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Benchmarking the Performance of Alternative Fuels on Container Vessels

by

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Abstract

The 4th IMO greenhouse gas study has revealed that emission estimates from previous IMO studies have been surpassed. The importance of decarbonizing the maritime industry is clear, however there is yet a consensus on what would be the most dominant fuel in 2050. A purely economic consideration on the choice of alternative fuels may only favour some stakeholders. For this reason, we assess and benchmark alternative fuels that are most likely to be part of the maritime fuel mix with the added consideration of emissions resulting from the combustion of these fuels. Two types of efficiencies are defined - economic and environmental - and the performance of alternative fuels is assessed according to these efficiencies in the years 2021 and 2050. The addition of a proposed compliance balance penalty by the EU commission is added to the price of these fuels in the 2050 scenario. Our results indicate that LNG is the most economically and environmentally efficient fuel of 2021. It is closely followed by LPG. H_2 proves to be environmentally efficient for short sea shipping, but quickly loses its position in longer voyages due to price of the fuel and loss in cargo carrying capacity. In 2050, we find that fossil-based fuels are displaced by zero-carbon fuels mainly due to the effect of the compliance balance penalties. With the added dimension of improvements in technological readiness levels in the production of alternative fuels, we find that competition between fuels erodes to a larger extent, making ammonia and H_2 the clear choice of fuels by 2050.

Acknowledgement

I started my thesis journey with the aim of distilling all my learnings over the last year into the research. This would cost me severely in keeping pace with the deadline. Most students faced a starting issue, and I was no exception. Fortunately for me, I had 3 incredible sources of support and strength.

With hardly any real life interaction during the master’s program, I would have been tempted to say that I finished an online masters had it not been for my internship at the venture building studio, ENVIU. I was introduced to some inspiring individuals from the THRUST program. The passion they shared for making the maritime industry green was infectious and provided the stimulating environment needed to ideate and discuss. A special thanks to Tim and Maarten for being patient “sparring” partners during my internship.

Although I was assigned a supervisor initially, it was clear to me that Prof. Michele Acciaro would have been a far better match, not only because of his familiarity with the topic, but simply because he was one of the best instructors we’ve had at MEL. Our discussions on the thesis topic spanned many zoom calls, which went well beyond the quota allotted by the university. His elaborate comments at every stage, helped me shape the thesis to what it is. Thank you Prof. Acciaro.

Special mention goes out to my friend and course mate, Abhilash Basavaraj, for introducing me to the methodology that I’ve chose to conduct my analysis, and for being my Excel/Word guru.

Finally, my entire time at MEL would not have been half as fruitful had it not been for the support I received from my wife Shiba. From her signature masala chai, which I’d relish even during the online class sessions, to her irreplaceable company. Well, there’s enough subject matter in between to constitute an entire thesis.

Nothing about 2020/21 was typical, including the MEL experience. But it was undoubtedly the “dry-docking” that my career needed. Thank you!

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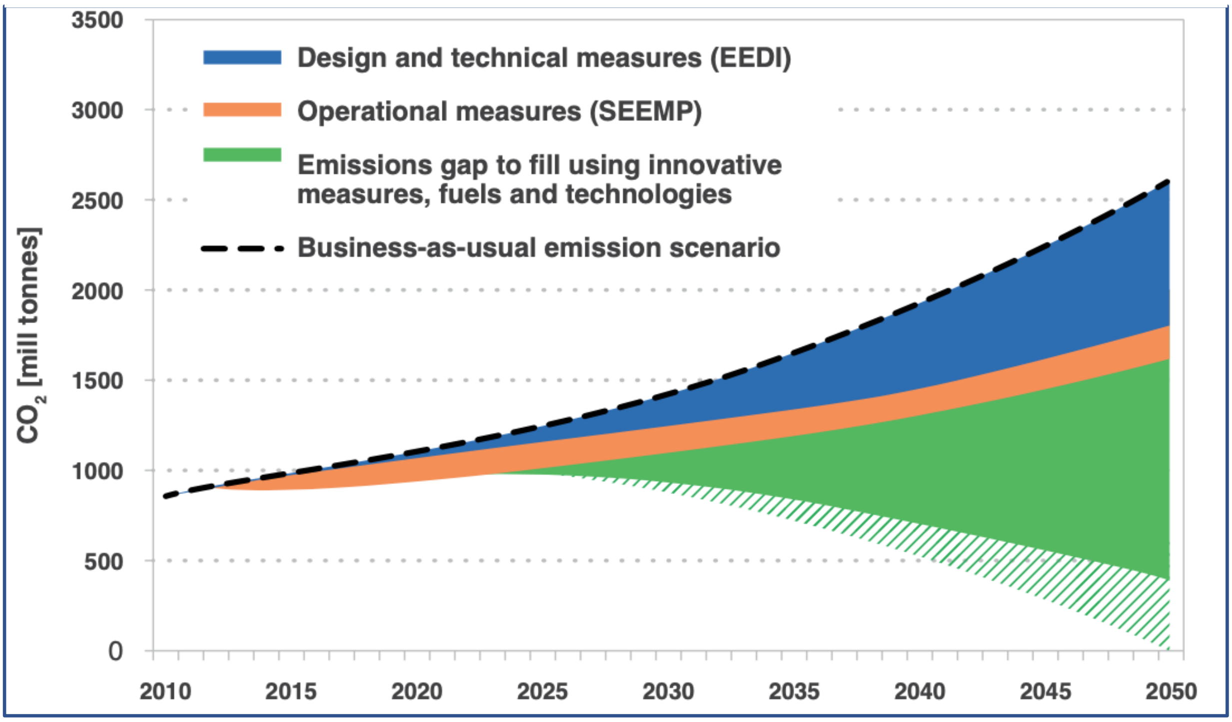
1 Introduction

1.1 Background and Objectives

Maritime transport's contribution to GHGs has been estimated at 2.5% and CO2 emissions amount to around 1052 million tons (IMO, 2020a). When examining the world container fleet, the growth of 45% between 2011 and 2019 led to a corresponding CO2 emission increase of only 2% (Asariotis et al., 2020).

Despite the reduction in carbon intensity, emission from international shipping has gained attention over the last decade (Shi, 2016); (Wang et al., 2015). Increasing awareness w.r.t the impacts on health and environment has called for collective (Unfccc, 2015). The IMO has recognized that operational measures alone would not be sufficient, but rather, adoption of new technology powered by alternative fuels would be the way forward.

Figure 1: IMO's GHG reduction pathway



Source: (IMO, 2020a)

1.2 Problem identification

Results of the 4th IMO GHG study have revealed that shipping's contribution to emissions has exceeded the previous estimates from the 3rd IMO GHG. The reason for this revised estimate was a shift from vessel-based emission estimation to voyage-based estimation. The use of AIS data has not only helped improve the classification of international shipping from earlier methodologies that categorized ships < 2000 GT as domestic ships (Harilaos et.al, 2020), but also made the methodology consistent with the guidelines set out by the Intergovernmental Panel on Climate Change (IMO, 2020a). Comparisons to the top-down approach and the bottom-up approach adopted in the 3rd and 4th GHG study respectively also show that the gap between the two methodologies is closing in. With the introduction of the measures such as the EU's Measurement, Reporting, and Verification (MRV) of greenhouse gas emissions and IMO's Fuel oil Data Collection System (DCS) in 2017 and 2018, accuracies in the calculation of emissions will be more accurate (DNV, 2019)

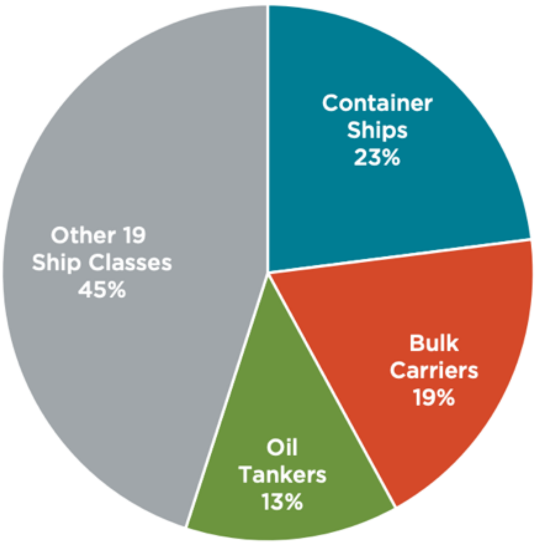
Table 1: Total shipping, voyage-based, and vessel-based international shipping CO2 emissions 2012-2018

Year	Global anthropogenic CO_2 emissions	Total shipping CO^2	Total shipping as a percentage of global	Voyage-based International shipping CO_2	Voyage-based International shipping as a percentage of global	Vessel-based International shipping CO_2	Vessel-based International shipping as a percentage of global
2012	34,793	962	2.76%	701	2.01%	848	2.44%
2013	34,959	957	2.74%	684	1.96%	837	2.39%
2014	35,225	964	2.74%	681	1.93%	846	2.37%
2015	35,239	991	2.81%	700	1.99%	859	2.44%
2016	35,380	1,026	2.90%	727	2.05%	894	2.53%
2017	35,810	1,064	2.97%	746	2.08%	929	2.59%
2018	36,573	1,056	2.89%	740	2.02%	919	2.51%

Source: Adapted from *(IMO, 2020a)*

Emission from container ships amount to nearly a quarter of the emissions in shipping Fig 2. However, wide scale adoption of alternative fuels is particularly challenging due to the lower energy per unit volume of these fuels (Mao et al., 2020).

