barriers addressed and opportunities offered by targets

Importantly, medium- and long-term emissions targets in the maritime sector could play a direct role in addressing a number of barriers to action to reduce shipping emissions, and to set a clear policy direction to facilitate investments, policies and behaviours aligned with the target. They also help to ensure that a particular outcome is reached by a particular time, and facilitate a body being held accountable for non-delivery against the target.

In terms of addressing barriers, the problem of externalities (i.e. that the costs to society of emissions are generally not borne by those who emit them) is significant (Brown, 2001). In this context, targets can help to generate buy-in from relevant parties to take action to reduce emissions in line with meeting those targets. Targets can also help to address organisational barriers (which arise due to the way in which organisations are structured and how they interact with each other) and behavioural barriers (which relate to the decision-making processes of individuals) (Sorrel et al., 2004) that limit action to reduce emissions.

For example, Frontier Economics et al. (2019) show that the short-term outlook of some decision makers could cause them to undervalue long-run cost savings. The short-term outlook could be due to short-term ship ownership structures (Stott, 2013) or the high frequency of short-term time charters (Rehmatulla, 2014). Targets could help address these 'myopic outlook' barriers by encouraging owners to take a longer-term view of their assets and investments. Targets could also contribute to creating goal congruency (alignment of goals within a firm) and thus overcome intra-organisational barriers (where interests of one employee or department may be in conflict with those of others) and inter-organisational barriers (where interests of one firm may be in conflict with other firms e.g. between ports

and shipowners), encouraging the multitude of companies and stakeholders within these companies to think in the same direction as the target. Thus, targets create the incentive to change behaviours to achieve something that might not otherwise be achieved.

In addition to addressing barriers, targets can send a clear signal about the nature of the UK's ambitions and the future policy direction, and allow opportunities to be identified. In particular, targets can allow a range of stakeholders to update their expectations about the potential future UK policy environment and the types of economic instruments that are likely to follow. This signal could affect different stakeholders in different ways:

- Firms in the maritime sector can update their expectations about the direction of maritime emissions policy and use this information to inform their investment and business planning decisions.
- Firms in the maritime supply chain, and other sectors producing technologies or services that could be adopted directly or adapted for application in maritime, may identify potential economic opportunities and build this into their investment and business planning decisions. For example, organisations and academics involved in researching, developing, designing and producing emissions reductions technologies or fuels, could adapt their research and development (R&D) efforts, investment plans, and even their skills development programmes. Likewise, providers of services to the maritime sector and its supply chain may also identify opportunities and build required capacity to be able to meet the needs of the sector as it takes action to meet the target.
- A target can raise the public awareness of an issue and the government's ambitions to address it. In some cases, this could affect consumer behaviour through their choice of products and services towards those which have lower emissions.
- More widely, a target can also signal the UK's leadership in taking actions to address, in this case, UK shipping emissions. In international sectors such as maritime, this could be an important sign of intent and commitment to underpin international co-ordinated action, and therefore could influence other countries' actions to address emissions.

Targets can take a range of forms, as described in the following section.

2.2 Typology of targets

There are many types of targets that governments or other organisations could implement in order to encourage emissions reduction. The most appropriate target in any particular situation will depend on a number of considerations. Importantly, individual targets do not operate in isolation. Some targets complement one another and can be combined to enhance their effectiveness. Other targets conflict and governments will need to decide which is more appropriate for the circumstances.

Figure 2 and Figure 3 present a typology of targets that could be used to encourage compliance with emissions objectives in the maritime sector, including examples of where these approaches have been used in other sectors or jurisdictions.

Figure 2 covers the three broad categories of targets: absolute, relative and rule-based. **Figure 3** describes some of the key dimensions of these types of targets: whether they are mandatory or voluntary; short-term, mid-term or long-term; grounded in science or social welfare; owned by government or by firms; and differentiated by geography or by sector

Figure 2 Typology of emissions targets – high level

Category	Target type	Definition	Example
Outcome based	Absolute	Target to achieve absolute reduction in an indicator by a given year, in comparison to a reference year.	"To reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008" (IMO, 2018).
	Relative	Target to achieve reductions relative to another indicator, (e.g. GDP, transport work) in comparison to a reference year.	"To reduce 'CO_2 emissions per transport work', as an average across international shipping, by at least 40% by 2030 compared to 2008"[3] (IMO, 2018).
Input-based	Rule-based	Includes general prohibition orders and obligations to meet certain indicators, such as prescription to use certain technologies.	"At least 10% of transport fuels should come from renewable sources by 2020" (European Commission, 2016).

Source: UMAS analysis

[3] 'Transport work' is a measure of shipping activity, usually measured in tonne nautical miles (tnm).

Figure 3 Typology of emissions targets – additional dimensions

Definition	Example
Grounded in science	
Science-based targets use the latest climate science (e.g. from the Intergovernmental Panel on Climate Change) as the basis for determining the target.	"Holding the increase in global average temperature to well below 2 degrees above pre-industrial levels and pursuing efforts to limit temperature increase to 1.5 degrees" (UNFCCC, 2015).
Grounded in welfare objectives	
Takes into account socio-political factors to determine and differentiate a target e.g. economic status of a country, importance (e.g. lifeline services).	"To achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance" (India, NDC) (International Energy Agency, 2015).
Timeframe	
Long-term targets in the context of national policy typically look 15-20 years ahead (Union of the Baltic Cities, 2010).	Shift 50% of road freight over 300 km to rail/waterborne transport by 2050 (European Commission, 2011).
Medium-term targets in the context of national policy typically look 5-10 years ahead (Carbon Trust, 2014). They are derived from breaking down long-term targets into smaller timeframes.	In 2011 the European Commission set a target to "Reduce GHG emissions by 20% by 2020 compared to 1990 levels" (European Commission, 2011).
Short-term targets in the context of national policy typically look 1-3 years into the future (Union of the Baltic Cities, 2010). They are often derived from breaking down long-term targets into smaller timeframes. Short-term targets help measure progress (Carbon Trust, 2014).	The European Commission has a rolling 1-year target on 1% reduction in transport GHG emissions on average (European Commission, 2011).
Enforcement	
Target is compulsory, typically set in law, so must be met or there may be legal and/or financial implications for non-compliance.	"By 2021, phased in from 2020, the fleet average to be achieved by all new cars is 95 grams of CO_2 per kilometre" (European Commission, 2014).
The target is voluntarily adhered to, usually to drive change, typically in the initial phases or to provide learning for a mandatory target in the future. Can also be used to demonstrate leadership or to pre-empt legislation.	Freight Transport Association's Logistics Carbon Reduction Scheme set HGV operators a target to reduce their 2015 carbon emissions by 8% compared to 2010 levels (Department for Transport, 2017).
Accountability	
Government: The target is developed, regulated and monitored by the government's regulating authority.	"Reducing greenhouse gas emissions by at least 80% of 1990 levels by 2050" (Climate Change Act, 2008).
Industry: The target is developed and monitored by stakeholders in the private sector i.e. industry, firm, association/group.	"Nippon Yusen Kabushiki Kaisha commits to reduce scope 1 GHG emissions 30% per ton-kilometre by 2030 from 2015 base year, and 50% per ton-kilometre by 2050 from the same base year" (NYK, 2018).
Scope	
Geographic: The target varies by the location of the targeted entity (firms, countries) or the indicator's impacts (e.g. local air pollutants).	Emission Control Areas (ECAs) designated under regulation 13 of MARPOL Annex VI for SO_x, NO_x and particulate matter (PM).
Sectoral: The target varies by the characteristics of the target entity, firm or sector.	Energy Efficiency Design Index (EEDI) relative to ship type and size (IMO, 2011a)

2.2.1 Examples of targets

Below are a number of specific examples of absolute, relative and rule-based targets, drawn from the maritime sector and environmental policy in general,

expanding on the examples in Figure 2. These are intended to indicate the types of targets that are most relevant for the maritime sector.

Absolute targets (outputs). A recent example of a government-led initiative that has had the backing of private industry is the Fossil Free Sweden initiative. The initiative contains several targets for sectors, including shipping, aviation, construction, mining, etc. Sweden has set a national target to cut GHG emissions from domestic transport, aiming for net zero in 2045 (Sverige, 2019). In 2015, the Swedish Shipowners Association set a target of net zero GHG emissions by 2050 (Sweship, 2015), which has now been brought forward to 2045 to be in line with the Fossil Free Sweden initiative.

Another example of an absolute, government, geographically differentiated target is Norway's target of making the Fjords zero emission zones (including air pollutants and GHG emissions) by 2026. This will impact all ferries and cruise ships operating in the Fjords (Lambert, 2018).

There are a number of recent examples of privately-owned absolute targets. As noted in Figure 3, Nippon Yusen Kabushiki Kaisha has set a science-based relative efficiency target to reduce emissions per unit of activity by 30% by 2030 and by 50% by 2050 (NYK, 2018). Similarly, container firm Maersk announced recently that it aims to reach carbon neutrality by 2050 (Maersk, 2018).

Beyond the maritime sector, the UK Climate Change Act 2008 and accompanying legally-binding 5-year carbon budgets, commit the UK government by law to reducing GHG emissions by at least 80% below 1990 levels by 2050 (Committee on Climate Change, 2018a). This is an example of an absolute, science-based, mandatory, government target.

The European Commission has a range of targets that are absolute and pertain to various sectors with respect to renewable energy sources, air pollution and GHG emissions. For example, on maritime, the target is to reduce EU carbon emissions (including international shipping connected to EU) by 40% (if feasible 50%) by 2050, compared to 2005 levels (European Commission, 2011).