Figure 2: Share of CO2 emissions by ship class

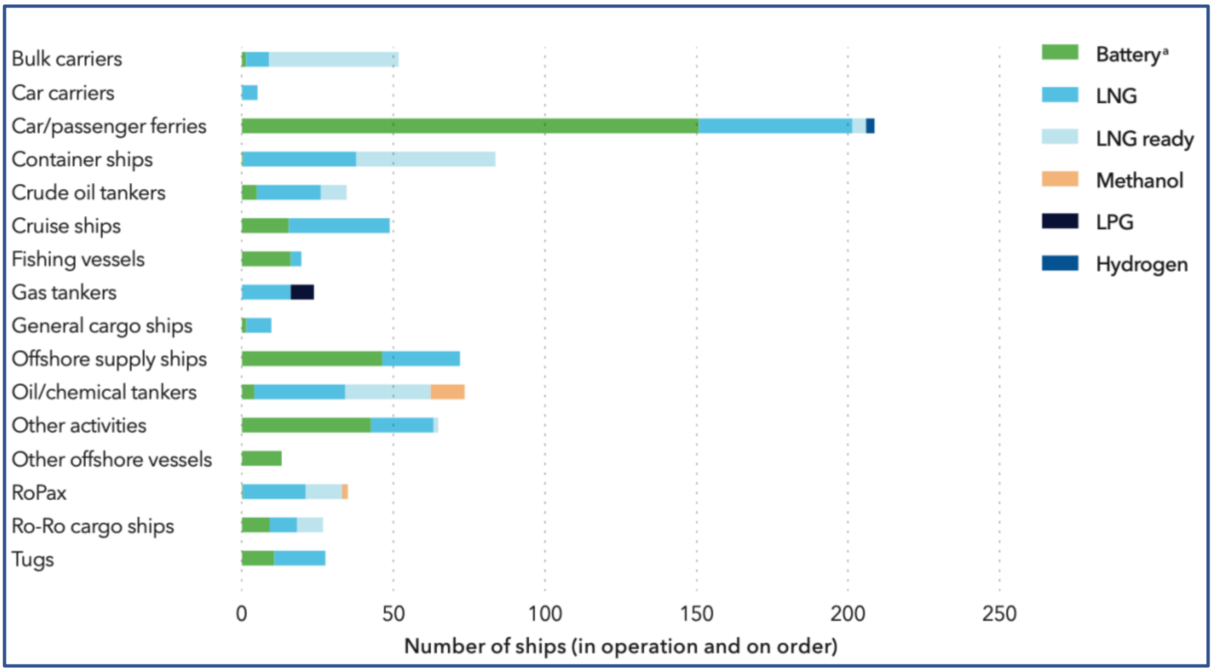


Source: (Olmer et al., 2017)

While keeping the broader goal of decarbonizing shipping in mind, the question that remains unanswered is which fuel types appear most promising in contributing to the reduction in pollutants.

The current orderbook shows that ship owners have a large appetite for LNG vessels (Clarkson Research, 2021). Although LNG is a cleaner burning fuel, wide scale adoption of fossil LNG will not be the solution to achieving the IMO goals of reducing greenhouse gas emissions from shipping by 50% in 2050.

Figure 3: May 2019 status of uptake of alternative fuels by ships in operation and on order



Source: (DNV, 2019)

1.3 Research question

Motivated by the problem statement discussed earlier, the study focusses on the following main research question:

How do you benchmark the performance of alternative fuels on container vessels?

The aim of this study is to understand how the current mix of alternate fuels affects the technical efficiency of container vessels of varying sizes. To achieve this understanding, we will use a model that not only considers parameters which assess the economic efficiency of the vessels, but also takes into account the impact of the emissions by the chosen fuel. The results will help guide stakeholders to allocate resources more efficiently, giving the necessary impetus to the adoption of alternative fuels.

By critically analyzing the results of the analysis, solutions to the below mentioned sub research questions can be derived. These questions are essential to comprehensively answering the main research question.

Sub research questions:

1. What are the inputs and outputs to be considered while applying the DEA technique to compare the technical efficiency of the vessels?
2. How is the efficiency score of each vessel impacted by variations in the vessel size and emissions?
3. What is the impact of GHG emissions on the efficiency scores of the vessel?
4. How do varying degrees of Technology Readiness Level (TRL) captured by variations in price of fuel impact the efficiency score of the vessel?
5. How do penalties from EU's *FuelEU* proposal affect efficiencies of the vessels

1.1. Research Design and Methodology

In this study, we benchmark the technical efficiency of alternate fuels on container vessels using the Data Envelopment Analysis (DEA) methodology. The efficiency measure will also include the undesirable output of GHG emissions.

In order to answer the main research question comprehensively, 4 sub-research questions have been formulated. The choice of parameters and model formulation are covered in sub-research question 1. Sub-research questions 2,3, 4, and 5 utilize the model to conduct the necessary analysis.

The non-parametric approach of the DEA to calculate the efficiency frontier is appropriate in our study since the data base does not follow any statistical distribution. Efficiencies are calculated on the basis of comparing a unit under evaluation to the best performing unit in that given data set. Since the conventional DEA model consists of multiple units on the frontier, we use the bootstrapped methodology to provide added discrimination to the efficiency scores. This will result in unique scores which can be considered an index or ranking order.

In sub-research question 1, parameters which contribute to the technical efficiency of the vessel are identified. They are classified as inputs and outputs. An important consideration while choosing these parameters is to maintain the condition of isotonicity. Since the data for the parameters are largely unavailable, empirical calculations would not be possible. The database will be constructed based on values derived from naval architectural principles and theoretical values of emissions from existing literature. The database will comprise a number of vessels units known as decision making units (DMUs). Each DMU is a distinct combination of TEU and alternative fuel type used. We will also define 2 measures of efficiency to conduct our analysis – Economic efficiency and Environmental efficiency.

In sub-research question 2, we run the model formulated earlier to establish a benchmark of the most technically efficient vessels. Multiple iterations of the model will be run to evaluate the efficiencies of the DMUs by varying the vessel size. This will provide an alternate list of efficient DMUs based on vessel size. Insights on the most efficient fuel type can be drawn under varying conditions of voyage duration and vessel size.

In sub-research question 3, the negative impacts of GHGs and other emissions are analyzed. A comparison of the efficiencies of the DMUs will be conducted. The inclusion of parameters such as equivalent fuel price, engine room volume, and emissions will provide an understanding of the gap that exists in making a choice a fuel more efficient.

In sub-research question 4, we translate the technological readiness level of the fuel mix into a price. Since the price variation occurs on the basis subsidies, carbon tax, and maturity levels of production, storage, and distribution mechanisms of the fuel mix, the analysis will provide insights into technical efficiencies during different time periods.

In the final sub-research question, we apply the compliance balance penalties to vessels in accordance to the proposal from the EU's FuelEU proposal, which is part of the Fit for 55 package.

1.4 Thesis Structure

The paper is organized as follows:

Chapter 1 contextualizes the study with a brief discussion of the background and problem identification. This is followed by a mention of the main research question, sub-research questions, and the methodology to be adopted.

Chapter 2 describes the state of the art, in which the existing literature on DEA methodology used in the maritime context is discussed. A discussion of viable alternative fuels is carried out detailing the properties, production technologies, and emission profile. The chapter also demonstrates the regulatory frame work and measures taken at the IMO and EU level currently in place.

Chapter 3 details the choice of methodology. The parameters for the study are defined and introduced. Relationship between the parameters is assessed under a set of reasonable assumptions. Population of the database is carried out in this chapter as well.

Chapter 4 presents the results and inferences made on the study. A sensitivity analysis is also conducted to understand the impact of price on the technical efficiency.

Chapter 5 provides the conclusion of the study with recommendations to various stakeholders along with the scope for future research.