The international aviation sector has also adopted an absolute GHG target of keeping the global net CO_2 emissions from international aviation at 2020 levels under Assembly Resolution A39-3 (ICAO, 2016). However, these targets are anticipated to be achieved largely through a global market-based measure that allows out-of-sector emissions reductions through carbon offsetting in the form of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The CORSIA also has elements of differentiation through economic status e.g. least developed countries and small island states are exempt unless they volunteer to participate. CORSIA is voluntary in the first two phases (pilot phase 2021-2023 and first phase 2024-2026) before becoming mandatory thereafter.[4]

Relative targets (outputs). The Energy Efficiency Design Index (EEDI) is one example of a current relative target in shipping. It is a CO_2 intensity metric that was adopted by the IMO in 2011, and considers the total emissions of a ship (at the design stage) relative to the transport work done by the ship resulting in grams of

[4] Additional detail is available at https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-FAQs.aspx

CO_2 per tonne nautical mile. The reduction targets are tightened by 10% every five years, reaching 30% reductions in phase 3 (2025 onwards) relative to reference lines[5] for each ship type (IMO, 2011a).

Other examples include NO_x emission standards for shipping, under MARPOL Annex VI, which limits NO_x (IMO, 2011b). As an example, for ships built on or after January 2016 and operating in Emission Control Areas (ECAs) (classed as Tier III):

- for engine speeds less than 130 revolutions per minute (rpm), the limit is 3.4 grams of NO_x per kilowatt hour;
- for engine speeds 130 and above but less than 2000 rpm, the limit is $9*n^{-0.2}$ grams of NO_x per kilowatt hour; and
- for engine speed above 2000 rpm, the limit is 2 grams of NO_x per kilowatt hour.

Another example of relative targets is fuel economy standard targets for road vehicles e.g. miles per gallon, kilometres per litre, litres per 100 km, adopted in many countries around the world e.g. the EU, USA, Japan, China, Australia, Canada. GHG emissions standards exist in the EU and California (An & Sauer, 2014). In the EU for example, GHG standards are included in Regulation 443/2009/EC which sets a target of 95 grams CO_2/km as average emissions for the new car fleet from 2020 onwards.

Rule-based targets (inputs). There are various examples of rule-based targets that prohibit or promote certain outcomes directly in order to achieve an environmental objective. In the EU (European Commission, 2011) these include targets to:

- reduce conventionally fuelled cars in cities by 50% by 2030;
- shift 30% of road freight over 300 km to rail/waterborne transport by 2030;
- increase airlines' use of low carbon fuels by 40% by 2050; and
- increase biofuels to 10% of the overall EU transport petrol and diesel consumption by 2020.

Low emissions zones in most EU urban areas and cities (e.g. the Ultra-Low Emission Zone in London and Area C in Milan) are also examples of rule-based targets which aim to reduce air pollutant emissions. In shipping, these include ECAs in the Baltic Sea, the North Sea and the North American and Caribbean Sea, that limit the sulphur oxide (SO_x), NO_x or particulate matter (PM) content of fuels (or some combination thereof) to a much lower level than standard limits. More generally, the limit on the global SO_x content of fuels will be reduced from 3.5% (by mass) to 0.5% in January 2020 in accordance with IMO resolution MEPC.280(70) (IMO, 2019b).

Rule-based targets also include mechanisms that are input-related. An example of this is the EU's target to invest 3% of GDP in R&D (European Commission, 2019b).

Renewable energy targets are also examples of rule-based targets. The EU's Renewable Energy Directive sets a binding target of 20% of final energy

[5] A reference line is a baseline EEDI for each ship type, representing EEDI as a function of ship size. For the purpose of calculating the reference lines, data relating to existing ships from 1 January 1999 to 1 January 2009 are used.

consumption from renewable sources by 2020 and 32% by 2030 (European Commission, 2009). In the UK, examples of this include the Renewables Obligation and the Renewable Transport Fuel Obligation (RTFO) (Department for Transport, 2018b).

2.2.2 Potential maritime specific targets for the UK

Figure 4 and Figure 5 describe four representative examples of how the typology of target options in Figure 2 could be implemented in the UK maritime sector. The four targets include one absolute target, one relative target and two input-based targets, drawing from examples presented in Figure 2 and Figure 3. Each of the examples of targets proposed in Figure 4 is acceptable under international law e.g. United Nations Law of the Sea (UNCLOS). Three of the four are already present in some form at the IMO, either in the Initial IMO Strategy on Reduction of GHG Emissions from Ships (IMO, 2018b) or are existing regulations under the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, such as ECAs and EEDI.

A public service contract (PSC) target is included because it is a national (rather than international) target. PSCs are governed at national level in the UK through The Public Contracts Regulations 2015, at the regional level through Directive 2004/17/EC[6] and Directive 2004/18/EC,[7] and at the international level through the World Trade Organization Government Procurement Agreement. An example where zero emission vessels have been procured through PSCs is in Norway, where public sector procurements of ferry services cover 130 ferry crossings and 200 ferries, owned and operated by private ferry companies (Tekna, 2019). Fjord 1 has successfully bid on a number of contracts that specify low and zero emissions in certain routes in the Norwegian Fjords, and as a result, Fjord 1 already has eight electric ferries operating on four routes (Hanley, 2019). Where it is not feasible to operate all-electric vessels, e.g. due to distance, hydrogen-fuelled ferries have been contracted, where for example Norled (another private operator), has won the PSC (Tekna, 2019).

A target equivalent to the EEDI (i.e. CO_2 intensity standard based on design) is not included because such targets focus on improving the design efficiency of new ships only. Due to the long life span of ships, typically 25-30 years (UNCTAD, 2018), only a small proportion of the fleet is decommissioned every year, so an EEDI type target would affect emissions only in the long term, even in a high-ambition scenario (Smith et al., 2016). As such, a target based on design efficiency would be less effective in meeting the UK and international climate goals in the medium term. However, this form of target could be valuable in a complementary capacity.

Figure 4 describes how these targets fit into the typology in Figure 2, their level of ambition, the jurisdiction they would apply to, and whether they would involve

[6] of the European Parliament and of the Council of 31 March 2004 Coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors.

[7] of the European Parliament and of the Council of 31 March 2004 on the Coordination of procedures for the award of public works contracts, public supply contracts and PSCs.

geographic or intra-sectoral differentiation. Figure 5 proposes indicators that can be used for each target, and how these could be measured.

Figure 4 Potential maritime emissions targets: typology, jurisdiction, differentiation and examples

Potential target	Typology	Differentiation	Related international/IMO target
Absolute emissions reduction by a specific amount below a specified baseline by a specific date.	Absolute, science-based target.	It is possible to differentiate the target by ship type, as shown in Smith et al., (2015).	"To reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008" (IMO, 2018a).
Reduce operational CO_2 intensity as an average by X% on current levels by a specific date.	Relative, science-based target.	It is possible to differentiate the target by ship type as shown in Smith et al., (2015).	"To reduce 'CO_2 emissions per transport work', as an average across international shipping, by at least 40% by 2030 compared to 2008"[8] (IMO, 2018a).
Zero or low emissions control areas established by a specific date.	Rule-based, geographic target.	It is possible to differentiate the target by ship type or geographic area e.g. Hebrides, Exclusive Economic Zone e.g. English Channel.	SO_x and NO_x emission limits in Emission Control Areas (ECAs) designated under MARPOL Annex VI.
Zero or low emission vessels, or zero or low emission routes in public service contracts (PSC) by a specific date.	Rule-based, sectoral target.	It is possible to differentiate the target by ship type or geographic area e.g. Hebrides, Exclusive Economic Zone or where potential for electro-fuels exist.	PSCs are governed at the national level.

Source: UMAS analysis

Notes: All targets are mandatory and government enforced.

[8] 'Transport work' is a measure of shipping activity, usually measured in tonne nautical miles (tnm).

Figure 5 Potential maritime emissions targets: indicators and measurements

Target	Indicators	Measurement
Absolute emissions reduction by a specific amount below a specified baseline by a specific date.	▪ Annual GHG emissions, in tonnes: (CO_2, CH_4, N_2O) ▪ Annual air polluants, in tonnes: (SO_x, NO_x, PM, volatile organic compounds, carbon monoxide, black carbon).	▪ Emission monitoring systems e.g. direct from smoke stack ▪ Fuel used by vessels and applying emission factors (IPCC Tier 1)[9] ▪ AIS-based emissions estimates (IPCC Tier 3).[10]
Reduce operational CO_2 intensity as an average by X% on current levels by a specific date.	▪ Grams of CO_2 per unit of work done e.g. tonne nautical mile (gCO_2/tnm).	▪ Emission monitoring systems e.g. direct from smoke stack ▪ Fuel used by vessels, applying emission factors (IPCC Tier 1) and transport work done ▪ AIS-based emissions estimates.
Zero or low emissions control areas established by a specific date.	▪ Annual GHG emissions, in tonnes: (CO_2, CH_4, N_2O) ▪ Annual air polluants, in tonnes: (SO_x, NO_x, PM, VOC, CO, BC).	▪ Emission monitoring systems e.g. direct from smoke stack ▪ Fuel used by vessels and applying emission factors ▪ AIS-based emissions estimates ▪ Number of Zero Emission Vessels.
Zero or low emission vessels or zero emission routes in public service contracts (PSCs) by a specific date.	▪ GHG emissions, in tonnes: (CO_2, CH_4, N_2O) ▪ Air polluants, in tonnes: (SO_x, NO_x, PM, VOC, CO, BC).	▪ Emission monitoring systems e.g. direct from smoke stack ▪ Fuel used by vessels and applying emission factors ▪ AIS-based emissions estimates ▪ Number of Zero Emission Vessels in PSCs.

Source: UMAS analysis

2.3 Criteria for assessment of targets

As shown in the previous sections, there are many different forms of targets, each with different characteristics. Criteria can be used to compare and contrast the different forms. The criteria used for this assessment are:

- **Clarity of emission impact:** Targets should provide decision makers with clarity on the level of environmental impact (e.g. the level of emissions reduction) to be achieved.

[9] There are three tiers of monitoring that could be applied to decarbonisation targets. Tier 1: Emissions are estimated using emission factors (for CO_2 and non-CO_2) based on fuel type as reported by obligated entities and carbon content at a general level. Tier 2: Emissions are estimated using emission factors which are country specific and, if possible, derived by in-country testing of fuels and combustion engines used in water-borne navigation. Tier 3 emission factors use country-specific emission factors and detailed activity data (e.g. annual hours of use and equipment-specific parameters, such as rated power, load factor, and emission factors based on power usage) mostly derived from AIS data.

[10] As presented in Scarborough et al. (2017) A review of the NAEI shipping emissions methodology.

- **Accountability**: Targets should relate to indicators for which the target owner can be held accountable (i.e. it has the levers to influence action to achieve them).
- **Emissions leakage**: Targets should consider the wider international context and the extent to which firms may shift their emissions activities abroad.
- **Using metrics that are already used and accepted internationally:** Targets should use the same metrics as internationally developed targets, such as those of the IMO, even if they differ in ambition (e.g. in their level of stringency and timeline).
- **Ease of practical implementation:** Targets should be easy to implement, monitor (measure), and would ideally be complemented by mechanisms to achieve them.

For the purposes of assessing different forms of targets against these criteria Figure 6 shows the thresholds used to assess each option against the criteria.

Figure 6 RAG rating thresholds, by criteria

Criteria	Red	Amber	Green
Clarity of emissions impact	It is not clear what is being aimed for so hard for others to understand.	The target clearly requires a reduction in emissions, but not clear how much this will be.	The target provides clarity on the level of emissions reduction to be achieved.
Accountability	The owner cannot be held accountable for meeting the target	The target owner has only minimal levers to change behaviour to achieve the target.	Meeting the target is within the direct control of the target owner, or it has the required levers needed to change the behaviour of others to achieve it.
Emissions leakage	Firms will have an incentive to move their emissions-generating activities to other jurisdictions.	Some firms will have an incentive to move their emissions-generating activities to other jurisdictions.	Firms will not have an incentive to move their emissions-generating activities to other jurisdictions.
Internationally accepted metrics	Target uses different metrics to international targets.	Target uses metrics which can be derived from internationally accepted measures.	Targets use the same metrics as international targets.
Ease of practical implementation	Targets will require disproportionately high monitoring, enforcement and administrative costs.	There will be proportionate monitoring, enforcement and administrative costs.	Targets will be low cost to administer and will require relatively simple monitoring and enforcement.

Source: UMAS analysis

2.4 Assessment of potential targets in the maritime context

This sub-section sets out how each of the targets presented in Figure 4 perform when assessed against the criteria set out in Section 2.3.

An overview of the RAG ratings given to the potential targets for each criterion can be found in Figure 7. Each potential target is then discussed in turn, providing context for the allocation of the rating.

Figure 7 RAG rating of targets against criteria

Economic instrument	Clarity of emission impact	Accountability	Emissions leakage	Internationally accepted metrics	Ease of practical implementation
Absolute emissions reduction by a specific amount below a specified baseline by a specific date					
Reduce emissions intensity by a specified date					
Zero or low emissions control areas established by a specific date					
Zero or low emission vessels, or zero or low emission routes in public service contracts (PSCs) by a specific date					

Source: UMAS analysis

Absolute emissions reduction by a specific amount below a specified baseline by a specific date

Figure 8 RAG ratings: absolute emissions reduction by a specific amount below a specified baseline by a specific date

Clarity of emission impact	Accountability	Emissions leakage	Internationally accepted metrics	Ease of practical implementation

Source: Frontier Economics

Clarity of emission impact: There is a high degree of clarity regarding the environmental impact. The target sets a clear ambition for emissions and at the

highest level of ambition bans fossil-fuelled ships. The target provides firms with a clear signal of future changes in the business and regulatory environment; hence this is green.

Accountability: Government can set the target, but it can only be achieved if additional policies are implemented and action is taken by the industry, so it can to some degree directly control the extent to which the target is met. The target provides firms with a clear signal of future changes in the business and regulatory environment, but it does not account for changes to external factors such as economic growth and trade volumes, which are beyond the control of firms, hence the amber assessment.

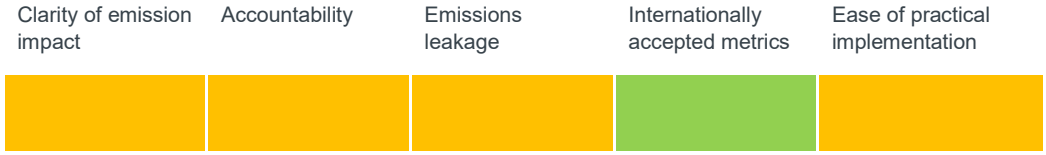
Emissions leakage: There is some risk of emissions leakage to other jurisdictions as a result of the target. This is more likely to occur if the UK target is more ambitious than other jurisdictions, though the scope for emissions leakage will vary, depending on the options that shipping firms have to shift their activities to other countries, the costs of doing so, and the extent to which any costs they face from meeting the target could be passed through into consumer prices.

Internationally accepted metrics: The target uses the same metrics as international targets. The IMO has also adopted an absolute emissions reduction target "to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008" (IMO, 2018b).

Ease of practical implementation: There are potentially high administrative burdens due to monitoring, reporting and verification of GHG and air pollutants by individual entities. However, the administrative burden can be reduced by using data that is already collected, or planned to be collected, for estimating emissions e.g. Automated Identification Service.

Reduce emissions intensity by a specified date

Figure 9 RAG ratings: Reduce emissions intensity by a specified date



Source: Frontier Economics

Clarity of emission impact: This is a relative measure so the absolute impact on emissions is only partially clear (it depends on how activity changes); hence this is amber.

Accountability: Government can set the target, but it can only be achieved if action is taken by the industry, hence the amber rating. Measuring the target in terms of emissions intensity means that it is not subject to the target being affected by unexpectedly higher or lower activity.

Emissions leakage: There is some risk of emissions leakage to other jurisdictions as a result of the target. This is more likely to occur if the UK target is more ambitious than other jurisdictions, though the scope for emissions leakage will vary

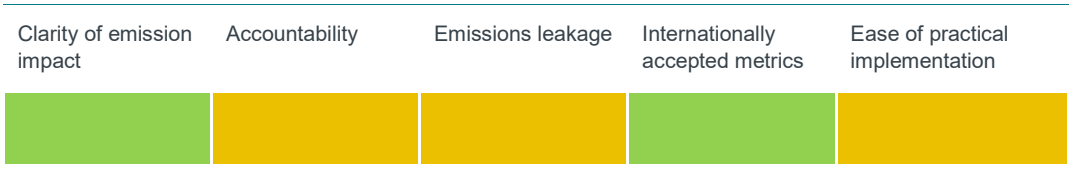
depending on the options that shipping firms have to shift their activities to other countries, the costs of doing so, and the extent to which any costs they face from meeting the target could be passed through into consumer prices, hence the amber rating.

Internationally accepted metrics: The target uses the same metrics as international targets and mechanisms. The IMO has adopted a relative emissions reduction target "to reduce 'CO_2 emissions per transport work', as an average across international shipping, by at least 40% by 2030 compared to 2008" (IMO, 2018b), so this is already being monitored.

Ease of practical implementation: There are potentially high administrative burdens due to monitoring, reporting and verification of operational efficiency by individual entities, hence the amber rating. However, the fact that the IMO target already exists means that existing monitoring and measurement processes, such as the Automated Identification Service, could be used (if appropriate).

Zero or low emissions control areas established by a specific date

Figure 10 RAG rating: Zero or low emissions control areas established by a specific date



Source: Frontier Economics

Clarity of emission impact: There is a high degree of certainty regarding the environmental impact, hence rated green. The target sets a clear ambition for emissions and at the highest level of ambition bans fossil-fuelled ships. The target provides firms with a clear signal of future changes in the business and regulatory environment.

Accountability: Government has control over whether zero or low emissions control areas are implemented and can therefore be held accountable for meeting this target. It does, however, need to ensure that ships take appropriate actions to comply with regulations.

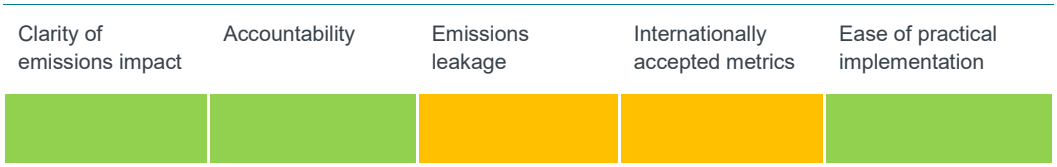
Emissions leakage: There is a risk of emissions leakage as the target could potentially lead to changes in behaviour to avoid the emission control area or to changes in behaviour outside the emissions control area (e.g. increases in speed in non-controlled areas which could have an adverse impact on total emissions), hence an amber rating.

Internationally accepted metrics: The target could use the same metrics as international targets and mechanisms. The IMO has also adopted ECAs in the Baltic Sea, the North Sea and the North American and Caribbean Sea, so the concept and legal framework exists, as do the monitoring and measurement mechanisms.

Ease of practical implementation: There is a low to medium administrative burden to establish and monitor the target (depending on the size of the emissions control area). The target can be monitored through measuring the number of zero emission vessels, dual fuel vessels, port state control or sniffer technology. There could be a medium administrative burden to enforce the area.

Zero or low emission vessels, or zero or low emission routes in public service contracts (PSCs) by a specific date

Figure 11 RAG rating: zero or low emission vessels, or zero or low emission routes in public service contracts (PSCs) by a specific date



Source: Frontier Economics

Clarity of emission impact: There is a high degree of certainty regarding the environmental impact. The target sets a clear ambition for emissions and at the highest level of ambition could ban fossil-fuelled ships in the delivery of lifeline services[11] or where public procurement is involved. The scale of emissions reduction would likely to be lower through this option, than for, say, the sector-wide targets under the options above, given its focus only on vessels that are publicly procured.

Accountability: Government has control over whether zero emissions routes and vessels are stipulated in public sector contracts and can therefore be held accountable for meeting this target.

Emissions leakage: There is a medium risk of emissions leakage as operators could move their least efficient vessels away from UK PSCs and deliver competitor services, perhaps outside the UK, without public service obligations.