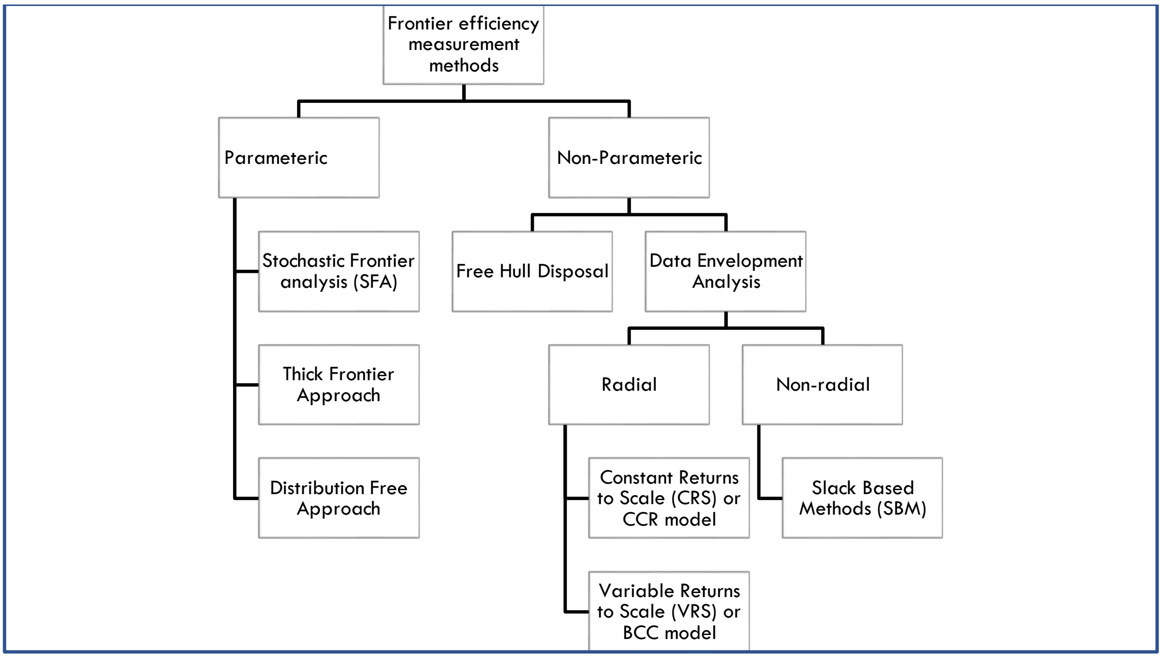
2 State of the Art

In this section we discuss the reasoning behind our choice in adopting the DEA methodology and summarize relevant studies in the maritime domain that have used the DEA method. Policies and initiatives from the IMO and EU are mentioned with a discussion on the roadmap to 2050. Finally, we describe the technological developments, key properties, and the current regulatory framework in alternative fuels.

2.1 DEA Methodology

Data envelopment analysis (DEA) was developed by (Charnes et al., 1978) to determine the production efficiency of different firms by estimating the production frontier. The efficient firms lie on the frontier and envelop the other non-efficient units. DEA uses liner programming to determine which one of the firms or decision-making units (DMUs) are efficient, and which ones are not. The non-parametric approach to estimating the production possibility set between the input and output parameter (Cooper et al., 2007), makes DEA a highly versatile tool which can be used in a number of industries such as healthcare, finance, engineering, education, logistics and supply chains, and transportation. Also, DEA has the unique ability to determine the efficiencies without allotting weights to the multiple input and output values (Abdullah Aldamak & Saeed Zolfaghari, 2017).

Figure 4: Frontier approaches to measuring efficiency



Source: Author's elaboration

Below are mentioned, as adapted from (Zhu, 2014) and (Cooper et al., 2007), the advantages and disadvantages of the DEA technique over the conventional regression-based production function.

Advantages:

- DEA can handle multiple inputs and outputs with different units.
- No requirement for any assumption of a functional form relating inputs to outputs.
- Targets for inefficient DMUs are set to make the DMUs under evaluation efficient.
- Slacks in inputs and outputs are identified
- No requirement for a priori judgment to the relative importance of the various outputs or knowledge of input prices.

Limitations:

- The non-parametric technique makes statistical hypothesis testing difficult
- The efficiency measure is not an absolute value.
- Since the measured efficiency is relative efficiency, comparison of the performance of a firm can be made with only those firms which are in the reference set.
- There is a degree of sensitivity associated with the choice of the input-output variables and number of firms.
- Results are influenced by the sample size. If sample size is small, discretionary power of model reduces.

2.2 DEA applied in Maritime Industry

DEA has been widely used in the maritime industry to evaluate supply chains, port and terminal efficiencies, container shipping lines, cruise lines, and bulk cargo shipping lines.

(Wilmsmeier et al., 2013) measured the efficiency of 20 container terminals in 10 countries. The DEA methodology was used to analyze the effect of rapid external economic shocks, such as a financial crisis, on port productivity.

(Lun et al., 2011) use DEA to evaluate the effect of scale operations in liner shipping firms using empirical data. The results indicated that non-major firms, with a market share of 5% or below, can operate their firms efficiently.

(Walden, 2006) addressed the criticism of DEA being deterministic by presenting a model using bootstrapped methodology. The paper analyzes the economic efficiency of the fisheries industry and how regulations may be affecting vessel profitability. The subject of study is the U.S. mid-Atlantic Sea scallop dredge fleet. Results show that the maximum sustained yield (MSY) level of output is well below the 95% confidence interval for technically efficient output, indicating scope for further improvement in the efficiency.

The inclusion of undesirable variables poses some additional challenges, especially zero and negative value data(Sarkis, 2002). (Halkos & Petrou, 2019) discuss 4 methods of treating undesirable data - ignoring them from the production function, considering them as regular inputs, considering them as normal outputs, and performing necessary transformations to take them into account - along with the benefits and drawbacks of these chosen methodologies.

(Korhonen & Luptacik, 2004) used DEA to measure the efficiency of 24 power plants in a European country. Technical efficiency and ecological efficiency are measure from each power plant. The paper uses the emissions (undesirable products of power production) as inputs in an input-oriented model.

(Kim et al., 2020) analyze the operational efficiency of coastal ferry operators with the inclusion of marine accidents as an undesirable output. Two slack based measure (SBM) models were built- one with only the desirable output of number of passengers carried, and another model with the inclusion of accident reports. Finally, an index was developed that depicted the effect of implementing additional safety measures on the operational efficiency of the operator.

(Gong et al., 2019) evaluated the economic and cargo efficiencies of 26 liner shipping companies. Using the SBM methodology, the undesirable output of emissions was also considered in an environmentally adjusted economic efficiency rating. The results indicate that container ships have a greater economic efficiency and bulk shipping has greater cargo efficiency.

These analyses are, almost entirely, based on empirical data. Parameters for measure are decided and collected from various firms that operate in the market to evaluate efficiencies and performance. In this paper, we simulate the existence of such firms by varying the duration of sea-time, size of the vessel, and the type of the fuel used. Studies related to benchmarking alternative fuels on vessels along with an impact assessment of the proposed EU greenhouse gas intensity index penalty (GHGIE) on various alternative fuels are scarce due to the absence of empirical data.

Table 2: Summary of previous studies and methodologies

Domain/industry	Author	DMUs	Inputs	Outputs	Methodology
Power Plants	(Korhonen & Luptacik, 2004)	24 Powerplants in a European country	• Total costs • Dust • NOx • Sox	• Electricity Generation	• CCR (Charnes et al., 1978) • BCC (Banker et al., 1984a)
Port and Terminal operations	(Wilmsmeier et al., 2013)	20 container terminals in 10 Latin American countries	• Terminal area • Labor • Quay side Crane capacity	• Container throughput	• CCR • BCC • Malmquist Productivity Index (Caves et al., 1982)
Port and Terminal operations	(Bergantino et al., 2013)	30 ports	• Quay dimensions • Number of cranes • Area available for handling • Number of container handling equipment	• Total movements (Tons)	• DEA • SFA
Liner Shipping Firm	(Lun et al., 2011)	20 Liner shipping Companies	• Shipping Capacity • Operating Cost	• Profit • Revenue	• CCR
Liner Shipping Firm	(Gong et al., 2019)	26 Liner Shipping companies	• Capacity and number of ships • Employees • Fuel cost • Total assets • Capital expenditure	• Revenue (economic efficiency) • Cargo Carried (cargo efficiency) • Air pollutants such as SOx, NOx, CO2 (environmental efficiency)	• SBM

Liner Shipping Firm	**(Caves et al., 1982)**	**14 Liner Shipping companies**	• **Assets and Capex (Financial Efficiency)** • **Number of ships and fleet capacity (operational efficiency)**	• **Revenue and Operating profits (financial efficiency)** • **Cargo Carried in TEU (operational efficiency)**	• **CCR and BCC** • **Tobit regression analysis**
Coastal Ferries	**(Kim et al., 2020)**	**44 Ferry operators**	• **Number of Ferries** • **Number of Ferry Services** • **Total passenger capacity**	• **Number of Passengers** • **Marine accident records**	• **SBM**
Fisheries	**(Walden, 2006)**	**201 scallop dredge vessels**	• **Total Dredge width** • **GRT** • **Horsepower** • **Vessel Length** • **Days at sea** • **Number of Crew**	• **Weight of Scallop meat** • **Weight of Summer Flounder** • **Weight of Monkfish**	• **Stochastic Production Frontier (SPF)** • **Bootstrapped DEA**