Internationally accepted metrics: The target relates to procurement specifications. PSCs in the UK are covered by two EU public procurement policies; Directive 2004/17/EC[12] and Directive 2004/18/EC.[13] Zero emissions vessels can be procured through these regulations, if a high priority is accorded to environmental factors, when considering tenders (Rehmatulla, 2014). Currently, there are no specific targets stipulating zero emission vessels or routes, so it would be for the UK to select an appropriate metric, and means of measuring and verifying it, that complies with the procurement regulations.

[11] Lifeline services refers to those that are of critical importance to the local economy as they provide the sole method of mobility as, for example, in the Scottish Hebrides.

[12] Directive 2004/17/EC of the European Parliament and of the Council of 31 March 2004 Coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors.

[13] Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the Coordination of procedures for the award of public works contracts, public supply contracts and public service contracts.

Ease of practical implementation: There is a low administrative burden associated with establishing and monitoring the target. The target can be monitored through measuring the number of zero emission vessels in PSCs.

Considerations for practical implementation: In addition to the assessment of the potential targets against the above criteria, there are a number of considerations that relate specifically to the target options identified in the typology.

Absolute targets: Absolute targets generally provide a high level of certainty about future emissions by entity, region, sector etc. However, absolute targets do not account for external factors such as variations in GDP, trade growth, or underlying shipping activity. Therefore, increasing underlying demand for shipping activity could increase the cost of achieving the absolute emissions target.

Relative targets: Relative targets, such as energy efficiency targets, fuel economy standards and GHG intensity targets have been investigated to a great extent (see, for example, Gallagher et al. 2007; Fontaras & Samaras 2007; An & Sauer, 2014). The literature finds that relative efficiency targets reduce the exposure of the target to external factors like GDP or trade growth. Therefore, the costs associated with achieving the targets may be more foreseeable.

However, the literature generally finds that relative targets are prone to two particular concerns:

- **Inability to account for scale effects:** Relative targets, such as fuel economy or GHG standards do not provide certainty over the absolute level of emissions reduction that is likely to be realised.
- **Rebound effects:** Rebound effects refer to the potential that the demand for emissions-generating activity increases as a result of the target. This could arise if, for example, emissions are reduced through fuel efficiency measures which therefore save fuel costs. One response to this could be to increase the level of shipping activity because it is now lower cost. This reduces the benefits of the emissions savings that may otherwise have been achieved (Sorrell, The Rebound Effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency, 2007). Lelliot et al. (2017) found that the operating speed increased on a cohort of ships retrofitted with propulsion efficiency devices, relative to the ships which were not retrofitted .

Rule-based targets: Rule-based targets are generally easy to implement because they are prescriptive and set the rules with which parties need to comply. However, rule-based targets that apply to inputs (e.g. % of renewable fuel blended into fuel supplied) rather than outputs (e.g. emissions) do not guarantee that overall emissions reduction objectives can be met. They can also lead to distortions or unintended consequences, for example if a firm were to divert investment from R&D in zero emissions technologies or fuels to focus on meeting a rule-based obligation.

Mandatory vs. voluntary targets: Analysis by Price (2005) of 23 voluntary target programmes found that voluntary programmes that were tied to future regulations (or credible threats) were in general more successful in meeting their stated goals compared to purely voluntary targets (Alberini & Segerson, 2002; Price, 2005).[14] If

[14] Voluntary agreement programmes can be roughly divided into three broad categories: 1) programmes that are completely voluntary, 2) programmes that use the threat of future regulations or energy/greenhouse gas

voluntary targets are pursued, Alberini and Segerson (2002) propose various points to consider for effective voluntary targets. These include understanding whether the level of emissions reduction is determined through negotiation or bargaining and assessing incentives for participation. This can help generate shared buy-in to the target and minimise the risk of a lack of participation and lack of ambition, as shown in German auto manufacturers' private industry target in the 1990s (Krarup & Ramesohl, 2000).

On their own, voluntary and private targets may be insufficient to achieve desired objectives (Krarup & Ramesohl, 2000), but they can play a very valuable complementary role in advance of a mandatory target or to generate information about how a mandatory target could be designed and monitored most effectively.

2.5 Policy insights

This analysis suggests that mandatory, absolute targets, grounded in science and set by the government (e.g. zero GHG and air pollutant emissions by a specified date), are the most effective way to ensure that zero emissions ambitions of *Maritime 2050* are realised. They provide a clear direction of travel for future total emissions per entity, region and for the sector, and send an unambiguous signal to the industry of future government policy. The following points should be considered when deciding on the target:

- The scale of ambition of targets can have an important role in sending a signal about the scale of ambition to domestic organisations and individuals and internationally. Where sector-wide targets are set, or targets that cover large sub-sectors, then this can signal a greater level of ambition than if targets have only a narrow focus.
- Achieving high-ambition targets that affect large parts of the economy will require action to be taken collectively and in a co-ordinated way. Given the diversity within the shipping sector, and its international nature, the ability to reduce emissions and hence the cost of achieving targets is therefore likely to differ. This is important to recognise so that appropriate complementary policies can be considered to ensure targets can be met in a cost-effective way.
- The targets should have a clear scope. Targeting some emissions and not others could lead to unintended consequences, such as reducing some emissions at the expense of others. Therefore, a holistic approach to setting targets is likely to be more effective. There would also need to be clarity around the coverage of emissions sources, such as whether the target relates to domestic shipping emissions only, or to international ones.
- The targets should have a clear timeframe and be supported by short- and mid-term targets that facilitate measurability and lead towards the long-term target. This would ensure that the target can be monitored and that triggers are set up for action or risk management activities to be undertaken.
- The targets do not have to be mutually exclusive; they can be complementary, e.g. absolute targets on decarbonisation can be complemented by relative and rule-based targets, or by voluntary targets set by industry, consistent with the

emissions taxes as a motivation for participation, and 3) programmes that are implemented in conjunction with an existing energy/GHG emissions tax policy or with strict regulations.

strategic government target. For example, the EU pursued all three types of targets for reducing CO_2 emissions from passenger cars.

- Relative targets and rule-based targets are not sufficient on their own as they do not guarantee total emissions reductions and could create perverse incentives.
- The economic instruments and other levers available to support the delivery of a target need to be considered because these have an important influence on the costs of meeting a target. These are considered in the next section.

3 ECONOMIC INSTRUMENTS

Maritime 2050 (Department for Transport, 2019), recommended that:

- "Government will assess how economic instruments could support the transition to zero emission shipping in the medium to long term."

This section sets out the economic rationale for using economic instruments to support the transition to zero emissions shipping.

3.1 Economic rationale for economic instruments

Government intervention may be required where a 'market failure' exists or where there are equity considerations that need to be addressed. A market failure refers to a situation in which a market, if left alone, would lead to outcomes that are not in the best interests of society as a whole. This may happen if, for example, an activity undertaken by one party imposes costs on others that they do not take into account when deciding whether and to what extent they undertake that activity. Equity considerations arise if the market would not, if left alone, lead to an equitable distribution of outcomes for society.

Frontier Economics et. al. (2019) described some of the potential market failures in the shipping industry as well as other barriers to the uptake of behaviours and technologies that would reduce emissions of GHGs and emissions to air of pollutants below the levels which they are otherwise expected to be. These barriers included economic barriers (such as where the price of fuel does not reflect the environmental damage cased to society when that fuel is consumed;[15] a lack of good information about the choice of options to reduce emissions and their relative costs and benefits;[16] high costs of capital to fund emission reduction technologies)[17] as well other types of barriers (such as those resulting from the structure of the industry; and policy or regulatory issues, organisational challenges and behavioural barriers). Economic instruments can be used to address some of these market failures and barriers.

In this context, economic instruments are defined as fiscal and other economic incentives used to incorporate environmental costs and benefits into decisions made by firms and consumers (OECD, 2003). Economic instruments aim to bring about better outcomes for society as a whole by ensuring that the individuals or organisations responsible for an activity account for the costs they impose on others through their decisions.

Other (non-economic) policy instruments include 'command and control' regulation, which prescribes the actions a firm must take or the environmental results it must achieve, and information-based policies, which require a firm to disclose information on its activities (Sterner & Robinson, 2018). Such policies are prescriptive and leave the regulated organisations with little choice over their own actions. For example, command and control regulatory measures usually lack the

[15] This is often referred to as a negative externality.

[16] This is often referred to as imperfect information.

[17] This is often referred to as credit constraints, such as a high cost of capital.

flexibility of economic instruments; once a firm has complied with the policy, there is little incentive to continue reducing emissions (HM Treasury, 2002).

4 POLICY EXAMPLE: RENEWABLE TRANSPORT FUEL OBLIGATION

4.1 Summary of the policy

Maritime 2050 (Department for Transport, 2019), recommended that:

- "Government will consider whether and how the Renewable Transport Fuel Obligation (RTFO) could be used to encourage the uptake of low carbon fuels in maritime…"

This section provides an overview of the RTFO and explores from a theoretical standpoint how it could in principle be implemented in the maritime sector. The following does not indicate government policy commitment.

What is the aim of the RTFO?

The RTFO is one of the government's main policies for reducing GHG emissions from transport fuel, by promoting renewable fuels. The RTFO was introduced in 2008, and used as a means to implement the EU Renewable Energy Directive (European Commission, 2009) and the subsequent Indirect Land Use Change Directive (European Commission, 2015). The RTFO obliges fuel suppliers to supply a minimum percentage of renewable fuel. It is a traded mandate system, with the option to buy out; equivalent to a tradeable permit scheme (baseline-and-credit) with a price ceiling.

Who must comply with the RTFO?

The obligation covers suppliers of road and non-road mobile machinery (NRMM)[18] fuel supplying petrol, diesel, gas oil or renewable fuel totalling 450,000 litres or more in a year. Renewable fuel used in aviation is also eligible for reward, although fossil aviation fuel is not obligated. There are currently approximately 35 obligated suppliers (Department for Transport, 2018a).

How is the level of the obligation set?

The obligation on each supplier is a percentage of its total volume of fuel supplied for road transport and NRMM purposes (Department for Transport, 2018b), which is around 52 billion litres equivalent (Department for Transport, 2018d). The total fuel supplied to the maritime sector in the UK is around 3.4bn litres per year (BEIS, 2018).[19] The obligation is currently set at 8.5%[20] for 2019, rising annually to 12.4% for 2032, providing visibility of the future obligation.

[18] The NRMM sector includes inland waterway vessels that do not normally operate at sea, tractors and recreational craft that do not normally operate at sea.

[19] Sum of the marine bunker fuel supply which covers deliveries to vessels under international bunker contracts, and fuel used in national navigation. Data refers to year 2017.

[20] Share of total fuel by volume.

How does the obligation work?

Fuel suppliers have an obligation to provide a volume of sustainable renewable fuel into the market. At the point when a supplier's fuel becomes liable for excise duty in the UK, it also becomes subject to the RTFO and the volume of renewable fuel that it must provide is calculated.

Obligated suppliers meet their obligation by redeeming Renewable Transport Fuel Certificates (RTFCs), gained by supplying sustainable renewable fuels or bought from others supplying them. Alternatively, suppliers can pay a fixed sum for each litre of fuel for which they wish to 'buy out' of their obligation. This mechanism is administered by the Department for Transport through the online RTFO Operating System and gives flexibility in compliance to obligated suppliers.

Which fuels qualify?

RTFCs are awarded per volume of qualifying sustainable renewable fuels, which can be either biofuels or renewable fuels of non-biological origin (RFNBOs) such as hydrogen produced from renewable electricity. There are certain restrictions on what types of fuels qualify for certificates under the scheme. To qualify, biofuels must meet sustainability criteria to count towards a company's renewable fuel obligation, including minimum GHG savings, which are based on EU RED sustainability criteria (Department for Transport, 2018c). One certificate may be claimed for every litre of sustainable renewable fuel supplied (or per kilogram for gaseous fuels).

The scheme differentiates between different types of fuels:

- There is a limit on the contribution that can come from crop-based biofuels.
- Fuel from certain wastes or residues, fuel from dedicated energy crops and RFNBOs are incentivised by awarding double the RTFCs per litre or kilogram supplied.
- From January 2019, a sub-target for 'development fuels' was introduced, to encourage fuels which can be used to decarbonise 'hard-to-decarbonise' applications, but are at an earlier stage of technology development, and so are more expensive than other fuels.
- From January 2019, RFNBOs and aviation fuel can also gain development fuel RTFCs, although suppliers of these fuels are not obligated (Department for Transport, 2017).

4.2 Examples of renewable transport fuel policies in different jurisdictions

There are a number of similar schemes which impose either a volume-based or energy-based obligation for blending low carbon fuel, or a GHG intensity reduction obligation for fuel supplied.

4.2.1 Volume/energy-based obligations

The Netherlands

The majority of EU Member States have blending obligations for low carbon fuels into the road transport fuel supply. As an example, in the Netherlands biofuels must be blended into fossil fuels at 8.5% in 2018, rising to 16.4% in 2020, on an energy basis (IEA Bioenergy, 2018). Similarly to the RTFO, biofuel produced from wastes can double-count towards a supplier's obligation (USDA, 2018). As in the UK, the Netherlands operates a certificate-based scheme where renewable fuel units (HBEs) can be traded so that obligated parties can either produce their own HBEs or can buy them from renewable fuel producers (E4tech, 2018). Renewable fuel supplied in the Netherlands can be counted towards the obligation, regardless if used in inland, short-sea or deep-sea shipping (NEA, 2018). Renewable aviation fuel is eligible for HBEs, but aviation fuel suppliers are not obligated (ICCT, 2018).

USA

The US Renewable Fuel Standard (RFS) is a national mandate for the use of biofuels which requires a minimum volume of biofuel to be used for transport each year. There are annual targets and sub-targets for supply of four categories of fuels: cellulosic biofuel, biomass-based diesel, advanced biofuel, and conventional biofuel (EPA, 2017). These percentage targets are applied to the annual fuel sales of importers and producers to determine each individual company's renewable volume obligation.

Each qualifying gallon of renewable fuel has its own unique Renewable Identification Number (RIN). At the end of each year, the supplier must have enough RINs to show it has met its share of each of the four mandated targets. Suppliers can also purchase RINs from others or bank RINs for use in a future obligation year. There are civil penalties for the failure to acquire sufficient RINs.

Jet fuel is not subject to the RFS, but producers of renewable jet fuel can generate RINs if their fuel meets specific requirements (EPA, 2017). Renewable fuel that is used in an ocean-going vessel does not qualify for RINs (Dunphy, 2018).

4.2.2 GHG reduction obligation

Germany

In Germany, suppliers are required to reduce the GHG emissions intensity of their fuel by a certain percentage compared to a baseline GHG intensity of 83.8 $gCO_2eq./MJ$ (Bundesrepublik Deutschland, 2017). In 2019, the required reduction is 4%, rising to 6% from 2020 onwards (USDA, 2018). Fuels which have a higher GHG saving therefore have a higher value in the market. There is no double-counting for fuels made from wastes and residues. The GHG reduction obligation applies to companies which trade with petrol or diesel fuels and pay tax on those fuels. Aviation and marine fuels are not subject to this tax and therefore are exempt from the obligation (Bundesrepublik Deutschland, 2017). Fuel volumes for each year are reported to the Main Customs Authority, which is part of the Federal Ministry of Finance (European Commission R. L., 2019).

California

In addition to the USA RFS, suppliers of fuel in California are subject to the California Low Carbon Fuel Standard (LCFS). The LCFS requires producers of fuels to reduce the average carbon intensity of their products by 10% by 2020 and

by 20% by 2030 compared to a 2010 baseline (California Air Resources Board, 2018; Kahn, 2018). Both renewable and non-renewable fuels are eligible as long as their lifecycle GHG emissions are lower than the baseline stipulated.

Credits are generated based on the volume of the fuel supplied and the amount of GHG savings. These credits can be traded between companies to allow the different fuel suppliers to meet their emissions reductions obligations. Low carbon aviation fuels are eligible for credits, but fossil aviation fuel is not obligated (Green Car Congress, 2018). Fuel supplied to ocean-going vessels is also not obligated (Ricardo, 2018).

4.3 Options for implementation

4.3.1 Option 1: Including maritime in existing RTFO

The RTFO currently covers only those fuels which are used for road transport or NRMM uses in the UK. Therefore it already encompasses a small amount of marine fuel (fuel used in inland waterway vessels which do not normally operate at sea and recreational craft that do not normally operate at sea come under the definition of NRMM), but the RTFO does not cover the majority of marine fuels.

Renewable fuels supplied in the maritime sector could be made eligible to receive RTFCs. If the renewable fuel was supplied by a company which has an obligation (a target for how much renewable fuel is blended with fossil fuel) then the fuel can contribute towards meeting that obligation. If the renewable fuel was supplied by a company which is not obligated, such as a company producing only renewable fuel, then the RTFCs could be sold to a company which is obligated. In either case renewable fuel supplied into the maritime sector would gain the same benefit as renewable fuel supplied into other transport sectors in the form of revenue from RTFCs.

There are two key options for how this mechanism could work:

a. **Marine fuel could be included without obligating marine fuel suppliers:** This would mean that suppliers of renewable fuel to ships could benefit from RTFCs which could be sold to other suppliers to help them meet their obligations. However, suppliers of fossil marine fuels would not have a blending obligation, and so would not incur the costs associated with meeting that obligation on their marine fuel. This is the same approach as has been taken for the inclusion of aviation fuel in the RTFO from January 2019.
b. **Suppliers of marine fuel could be obligated:** If this approach was adopted, suppliers of renewable fuel to ships could benefit from the RTFCs, and suppliers of fossil marine fuel would incur the costs associated with blending the required volume of renewable fuel or purchasing an equivalent number of RTFCs in order to meet their obligation.

Under both options 1a and 1b, there is no guarantee that renewable fuel will be supplied into the maritime sector. The amount of fuel supplied into the maritime sector will depend on the relative prices of fossil and renewable fuels in each sector. The price of fossil marine fuel is substantially lower than the price of fossil

diesel, gasoline or kerosene. Therefore, renewable fuel is only likely to be supplied into the maritime sector if the production cost of renewable marine fuel is substantially lower than for renewable fuel for the road or aviation sector, or if marine fuel receives additional support within the RTFO, for example as a development fuel. Even if the suppliers of fossil fuel for shipping were obligated (option 1b), they could purchase RTFCs from suppliers of renewable fuel into other sectors, such as road transport, if this is cheaper than supplying it directly into the maritime sector, or they could buy out.

The existing RTFO obligates only fuel supplied in the UK into the road and NRMM sector which is then predominantly used in the UK. In contrast, in the marine sector, many ships docking in the UK will have re-fuelled in foreign ports, and many ships refuelling in the UK will then travel elsewhere. For consistency with the existing RTFO, it is likely that under option 1b the obligation would be placed on fuels supplied in the UK to the maritime sector.[21] In this case, some of the low carbon fuel would be used outside UK waters, and ships refuelling outside the UK would not have to use low carbon fuel. If suppliers of marine fuel in the UK are obligated, it is likely that the costs associated with meeting this obligation would be passed on to consumers so that the price of marine fuel in the UK would rise. As a result, there is a risk that ship operators refuel in foreign ports instead of in the UK. This may have an economic impact on the UK and could reduce the GHG savings realised by this policy if overall less marine fuel is sold in the UK.

Advantages and disadvantages of approaches 1a and 1b are summarised in Figure 12.

[21] See assessment of option 2 for discussion of other options for how marine fuel could be obligated.