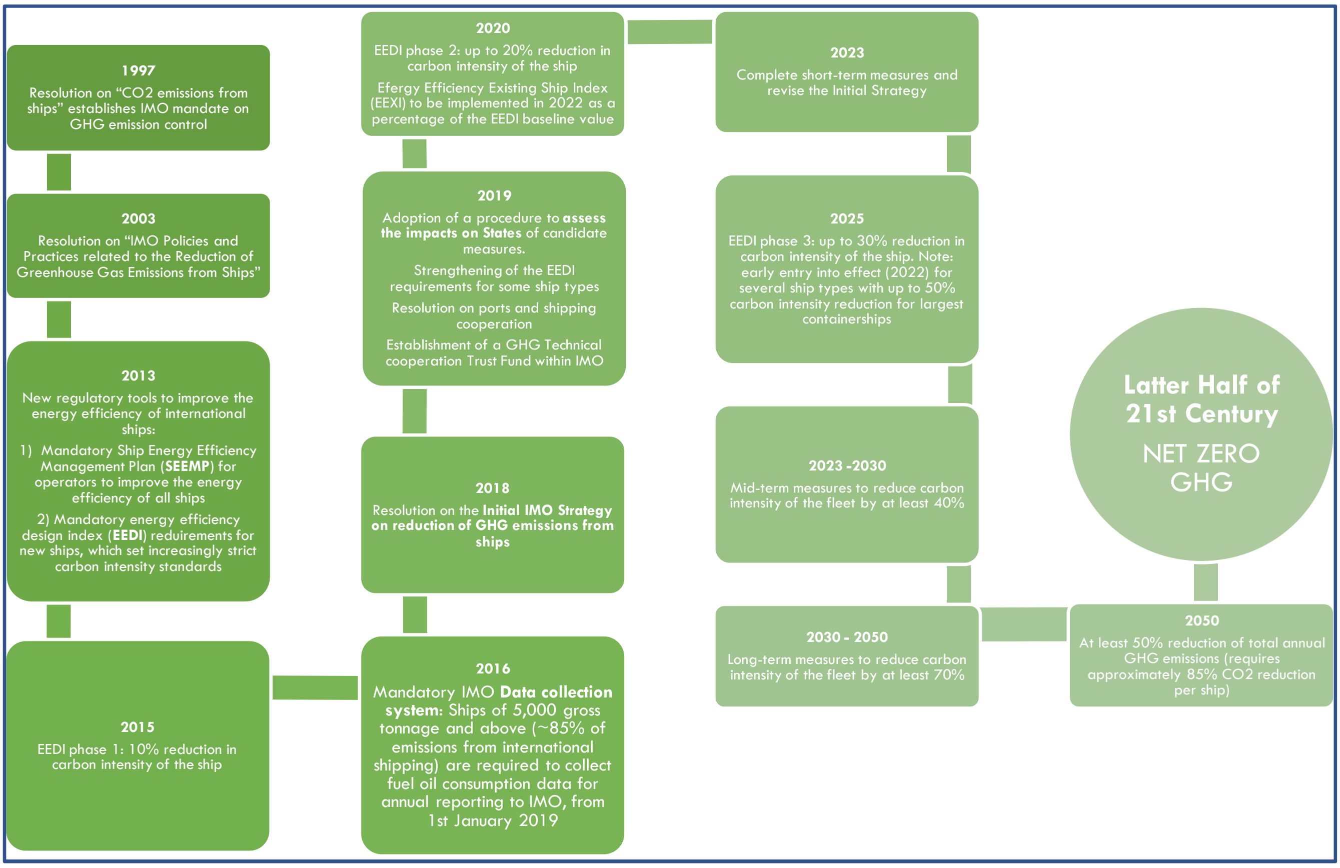
Source: Author's compilation

2.3 IMO initiatives

The Initial IMO Strategy on Reduction of GHG Emissions from Ships is the first milestone set out in the “roadmap for reduction of greenhouse gases (GHGs) from ships” (IMO, 2018). This Initial Strategy falls within the broader goals set out by the United Nations Convention on the Law of the Sea (UNCLOS), The United Nations Framework Convention on Climate Change (UNFCC) and its related legal instruments which include the Paris Agreement (Unfccc, 2015).

The strategy aims to reduce CO2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, compared to 2008 levels and 70% by 2050, compared to 2008 levels.

Figure 5: A Road-map of IMO action to reduce GHG

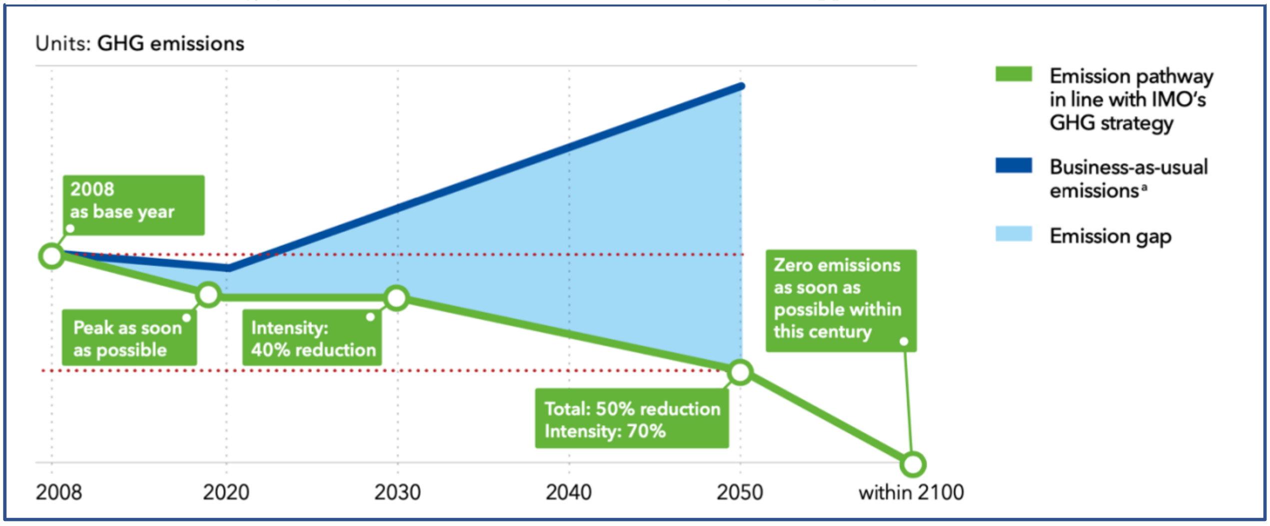


Source: Author’s adaptation from (IMO, 2020b)

At its 76th session held in June 2021, the Marine Environmental Protection Committee adopted amendments to the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI. These amendments are directed at reducing the GHG emissions from ships. The amendments consist of technical and operational approaches to reduce emissions in line with the targets set out by the (IMO, 2018). The measures are to envelop all ships with the calculation of the Energy Efficiency Existing Ship Index (EEXI) and the annual operation Carbon Intensity Indicator (CII). The EEXI applies to ships above 400GT, whereas the CII applies to ships above 5000 GT. These measures come into force on the 1st January, 2023.

In addition to the EEXI and CCI, further phases of the Energy Efficiency Design Index (EEDI) for new ships will be introduced as part of the IMO's Initial strategy.

Figure 6: IMO strategy for major reductions in GHG emissions from shipping

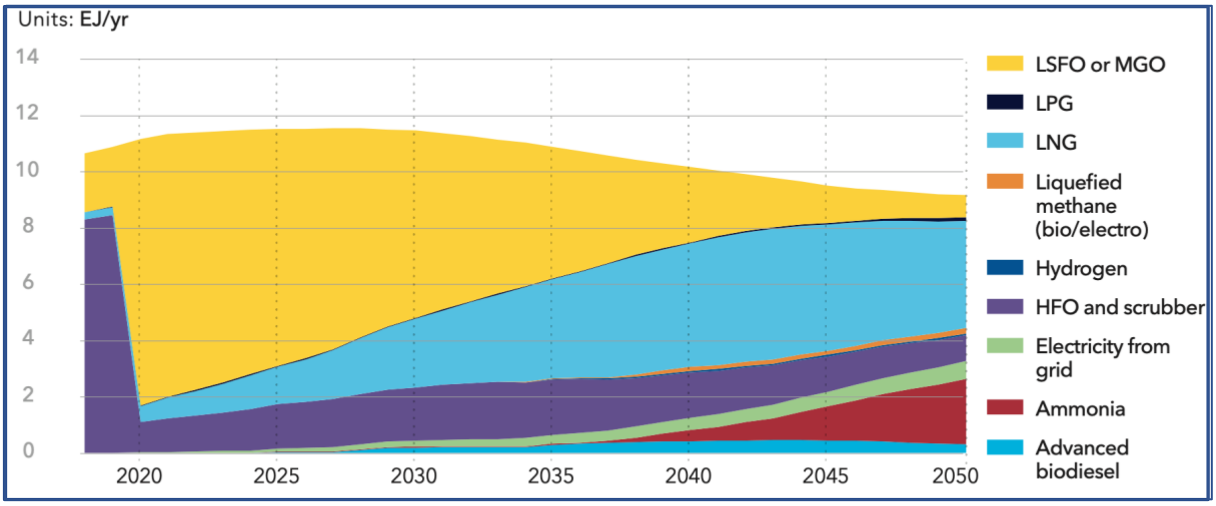


Source: (Witt et al., n.d.)