Figure 12 Advantages and disadvantages of options 1a and 1b

	Option 1a: marine fuel included without obligating marine fuel suppliers	Option 1b: marine fuel suppliers are obligated
Advantages	▪ Maintains existing regulatory and administrative set-up. ▪ Obligated parties remain the same. ▪ More supply options to the system could reduce the costs to obligated suppliers of meeting obligations.	▪ Cost of renewable fuels supply is spread among road consumers (UK) and maritime sector consumers (UK and others). ▪ Introducing new obligated suppliers (marine) means that overall volume of renewable fuel in the transport sector would increase, even if the percentage blend obligation remains the same.
Disadvantages	▪ Unless percentage blend obligation is increased, overall volumes of renewable fuel in the transport sector do not increase. ▪ Road and NRMM consumers in the UK pay for the maritime sector emissions savings, because maritime sector fuel suppliers are not obligated. This is likely to be acceptable to road transport consumers only as long as the amount of fuel supplied into the marine sector is small.	▪ Some new companies may become obligated parties – need to adjust to regulatory pressures and administrative requirements. ▪ Increased overall volume of renewable fuel in the transport sector obligation means RTFC prices could increase in the near term, increasing the cost to all consumers.

Source: E4tech analysis

In 2016 the Department for Transport consulted on several changes to the RTFO (Department for Transport, 2016). In its response to the consultation (Department for Transport, 2017) the government addressed requests from stakeholders to include marine fuels in the RTFO, stating that: [22]

> "At this point we do not intend to bring maritime fuels into scope of the RTFO. This is because there is not yet international agreement on how the shipping sector should decarbonise and there may be better alternatives to decarbonise shipping. There is a finite resource of biofuel feedstocks and we need to make sure that it is allocated effectively. As with the inclusion of

[22] The RTFO uses the point at which tax is imposed as the 'control point' for the obligation on suppliers of road fuel. However maritime fuel is not taxed in the UK so alternative administrative arrangements would need to be made.

> aviation fuel, specific administrative measures would also need to be developed as maritime fuel is not subject to the road fuel duty system which the RTFO system uses to minimise the regulatory burden on industry. We will however keep this under review as the International Maritime Organisation develops its carbon reduction strategy."

In addition, a number of other points would need to be considered if the maritime sector were included in the existing RTFO:

- In the UK, renewable fuel supplied into the aviation sector is eligible for development RTFCs, which offer a higher level of support through having a higher buy-out price. If marine fuel were included in the RTFO it should be considered whether renewable marine fuels should be eligible for development RTFCs. The development fuel target was introduced in January 2019 and aims to drive innovation in and deployment of fuels which can decarbonise strategic sectors (Department for Transport, 2016). To qualify as a development fuel, fuels must be made from a qualifying feedstock, and must be either hydrogen, aviation fuel, substitute natural gas, or a high-blend petrol or diesel.[23] If fuel supplied into the marine sector were also a qualifying fuel type for development fuels, it would be important to assess the risk that the development fuels target could be met more easily with fuels supplied into the maritime sector compared to other sectors. In particular, the ability to use lower quality fuels in shipping compared to other sectors may mean that development fuels for shipping can be produced at lower cost and therefore may be supplied preferentially to development fuels supplied to other sectors. Moreover, the impact of the ability to use large quantities of methane in shipping should be considered (given that bio-derived synthetic natural gas is a development fuel), as this could be substantially bigger than the current market for biomethane in road transport in the UK (Fevre, 2018).
- Under the revised Renewable Energy Directive (RED II) (European Commission, 2018) to be implemented by Member States from 2021, renewable fuel supplied into the maritime and aviation sectors counts towards countries' national targets for renewable fuel in transport at 1.2 times their actual volume. If this directive were implemented in UK policy, it would mean that renewable fuel supplied into the maritime and aviation sectors would count towards UK renewable fuel targets at 1.2 times their energy contents. This higher incentive could be passed on to the obligated party, so that maritime and aviation fuel contribute 1.2 times towards each supplier's obligation. However, this is not required under the Directive. Introducing such a multiplier into the policy mechanism could have other market impacts, which should be fully reviewed.

[23] In order to qualify as a development fuel, a fuel must be made from a particular feedstock (renewable electricity or wastes or residues apart from used cooking oils and tallow). In addition, it must be one of a particular type of fuel (hydrogen, aviation fuel, substitute natural gas, or a fuel that can be blended at least at 25% into petrol and still meet EN228 or at least at 25% into diesel and still meet EN590). Aviation fuels which are not made from a qualifying feedstock will not be a development fuel but would still be eligible to receive normal RTFCs (Department for Transport, 2018b).

Conclusion

Inclusion of the maritime sector within the existing RTFO may offer some advantages because the policy framework is already in place. While Option 1a above would be easier to implement, Option 1b would be slightly more likely to engage the maritime sector in the use of renewable fuels and increase the level of renewable fuel supplied, and so enhance GHG savings.

For suppliers of many types of renewable fuel it would provide a wider range of end-markets into which their fuel could be sold. Marine fuel is not taxed in the UK[24] (HMRC, 2019), but even excluding the tax imposed on diesel and gasoline the price of fossil marine fuel is substantially lower than the price of fossil diesel, gasoline or kerosene.[25] Therefore, renewable fuel is only likely to be supplied into the maritime sector if the production cost of renewable marine fuel is substantially less than the production cost of renewable fuel for the road or aviation sector, or if marine fuel receives additional support within the RTFO, for example as a development fuel. New renewable marine fuel policy of any type could stimulate producers to expand their products supplied to include a lower-cost renewable marine fuel.

The cost differential between fossil marine fuel and fossil fuel in other sectors may decrease as more stringent air quality and sulphur regulations are introduced and, moreover, renewable fuels could aid compliance with these other regulations.

As with the existing RTFO, inclusion of marine fuel in the RTFO would contribute to the reduction of GHG emissions from fuel but would not directly support other methods to reduce the GHG emissions from ships.[26]

4.3.2 Option 2: Developing a separate maritime RTFO

A separate maritime RTFO could place a blending obligation or GHG reduction requirement on fuel used in the maritime sector, separate to the obligations based on road and NRMM fuel suppliers under the RTFO. This would ensure that renewable fuels were used in the maritime sector and would therefore send a stronger signal that this was a desired policy goal.

For the purposes of this study it is assumed that a separate maritime RTFO (mRTFO) would have the same aims as the existing RTFO, to reduce the GHG emissions from fuel supplied into the maritime sector. There are a range of other measures which could be taken to reduce the GHG emissions from shipping, such as efficiency measures or alternative propulsion systems. These are not considered to be within scope of a maritime RTFO but could be brought within scope of a more comprehensive policy approach to decarbonising shipping. Similarly, reducing air quality emissions from shipping would require a more comprehensive approach, given that air quality emissions relate to propulsion

[24] As long as it is used for ocean-going (i.e. not inland waterway) commercial craft.

[25] Current Low-sulphur marine gas oil price is around £11/GJ (converted from US$600/metric tonne, as given by: https://shipandbunker.com/prices/emea/nwe/nl-rtm-rotterdam#LSMGO), whereas current wholesale price of diesel and gasoline is approximately £29/GJ (converted from 100p/L as given by https://media.rac.co.uk/blog_posts/average-uk-wholesale-and-pump-fuel-prices-since-january-2015-42326 for wholesale price of diesel and gasoline)..

[26] Energy efficiency measures would be indirectly supported if marine fuel prices were to rise under option 1b.

technology and after-treatment as well as fuel choice. However, as a minimum, it could be possible to place conditions on the award of RTFCs being made only to renewable fuels that are able to meet minimum standards on the sulphur or nitrogen content of the fuel, for example. Importantly, the emissions of air pollutants are dependent on the technologies fitted on the ships using the fuels (such as selective catalytic reduction technology).

A key difference in creating a separate marine fuel RTFO, compared with inclusion of the maritime sector in the existing RTFO, is that this would guarantee that renewable fuels were used in the maritime sector (unless the buy-out price is paid). RTFCs would not count towards mRTFO obligations and vice versa. This may not result in the overall lowest-cost emissions abatement – given that it may be cheaper to achieve the same GHG savings through using the fuel in the road transport sector – but it would ensure that supply chains and capability in the shipping industry were established. The buy-out price could be set above the production cost of renewable marine fuel in order to make renewable marine fuel supply cost-competitive. It could also take into account additional costs in the supply chain, such as fuel storage and delivery, and the operational disruption that may be associated with changing fuel type, in order to be high enough to incentivise supply of renewable fuel into the marine sector.

The advantages and disadvantages of the mRTFO would be dependent on the design of the scheme and level of renewable fuel obligation set. Figure 13 outlines some high-level considerations.

Figure 13 Advantages and disadvantages of option 2

	Maritime RTFO
Advantages	■ Ensures that low carbon fuel is supplied into the shipping sector. ■ As the scheme and regulation would be new and separate to the RTFO, the mRTFO could be set up to be appropriate specifically to the maritime sector. ■ Costs of decarbonising shipping are passed on to customers of the shipping industry (UK and elsewhere).
Dis-advantages	■ May not result in lowest overall cost of decarbonising transport fuel, given that fuel must be supplied into the maritime sector. ■ Would require new regulation, design of the mechanism, enforcement scheme, etc. ■ May make the cost of marine fuel in the UK more expensive than in other countries so could discourage ships from refuelling in the UK and give a competitive disadvantage to UK-based operators (similar challenge has prevented obligation being placed on aviation sector).

Source: E4tech analysis

If a new maritime RTFO were developed, the following factors would need to be considered:

Policy mechanism

It should be decided whether the new maritime RTFO should be a blending obligation or a GHG reduction obligation. A blending obligation could be either volume-based or energy-based. A GHG reduction obligation directly incentivises lower GHG emissions by giving greater support to those fuels which have greater GHG emissions savings.

A policy based on tradeable certificates would be likely to reduce compliance costs across numerous and diverse maritime fuel suppliers for whom the costs of supplying a unit of renewable fuel might vary. The existing RTFO has a buy-out price which caps the cost of compliance and protects the consumer from very high fuel prices, and it is likely that for the same reason a buy-out would be required in the mRTFO. Setting the buy-out price at the correct level would be critical to provide sufficient incentive to new fuel types, without undue cost burden on obligated parties.

It should also be carefully considered whether the maritime RTFO would adopt the same double-counting and development fuels policies as the existing RTFO, which gives higher levels of support to some types of fuels. Adopting a different approach to the existing RTFO may cause confusion and an administrative burden on fuel suppliers and traders.