2.4 EU initiatives and "Fit for 55" package

In September, 2020, the European Commission adopted a proposal to reduced GHG emissions from maritime transport by at least 55% by 2030. This ambitious target set out by the Commission aims to put the European Union (EU) on the path to climate neutrality by 2050. In order to achieve this, it has been understood that a reduction of 90% in transport emission will be needed (European Commission, 2021). Contributions from all modes of transport will be necessary. The Commission also explains in the 2030 Climate Target Plan (CTP) that aviation and maritime will need to scale up efforts to meet the targets (EU Commission, 2020). Under the policy scenarios assessed by the Commission, renewable and low-carbon fuels (RLF) should account for 6% to 9 % of the international maritime fuel mix by 2030 and between 86% and 88% by 2050 (European Commission, 2021)

Figure 7: Energy use and projected fuel mix 2018–2050 for the simulated IMO ambitions



Source: (DNV, 2019)

The current mix of fuels driving the maritime industry is entirely based on fossil fuels. The uptake of low-carbon fuels faces challenges such as:

- Insufficient incentives for operators to cut emissions due to lack of mature and affordable alternative fuel options
- Lack of visibility of the regulatory environment
- Long asset life (economic life of a ship is typically 25 years (Stopford, n.d.))
- Interdependencies between fuel producers, fuel suppliers, and ship owners (Chicken and Egg problem)

The FuelEU Maritime is part of the basket of measures created by the Commission to tackle the emissions issues from maritime transport, while maintaining a level playing field. Other measures include the European Emissions Trading System (ETS), Energy Tax Directive (ETD), Alternative Fuels Infrastructure Directive (AFID), and the Renewable Energy Directive (RED II).
The FuelEU Maritime in combination with the other mentioned measures aim to maintain competitiveness while transitioning towards a low-carbon fuel alternative.

Since fuels contribute for anywhere between 35% to 53% of the total operating cost of the ship (Stopford, n.d.), the impact of these packages will be significant to the economic performance of the vessel to ship owners/operators.

In this paper, we also assess the competitiveness of alternative fuel types when the greenhouse gas intensity index (GHGIE) penalty is imposed on fossil-based fuels. The yearly limit of the GHGIE will be reduced according to Table 3

Table 3:GHGIE period limits

Percentage change	Period
-2%	from 1 January 2025;
-6%	from 1 January 2030;
-13%	from 1 January 2035;
-26%	from 1 January 2040;
-59%	from 1 January 2045;
-75%	from 1 January 2050.

Source: Author's adaptation from (European Commission, 2021)

2.5 Alternative Fuels

Alternative fuels will play a decisive role in the decarbonization objectives set by the maritime industry (IMO, 2020a). Some of the factors that will be decisive in the uptake of these alternative fuels are policy visibility, commercial viability, infrastructure development, and sustainability. We have compared these factors for the fuels discussed in this paper in the Table 4 below.

Table 4: Comparison of key factors for alternative marine fuels

Factor	VLSFO	MGO	H2 (Liquid)	Methanol	LNG	LPG	NH3
Marine Propulsion Technology	Available	Available	Approved in Principle	Available	Available	Available	Available
Safety Regulations	In place	In place	Under development	Similar to existing low flash point fuels. Dedicated chapter under development	In place	In place	Only for carriage as cargo
Bunkering	Available	Available	Not Available	Available	Available	Available	Only terminals
SCR for Tier III compliance	Required	Required	Not Required	Not Required if water injected to combustion chamber	Not Required *	Required	Required
Price in 2021	525 $/t	590 $/t	10 $/kg for green H2	500 $/t	600 $/t	570 $/t;	450 $/t; 50% green & 50% grey
Storage volume equivalent to VLSFO	1	1.1	4.6	2.6	1.6	1.6	3.1

Source: Author's compilation

The main costs to a ship owner are capital costs (42 %), voyage costs (40 %), and vessel operating costs (14%) (Stopford, n.d.). Although fuels determine nearly 66% of the voyage costs, we discuss other important properties that factor into a decision to adopt a certain type of fuel.

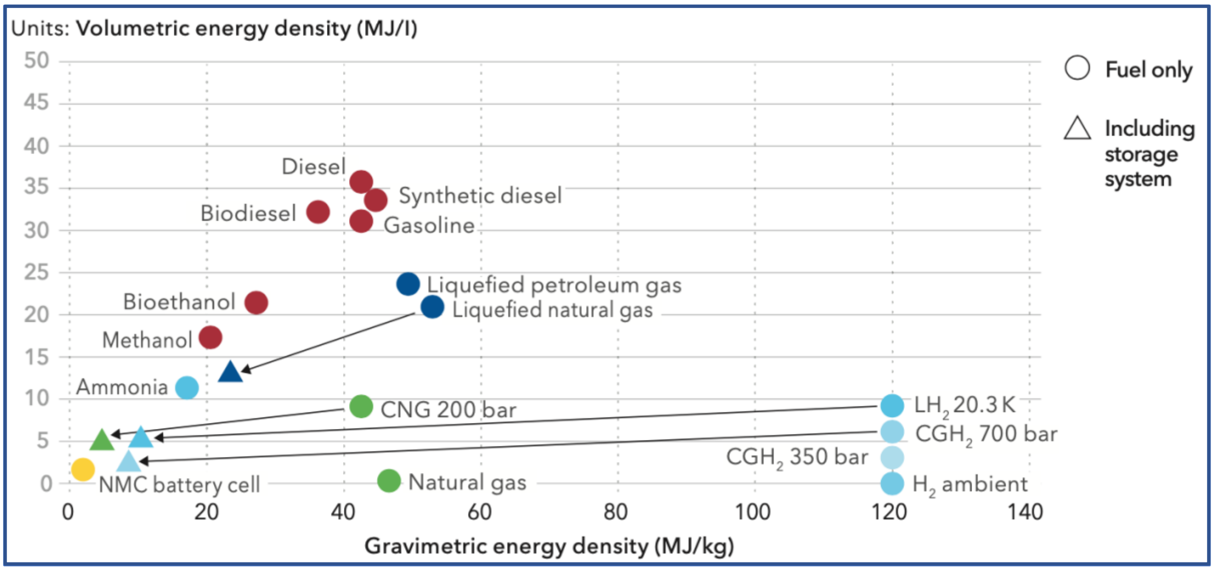
2.5.1 Energy Density:

There are 2 measures of energy density- Volumetric and Gravimetric (U.S Energy Information Administration, 2021).

Volumetric Energy density is the ratio of energy content (Mj) to unit volume (l). If a fuel has lower volumetric energy density, then it stores less energy for the same space compared to another fuel. Low volumetric energy density implies that more storage space is needed.

Gravimetric Energy density is the ratio of the energy content (Mj) to unit mass (kg). If a fuel has lower gravimetric energy density, it weighs more for the same amount of energy as a fuel being compared to.

Figure 8: Comparison of Gravimetric and Volumetric energy densities of fuels.



Source: (DNV, 2019)
Note: Arrows show the shift in the energy density when storage is required
CGH_2, compressed gaseous hydrogen; CNG, Compressed Natural Gas; LH_2, Liquefied hydrogen; NMC, nickel manganese cobalt oxide.

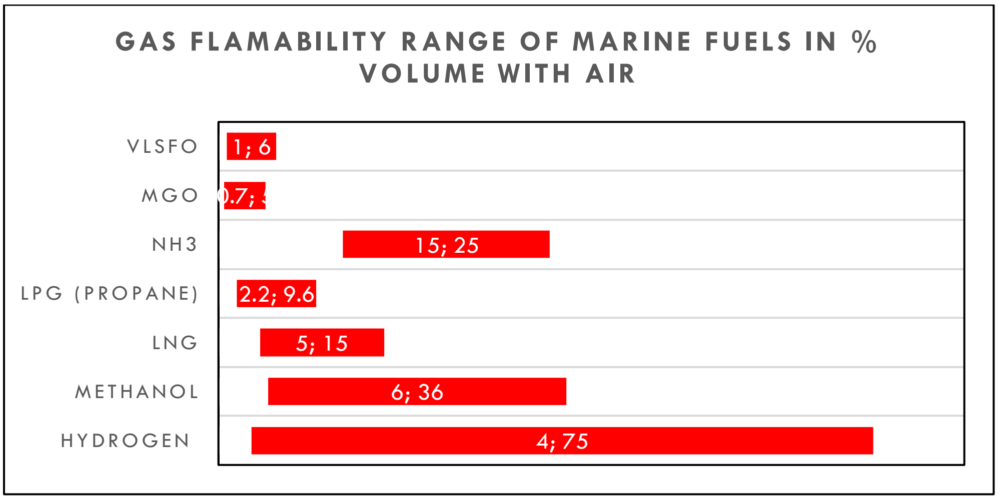
2.5.2 Flash point and Flammability:

When liquids are exposed to air, they release vapour. The volatility of the liquid determines the degree to which these vapours are formed. The lowest temperature at which this happens is the flash point of the liquid (E LOIS, 2003).

Since fuels with a low flashpoint can present an increased handling risk, The International Convention for the Safety of Life at Sea (SOLAS) (IMO, 1974) has introduced The International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) which gives guidelines on ship construction and handling of such fuels.

When sufficient vapours are present, the atmosphere will approach the lower end of its flammability range. One of the challenges alternative fuels presents is the safety requirements of handling such fuels. The broader the range of flammability, the more dangerous the fuel is.

Figure 9:Gas flammability range of marine fuels in % volume with air



Source: Author's compilation

2.5.3 Technology Readiness level:

Technology readiness level (TRL) is used to describe the stage of development of a certain technology. They are measured on a scale from 0 to 9; 0 depicting an idea or conceptual stage and 9 denotes the full commercial application (IMO-Norway Green Voyage 2050 Project & E4Tech and Houlder, 2021)

The TRL is an important consideration as it translates to costs of the fuel from an underlying production technology. Details of the various production technologies for alternative fuels are mentioned in the following pages.