Obligated party

The obligated party would need to be defined under a new maritime RTFO and could include ship operators or suppliers of shipping fuel in the UK.

It would likely be most straightforward to implement if the obligated party was the supplier of shipping fuel, as in the existing RTFO, rather than the ship operator. In addition, some of the companies obligated may have experience of the existing RTFO if they supply fuel into both the road and maritime sectors. As discussed in Section 4.3.1, it is likely that UK legislation could only obligate suppliers of marine fuel in the UK. This may increase the cost of marine fuel in the UK, which could result in ship operators choosing to refuel in foreign ports instead. However, large ports such as Rotterdam are already a generally more competitive place to bunker than the UK, with greater choice and volume of fuels and therefore lower prices, so the impact of RTFO-mediated price increases may be limited.

If the obligated party was the ship operator, this might provide an opportunity to integrate low carbon fuel supply with other measures for reducing GHG emissions from shipping, such as efficiency measures or alternative propulsion systems, which could enable a lower overall cost of GHG emissions reductions. The information collected through the EU Monitoring, Reporting and Verification (MRV) regulation (European Commission, 2015a) provides an example of how such a scheme could be implemented, and the data collected through the MRV regulation could facilitate an mRTFO if this regulation is adopted in the UK. However, the ship operator often does not own the ship, leading to owner–operator barriers to action, as described in (Frontier Economics et al., 2019).

It should be decided whether some operators or fuel supplied into certain end-uses are excluded from the obligation, such as suppliers or users of very small volumes of fuel, or for specialised craft such as emergency services.

As noted in Section 4.3.1 maritime fuel is not subject to the road fuel duty system, which the current RTFO system uses as the 'control point' at which a supplier's obligation is calculated. Therefore, an mRTFO would need to define an appropriate control point at which reliable and consistent data is available so that the obligation could be calculated. The decision of who would be the obligated party would impact the choice of control point at which the policy acts.

Level of the obligation

The level of the obligation, i.e. the percentage of each supplier's fuel supply which must be renewable or the percentage emission reduction, would need to be decided. For industry players to be able to invest in new plants, it is important that there is certainty around the level of the obligation for a long period of time into the future.

Qualifying fuels

It would need to be decided which fuels were eligible to count towards a blending obligation or GHG reduction requirement in the maritime RTFO. Under the existing RTFO, biofuels and RFNBOs (generally fuels produced from renewable electricity) can contribute towards a company's blending obligation. Including the same fuels covered by the existing RTFO within the marine RTFO would minimise distortions, although reasons for adopting a different scope should also be examined. Whether the same sustainability criteria are imposed on fuels under the maritime RTFO as under the existing RTFO should also be decided, though these would need to be at least as stringent as for the RTFO.

By making a new maritime RTFO there may be opportunity also to bring in other sustainability criteria, for example concerning air quality, which may be specific to the maritime sector and which are not included under the existing RTFO.

4.3.3 Assessment of options for implementation

This sub-section assesses the proposed options for implementing economic instruments to reduce the GHG emissions of marine fuel (see Figure 14).

Figure 14 RAG rating for RTFO alternatives

	Option 1 – inclusion within RTFO		Option 2 – new maritime RTFO
	a: not obligated	b: obligated	
Business flexibility	Fuel can go into road transport sector if lower cost.	Fuel can go into road transport sector if lower cost.	Allows flexibility within maritime sector.
Certainty of emissions impact	Provides certainty, except if companies buy out of the obligation.	Provides certainty, except if companies buy out of the obligation.	Provides certainty, except if companies buy out of the obligation. Requires robust sustainability criteria as in the RTFO.
Encourages technological innovation	Does not necessarily drive innovation in ships or shipping fuels.	Does not necessarily drive innovation in ships or shipping fuels.	As long as the buy-out price is set at an appropriate level to ensure fuel is supplied into the maritime sector, shipping companies and fuel suppliers have to innovate.[27]
Wider benefits	May be some technology development as a result of policy.	May be some technology development as a result of policy.	More likely to have technology development if fuels are incentivised into maritime sector. Opportunity to integrate with other policies e.g. AQ.
Emissions leakage	Little risk of emissions leakage - the obligated companies are still road transport sector, which cannot easily move operations outside the UK.	Some risk of emissions leakage – ships could refuel outside of the UK to avoid paying higher price for fuel. This would not necessarily create additional emissions, but could reduce the overall GHG saving achieved.	Some risk of emissions leakage – if suppliers of fuel in the UK are obligated then ships could refuel outside of the UK to avoid paying higher price for fuel; if ships passing through UK waters are obligated then ships may divert to avoid UK waters. This could reduce the overall GHG saving achieved.
Ease of practical implementation	Easy integration into existing RTFO.	Easy integration into existing RTFO. Some new suppliers may be obligated, therefore facing costs of verification and compliance.	New legislation needed. Some new suppliers may be obligated, therefore facing costs of verification and compliance.
Investor certainty	Fixing blend obligation for the longer term helps with investor certainty, but value of certificates can fluctuate so hard to put together 'bankable' project based on their value.	Fixing blend obligation for the longer-term helps with investor certainty, but value of certificates can fluctuate so hard to put together 'bankable' project based on their value.	Opportunity to provide good investor certainty. Dedicated RTFO for maritime sector would allow the buy-out to be set at a level to encourage marine fuel supply, and so give greater certainty to marine fuel supply chains. Long-term certainty in level of obligation still required.

Source: E4tech analysis

4.4 Policy insights

Option 1, including marine fuel in the existing RTFO (with or without obligating marine fuel suppliers), provides perhaps the most straightforward option for integrating marine fuel into existing RTFO legislation. It would provide a high degree of flexibility for decarbonisation of the transport sector as fuels could be used in the road, aviation or maritime sector in order to meet a company's blending

[27] The existing RTFO has a buy-out price, and this assessment assumes there is also a buy-out price in the marine RTFO

obligation. This could reduce the overall cost of compliance. However, this also creates a risk that renewable fuels are concentrated in the sector with the most attractive economics, discouraging innovation in other fuel production methods or end-use sectors which could be important for longer-term decarbonisation.

Option 2, developing a separate maritime RTFO, would require additional legislation but would ensure that renewable fuel is supplied into the maritime sector. This could stimulate innovation in low carbon marine fuel. With option 2 it could also be possible to design the new marine RTFO to provide wider benefits, for example in terms of air quality, or even to support a wider suite of shipping decarbonisation options beyond low carbon fuels.

For both option 1 and option 2, providing a long-term outlook and relatively stable level of support is important to give investors certainty to develop the infrastructure and technologies required to bring renewable marine fuels to market.

5 POLICY EXAMPLE: NORWEGIAN NO_X FUND

This section looks at a case study of the Norwegian NO_x Fund which has been operational in Norway. The potential impact of the Fund on market incentives and behaviour is considered along with its pros and cons. The following is a case study of one particular policy instrument applied in another jurisdiction. It does not represent UK government policy, which is a matter for the Treasury.

5.1 Introduction to emissions levies

How does an emissions levy work?

Emissions levies can be applied ex-ante or ex-post. In the former case, the fee is applied and then the funds from the fees are used to fund an abatement activity. In the latter case, the abatement investments are made and then the fee is imposed on parties to fund the cost of those activities. Emissions fees can be applied, either on quantity of emissions produced, for example a particular charge per tonne of emission, or they can be applied as flat rate fees, for example a particular charge from each relevant organisation.[28] In practice, such charges often vary in order to have differing impacts on incentives, or to address distributional issues. For example, the charge per unit of emissions could vary depending on how many emissions are produced, or the flat rate charge per organisation could vary depending on the characteristics of the organisation (such as its size, location, nature of business, level of prior emissions efficiency, among others).

What barriers are addressed by the policy?

Emissions levies (and emissions subsidies) are intended to address a number of barriers that can otherwise hinder action to reduce emissions. These include:

- Negative externalities which arise because the prices paid for the most polluting fuels do not reflect the cost to society of the environmental or other damage they cause. In this case, the levy can ensure the price paid better reflects the true 'social' cost of the fuel.
- Imperfect information on abatement opportunities which arise because some parties do not have access to sufficient or correct information about how to reduce their emissions. For levies which provide funding back to organisations to fund abatement technologies, it is likely that information on those technologies is revealed.
- Myopic outlook whereby some parties only consider the immediate or short-term outcomes or costs they face and not what could happen in the future. By encouraging investment in abatement options, this encourages the parties to consider the options likely to be of benefit to them over the medium to long term.

[28] Flat rate fees are usually tiered according to different variables e.g. emissions at design stage, type of vehicle/activity, where the activity is taking place.

- Access to credit (cost of capital) is an issue because some organisations find it challenging to raise sufficient low cost capital to make long-term investments, such as emission reduction technologies, which may have a pay-back period of several years. If the revenues from the levy are used to provide funds for organisations to lower the cost of those emissions reduction technologies, or lower the cost of capital, it can increase the uptake of those technologies.

How do emissions fees address resistance to pricing instruments?

Carattini et al. (2017) provide a meta-analysis of over thirty studies on the acceptability of economic instruments and show that emissions levies have considerable advantages over other approaches to pricing emissions. Refunding the revenues generated from the levy can significantly ease the burden on the polluting firms and thereby reduce industry resistance to the levy (Sterner & Robinson, 2018). In turn, this can in some cases reduce the risk of emissions leakage that may otherwise occur (where firms could move their business or service location to another jurisdiction in order to avoid an emissions levy) (Sterner & Robinson, 2018). When revenues go into the general government revenue budget, evidence suggests that public acceptance of the payments is lower (Baranzini & Carattini, 2017), whereas when they are hypothecated for environmental purposes, they are generally more acceptable (Carattini et al., 2017).

An example of an emissions levy that has been implemented in recent years is the Norwegian NO_x Fund, discussed in the next section.