The current fleet of ships primarily use robust and well developed two-stroke engine working principle. It is the most dependable and cost-effective choice for propulsion of trans-ocean vessels in the medium term (MAN Energy Solutions, 2019). The diesel principle is one of the most important engine design parameters. It is the primary reason that the engine readily combusts a wide range of fuels, including those that are otherwise difficult to ignite and burn, with minimal loss of efficiency.

2.5.4 Lifecyle Emissions:

The primary reason to adopt alternative fuels is to reduce emissions. However, if measures of these emissions do not account for the entire lifecycle of the fuel, we will arrive at a gross miscalculation of the emissions post combustion (EU Commission, 2020). The emissions (NOx, SOx, PM10, CO2, and CH4) associated throughout the lifecycle of the fuel are classified as follows:
Well to Tank (WtT)- emissions released as a result of the manufacturing process of the fuel from the feedstock to the point of delivery on a ship's fuel tank

Tank to Wake (TtW) – emissions released as a result of the combustion process of the fuel on the ship, resulting in the creation of a wake as the ship moves

Well to Wake (WtW) – emissions released throughout the lifecycle of the ship. This includes WtT and TtW.

Fuels are assigned color codes depending on the production technology used (ABS, 2021c):

Grey fuels: Produced entirely from fossil fuels
Green fuels: Produced entirely from renewable sources
Blue fuels: Produced from carbon capture sequestration (CCS) technology
Orange fuels: Assumed to be a 50-50 mix of green and grey fuels

From a fuel cost perspective, the FuelEU, along with other measures in the Fit for 55 package, aims to level the playing field for the uptake of alternative fuels. We have discussed factors other than the cost of the fuel itself that play a decisive role in the choice of an alternative fuel. These non-cost criteria require technological maturity to be achieved for the adoption of the corresponding alternative fuels on a larger scale. Also, since the criteria for selecting a fuel is not singular, the DEA is chosen as the appropriate tool to analyze each fuel.

In the following section we briefly describe the regulatory framework w.r.t the use of alternative fuels, the engine technologies that are currently and soon to be available, and the variation in emissions from well to wake, depending on the feedstock or production technology.

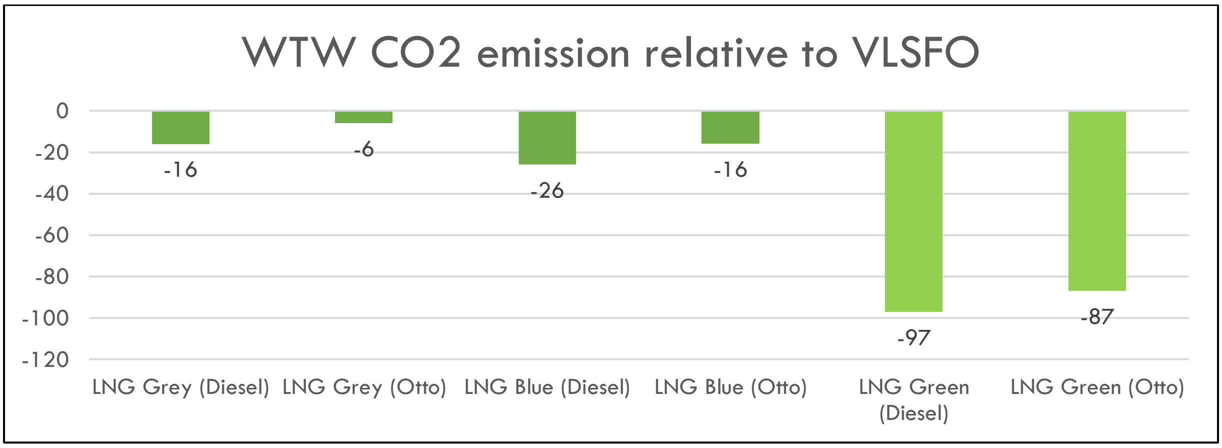
2.5.5 Liquefied Natural Gas (LNG):

The regulatory framework governing the design and construction of LNG powered vessels was introduced by the IMO IGF Code for LNG and CNG on 1st January, 2017. Regulations governing bunkering activities are subject to national regulations and guidelines have been developed by SGMF, IACS and ISO.

Engine technologies that use LNG as a marine fuel are steam turbines, 2 stroke low-pressure injection dual-fuel (LPDF - based on diesel cycle), 2 stroke high-pressure injection dual-fuel (HPDF - based on Otto cycle), and gas turbines.

Although the efficiency of otto cycle is higher than that of the diesel cycle, the latter offers lower GHG missions due to lower methane slip. GHG emissions as a result of methane slip were calculated in the 4th IMO GHG study. The values have been found to be 0.2 g/kwh for diesel cycle and 2.5 g/kwh for the otto cycle (IMO, 2020a) . HPDF or Diesel cycle engines are not the popular choice for ship owners, accounting for only 90 of the 750 LNG fueled ships in service (Pavlenko et al., 2020).

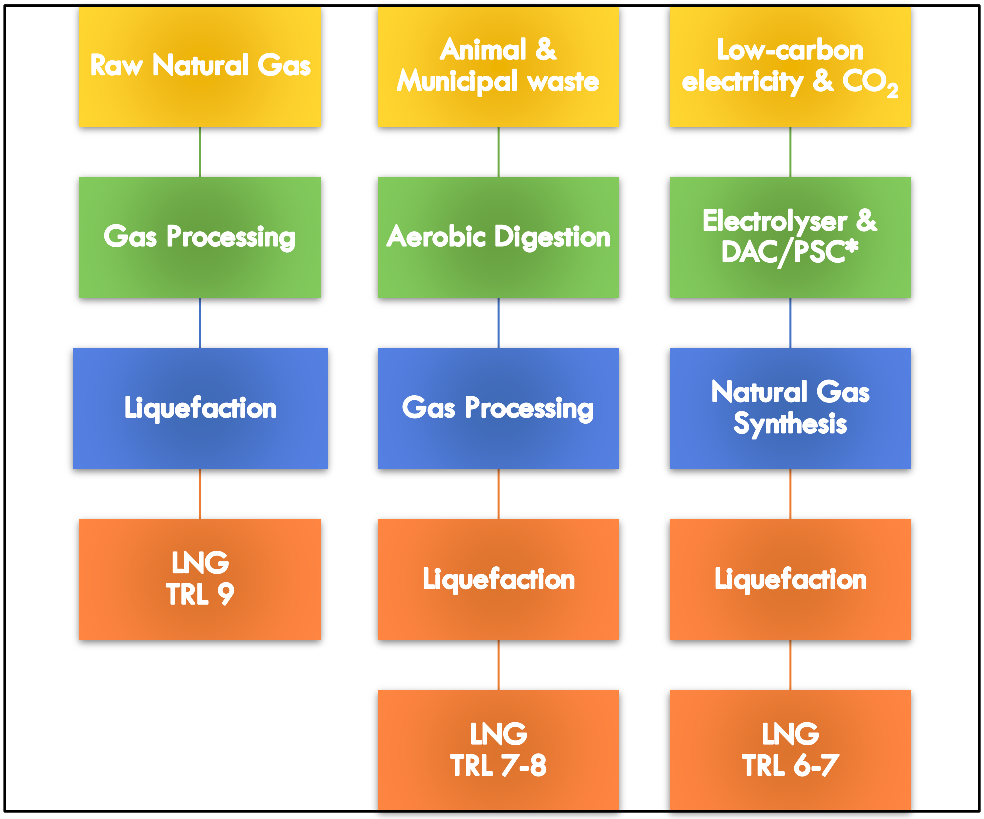
Figure 10:WtW CO2 emissions from various LNG production technologies



Source: Author's adaptation from (ABS, 2021c)

Among the available fossil fuels today, LNG is among the cleanest with almost zero SO_x and PM_{10} emissions, however, compliance with Tier III emissions will require an exhaust gas recirculation system (EGR) or a selective catalytic reduction system (SCR).
The current price of green LNG at $1782/ton for compared to $240/ton grey LNG (ABS, 2021c) makes the uptake of carbon-neutral LNG challenging for ship owners.