5.2 Example of emissions levies in different sectors and jurisdictions – the Norwegian NO_x Fund

Background

The Norwegian NO_x Fund evolved from the NO_x tax that was introduced in 2007 by Norway. The NO_x tax, of NOK 15 per kilogram (kg) of NO_x (approximately GBP £1.35 per kg in 2007 prices) was introduced in response to the Gothenburg Protocol, which was adopted in 1999 (EDF, 2018).

The Norwegian oil and gas industry spearheaded the creation of the NO_x Fund as they wanted an alternative to the NO_x tax. After several negotiations between the authorities and industry associations, 14 industry associations and the Ministry of Climate and Environment signed an Environmental Agreement on NO_x, which entered into force on 1 January 2008. The agreement allowed the industry to pay an amount of money, lower than the original tax, to the Fund that would be then used to finance NO_x reduction measures.

Industries covered by the NO_x Fund

Industries covered by the NO_x Fund agreement (those paying the lower NO_x Fund fees compared to the NO_x tax) include oil and gas, mining, railways, aviation and shipping (including fishing). For shipping, which is represented by the Norwegian Fishing Vessel Owners Association, the Norwegian Shipowners' Association and

the Federation of Norwegian Coastal Shipping, the NO_x Fund covers emissions from vessels within Norwegian territorial waters and Norwegian flagged ships (even if part of the voyage takes part outside Norwegian waters) (EDF, 2018).

NO_x Fund fees

The original NO_x tax was set at NOK 15 (GBP £1.35) per kg of NO_x. The NO_x Fund charges a lower emissions levy of NOK 8.5 (GBP £0.77) per kg of NO_x (NOK 14.5 or GBP £1.30 per kg for the oil and gas sector). The emissions levy is differentiated by sector because some sectors face a higher cost of abatement compared to other sectors. For example, the offshore oil and gas sectors face higher costs of reducing emissions than other sectors such as shipping (based on the analysis by the expert advisory panel) and therefore the levy is higher for this sector (NHO, 2019). For the years 2020-2025, levy rates are expected to be NOK 16 (GBP £1.42) for oil and gas, and NOK 11 (GBP £0.98) per kg NO_x for all other sectors (EDF, 2018).

The charges per kg of NO_x are determined by the Board of the Fund, based on analysis by an independent entity (DNV GL), illustrating how much money is required to achieve the reductions necessary to meet a particular emissions ceiling (in tonnes), which has been agreed in the NO_x Agreement. The NO_x emissions ceilings are reduced by 20,000 tonnes every two years, meaning more and more action to reduce emissions is required (particularly in the face of growing emissions-generating activity). The combined total ceiling for 2018 and 2019 is 202,510 tonnes of NO_x and the combined total for 2020 and 2021 is 192,510 tonnes of NO_x (NHO, 2019). The cost of the emissions levies is generally more stable compared to the cost of permits under a cap-and-trade instrument, where the market determines the price participants pay (and is therefore subject to volatility), because it is set for a period of time.

Distribution of revenue

The revenue raised from the NO_x Fund has provided $468 million in direct financial support for over 1,000 projects and has leveraged private spending of $1.64 billion (USD) for broader NO_x reduction measures. The NO_x Fund provides up to 80% of the investment cost of NO_x reduction measures that require that support in order to be commercially viable. Of the 1,139 projects, by far the most have been in shipping (927), followed by oil and gas (110) and a small number in other sectors. The projects funded by the Fund have been in the areas of emissions abatement technology, with the majority around energy optimisation, selective catalytic reduction, motor technical conversions, LNG conversions and shore power.[29] Between 2008 and 2010, the Fund led to a total reduction of 18,000 tonnes of NO_x, while the 2011-2017 agreement has resulted in 16,000 tonnes of NO_x reductions, and by 2019 a further 11,000 tonnes of NO_x reductions will be achieved, resulting in a total of 45,000 tonnes of NO_x reductions over the life of the fund to date (EDF, 2018).[30]

[29] Data analysed from NHO (2019).

[30] The reductions are expected to increase as the emissions ceilings agreed under the NO_x agreement get tightened; between 2018-2025, the emissions ceiling is reduced from 202,510 to 172,510 tonnes of NO_x, thus a minimum of 30,000 tonnes of NO_x is guaranteed to be reduced under the fund.

Operation of the NO_x Fund

There are three key steps in the operation of the Norwegian NO_x Fund:

1. Fund members submit a NO_x report to the Fund each quarter detailing all their NO_x emissions. Various verification checks are carried out. For shipping, these include the use of Automatic Identification System (AIS) data. Tracking the NO_x emissions by quarter allows the Fund to monitor the extent to which the NO_x reductions are on track to meet the targets.[31]
2. Fund members **pay the NO_x levy** into the Fund
3. Once the fees are paid (ex-ante), members are eligible to **apply for investment support** for NO_x abatement measures that would otherwise not have been cost-effective or would not have been considered. However, the final support amount received is determined after the measure has been completed and the NO_x reduction is verified by the independent entity, which also provides recommendations regarding the prioritisation of measures to ensure the most cost-effective use of the Fund's finances.

Conclusions

The Norwegian NO_x Fund presents a relevant example of how a levy-based economic instrument can be applied, targeting a particular pollutant. It takes a ceiling element from a cap-and-trade instrument, which gives certainty on the emissions reduction for the particular pollutant being targeted, and sets a levy rate which remains the same per unit of emission which gives it the certainty over the charge per unit of emissions in the short to mid-term. Moreover, the revenues generated from the levy are directly used in the sector for emission reductions, so there is transparency over how the revenues are used and a lowering of the costs of investing in emissions reduction actions or technologies. This was seen to enhance its public acceptability (Carattini et al., 2017). Furthermore, the participatory approach (involving public and private stakeholders) of the Fund creates intangible benefits, such as increased cooperation of the entities that are being targeted, under the polluter pays principle.

Other aspects that appear to be relevant to the effectiveness of the NO_x Fund are:

- Clarity over the charge base and scope: it was clear that NO_x emissions were targeted by the intervention, and the relevant participants that were required to pay the charge were clearly identified in the NOx Fund agreement.
- Independent setting of the level of the levy rate: the Board of the Fund determines the charge, with independent specialist advice.
- Ability to measure and verify emissions: various verification checks are carried out. For shipping, these include the use of AIS data.
- Clarity over how the revenues are to be used: the Fund supported investment in emissions reduction options.

[31] In order to improve the documentation of NO_x emissions, the NO_x Fund also provides support for NO_x measurement on ships and removable rigs.

However, there are several draw-backs to the NO_x Fund. The first is that it targeted only one form of pollutant – NO_x – and that, as only those emissions are monitored as part of the operation of the Fund, there may inadvertently be adverse impacts on other emissions. For example, some of the technologies or actions that reduce NO_x emissions can inadvertently increase other emissions, such as GHG emissions. Therefore, there is a potential risk that improvements can be made in addressing the emissions of NOx, but the problem then shifts to making emissions of other pollutants or GHG emissions worse. This could potentially be a worse outcome for society as a whole.

Analysis of granted support in the Norwegian NO_x Fund shows that almost 10% of the 1000 projects supported LNG conversion/retrofit and newbuilds (NO_x-fondet, 2018). Of these LNG projects, the majority were in shipping (67 projects), mainly on LNG conversions of existing vessels and one infrastructure project. This indicates a possible case of perverse incentives or unintended consequences led by policy. This is because, as Baresic et al. (2018) and Speirs et al. (2019) show, there is no significant GHG reduction achieved using LNG as marine fuel, rendering it as an obsolete investment (or risk of stranded assets) if genuine efforts were made to achieve the IMO's 2050 objectives or UK's Climate Change targets.

The second draw-back is that it is not clear why NO_x has been targeted, as opposed to, for example, sulphur emissions or particulate matter. The focus on NO_x could send a signal to the public that the other pollutants are in some way not as important or harmful.

Third, the focus on NO_x emissions could potentially miss the opportunity to take a more integrated and cohesive approach to addressing emissions from industry, or in this case, shipping. By considering emissions reduction options that are able to address multiple emissions and taking a co-ordinated approach could lead to greater efficiency in addressing emissions than focusing only on one pollutant within the economic instrument design.

5.3 Policy insights

The NO_x Fund is a combination of an emissions fee and a subsidy (i.e. revenues from the fee or levy are used to distribute back to industry to fund emissions-reducing activity or technologies).

Although there are many advantages of the Norwegian NO_x Fund, a major challenge is that in focusing on NO_x only may result in investments being made to reduce NO_x emissions at the expense of GHG emissions or other air pollutants, or missing opportunities to invest in different abatement options to reduce those wider emissions alongside NO_x.

A fund which considers air pollutants and GHGs as a package could be more effective in avoiding unintended adverse outcomes on other emissions.

The Norwegian fund shows that the key issues for successful implementation were:

- **Clarity over the charge base and scope**: Defining which ships or shipping activity would be subject to the levy (or charge). This took into account practical issues (such as what information would be required from which ships and in

what format); enforcement issues (such as what would happen if a shipping firm did not pay the required levy or did not report emissions); the potential for competitive distortions; and, the extent to which funds were distributed to foreign shipping firms.

- **Interaction with existing policies**: Consideration of how the fund interacts with other policies such as the Emissions Control Areas (ECAs), in which there are already constraints applied to shipping within defined areas.
- **Responsibility for the fund**: Defined structures for who is responsible for the implementation of the levy; who is responsible for enforcement; who is responsible for distribution of the revenues.
- **Costs and benefits of the intervention**: The responsiveness of different parts of the shipping industry to the implementation of a levy, the likely cost burden on industry, the level of revenue generated, the level of emissions reduction that could be delivered (whether through behaviour change to reduce emissions so that the levy burden is lower, or through the reduction in emissions if the revenues can be used to fund emissions-reducing investments), and any potential unintended consequences.
- **Monitoring and evaluation**: For the Norwegian NOx levy to be effective, it needed to be appropriately monitored to ensure that the desired outcomes were being achieved, at the anticipated cost, and that unintended impacts were identified and managed. Learning and adapting the intervention is important to ensure it remains effective and least cost over time.

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