Figure 11: LNG production technologies and TRL level



Source: Author's adaptation from (IMO-Norway Green Voyage 2050 Project & E4Tech and Houlder, 2021).
**DAC = Direct air capture / PSC = Point source capture*

The potential of E-Lng to bring down emissions by nearly 80% is significantly higher than the current fossil-based LNG, but the technology needs to mature to make it an attractive option for shipowners (IMO-Norway Green Voyage 2050 Project & E4Tech and Houlder, 2021)

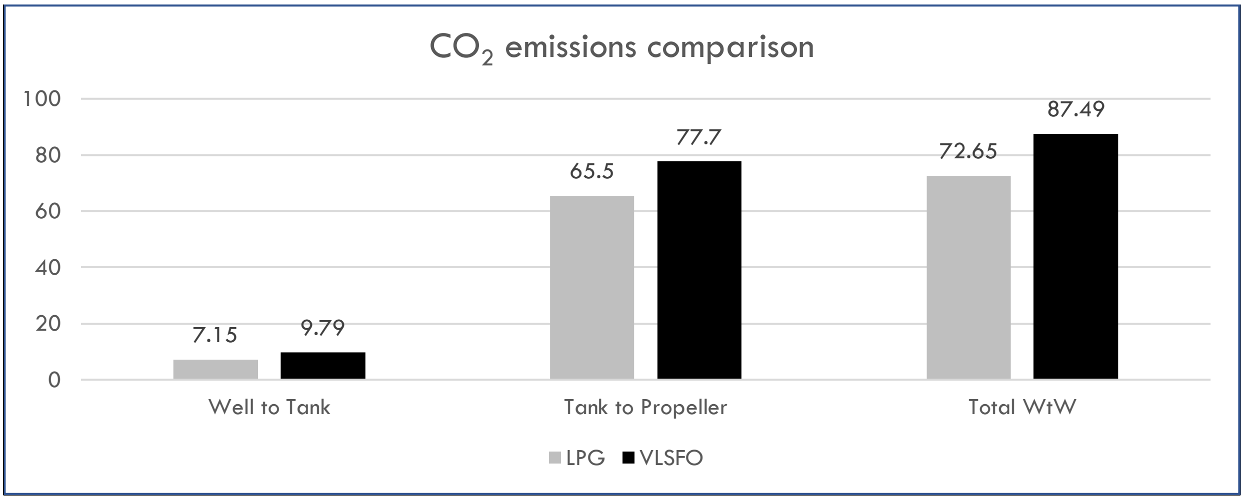
2.5.6 Liquefied Petroleum Gas (LPG):

The carriage of LPG as a cargo is covered by the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code). This code applies to all ships for the safe carriage of liquid cargoes with a vapor pressure above 2.8 bar at 37.8 deg C. If such an LPG tanker were to be powered by LPG, then the regulatory framework of the IGC code will continue to apply. However, for compliance in the use of LPG as a fuel on any other ship, the International Code of Safety for Ship using Gases or Other Low-flashpoint Fuels (IGF) will need to be followed.

LPG is a mixture of propane and butane in liquid form. The use of normal butane is difficult in colder regions due to the high boiling point of normal butane. Thus, to use LPG as a fuel, a purely propane or propane rich mixture of propane and butane will be needed (DNV, 2017).

LPG can be used as a fuel in 3 ways – in a diesel cycle 2-stroke engine developed by MAN as part of the MAN ME-LGI series of engines, in an Otto cycle on a 4-stroke Wartisila engine, or in a gas turbine (DNV, 2017).

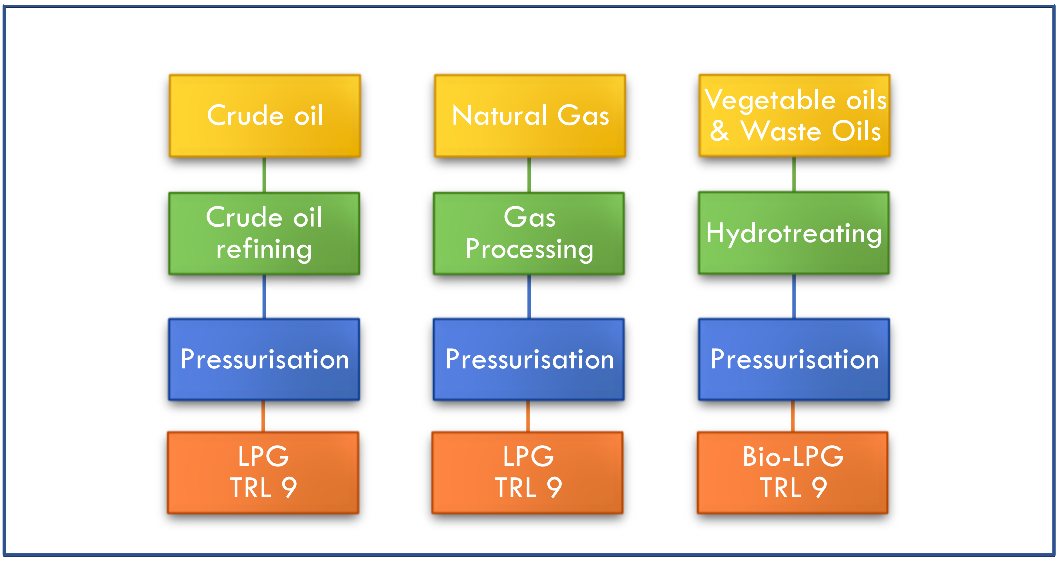
Figure 12: CO2 WtW comparison between LPG and VLSFO, in Kg CO2eq/GJ



Source: Author's adaptation from (DNV, 2017)

The emissions from LPG combustion results in lower CO_2 emissions compared to residual fuels. This is due the lower carbon to hydrogen ratio. The NO_x emissions however, depend on the engine technology. The 2-stroke diesel cycle engine will require an EGR or SCR for Tier III NO_x compliance. The 4- stroke Otto cycle engine emits significantly lower NO_x which makes it readily compliant with IMO Tier III (MAN Energy Solutions, 2018), (DNV, 2017).

Figure 13: LPG production technologies and TRL level



Source: Author's adaptation from (IMO-Norway Green Voyage 2050 Project & E4Tech and Houlder, 2021)

Although LPG is currently more expensive than HFO and MGO, the potential for cost reductions is high. (Pressu & Lin, 2019)

2.5.7 Hydrogen:

Since hydrogen is a low flashpoint fuel, it is subject to the International Code for Safety of Ships using Gases or Other Low-flashpoint Fuels (IGF Code). The current IGF code does not include regulations pertaining to hydrogen. In the interim, hydrogen storage and use must follow the alternative design approach in accordance with SOLAS Regulation II-1/55 to demonstrate an equivalent level of safety.

Bunkering infrastructure for hydrogen powered ships do not currently exist due to lack of demand. For the smaller inland vessel applications powered by fuel cells, pressurized containers (350 bar or 700 bar) are used. Liquid hydrogen containers also exist as 40-foot containers which have a capacity of 3600 kg of hydrogen (DNV, 2019).

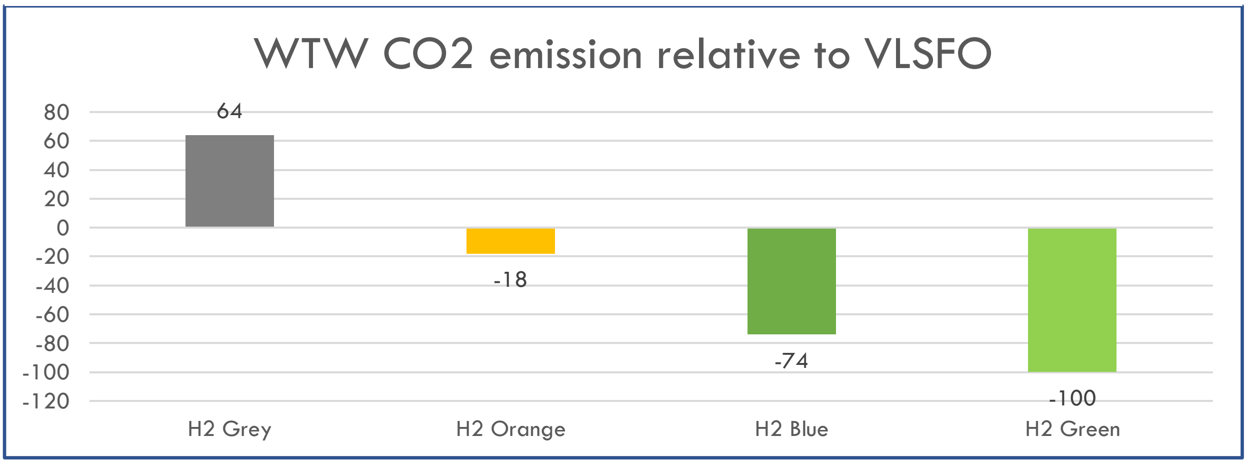
Table 5: Fuel cell efficiency classified by type of energy converter

Type of energy converter	System Efficiency
ICE with Diesel as Pilot	49.4
SOFC	60
PEM	60
AFC	60
PAFC	40

Source: Author's compilation from (ABS, 2021a) and (Mao et al., 2020)

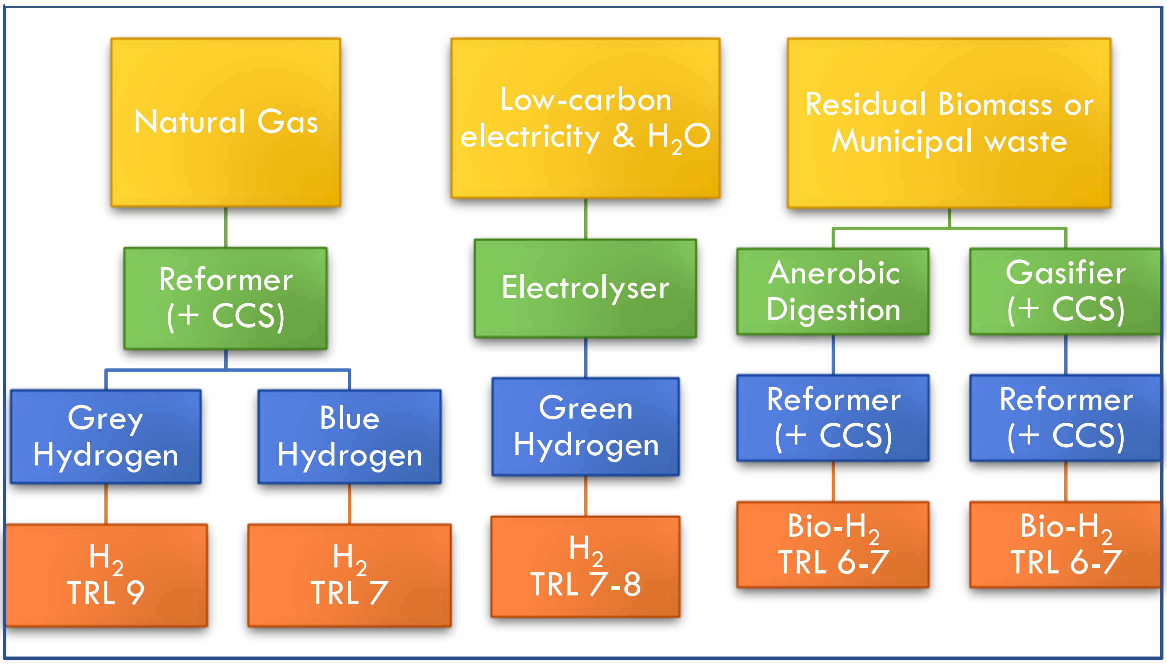
There has been significant progress in fuel cell technology. The solid oxide fuel cell with its large energy density shows high potential in maritime application (Terün, 2020). The table above shows the efficiencies attained in different H_2 fuel cell technologies.

Table 6: WtW CO2 emissions from various LNG production technologies



Source: Author's adaptation from (ABS, 2021c)

Figure 14: Hydrogen production technologies and TRL level



Source: Author's adaptation from (IMO-Norway Green Voyage 2050 Project & E4Tech and Houlder, 2021)

The robust and proven reliability of combustion engines offer durability as well as lower costs. Conventional internal combustion engines (ICE) can be modified to run on hydrogen blends. Fuel cells have the advantage of noise less and emission free operation, however, further development is still required.

2.5.8 Ammonia:

Although ammonia as a marine fuel is promising, the adoption will have to take place in steps(Niels de Vries, 2019):

- First, as an internal combustion engine (ICE) with MGO as a pilot fuel
- Second, as an ICE with ammonia-hydrogen mixtures
- Third, as a solid oxide fuel cell using ammonia

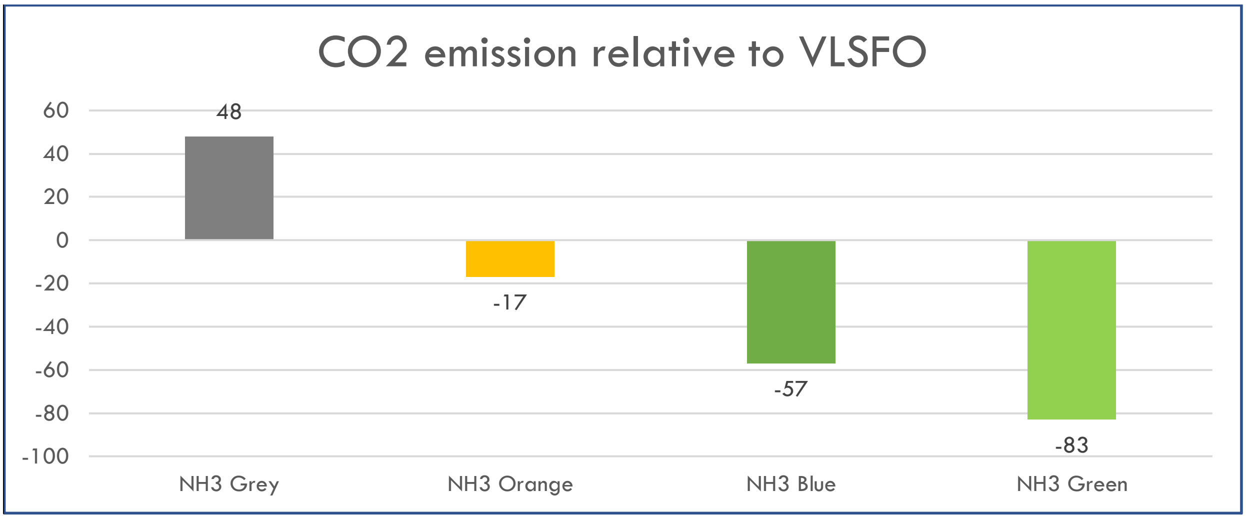
Table 7: Comparison of the methods available to use ammonia as a marine fuel

Type of energy converter	System Efficiency
ICE with Diesel as Pilot	49.4
SOFC	53.9
PEMFC	44.5
AFC	44.8

Source: Adapted from (Niels de Vries, 2019)

When all ammonia power generation options are considered, the Solid Oxide Fuel Cell (SOFC) is the most efficient. It does, however, face practical challenges because the power density and load response capability are not yet at an acceptable level (Niels de Vries, 2019). Using ammonia in internal combustion engine in the short term is certainly a viable option, however, research will have to continue to make SOFC the choice of the future.

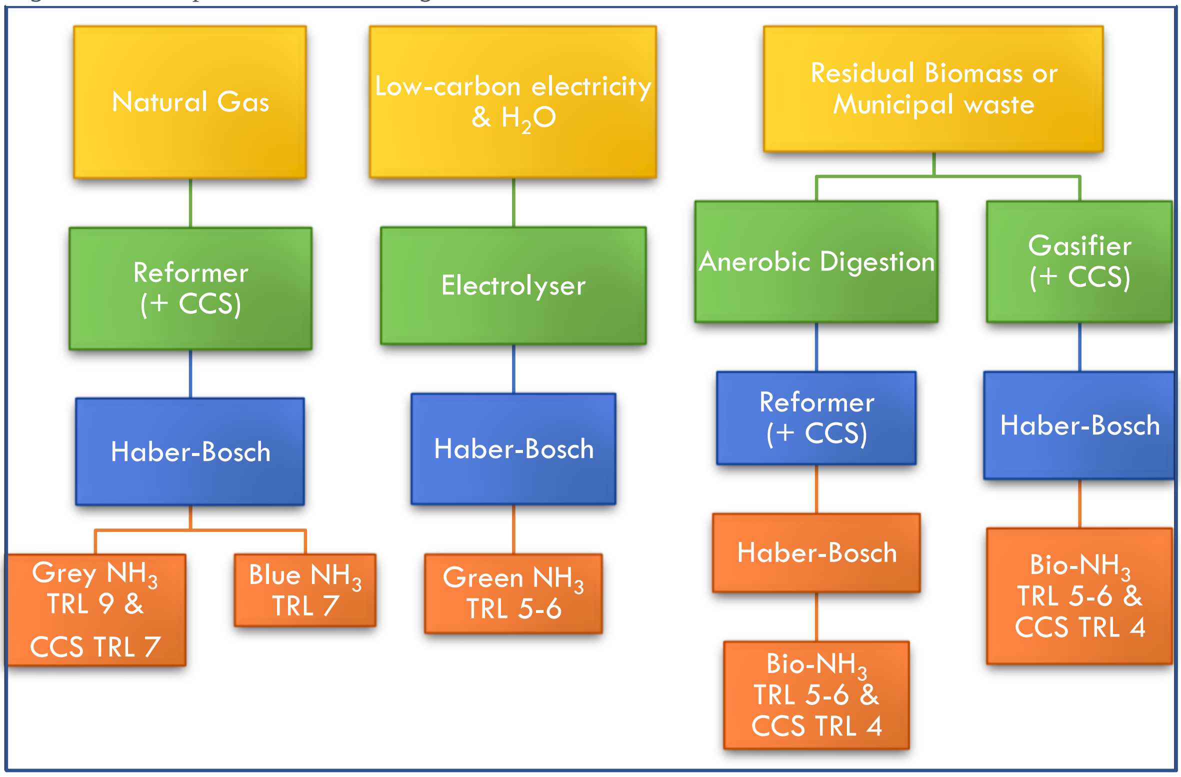
Figure 15: WtW CO2 emissions from various NH3 production technologies



Source: Author's adaptation from (ABS, 2021d)

A significant advantage that ammonia has over LNG is the head start available in terms of existing infrastructure for bunkering capabilities. This eliminates the "chicken and egg" problem that shipowners are often plagued by. Since the deployment of ammonia-based FCs will require more maturity, the immediate solution to reduce GHGs will be to use it in ICE (EDF, 2019).

Figure 16: NH3 production technologies and TRL level



Source: Author's adaptation from (IMO-Norway Green Voyage 2050 Project & E4Tech and Houlder, 2021)

Ammonia internal combustion engines are in development but are not yet commercially available (MAN Energy Solutions, 2018). Since the onshore infrastructure and equipment for storage and transportation of ammonia is already well understood, scaling up and extension to new locations will be needed to drive demand for ammonia powered engines.

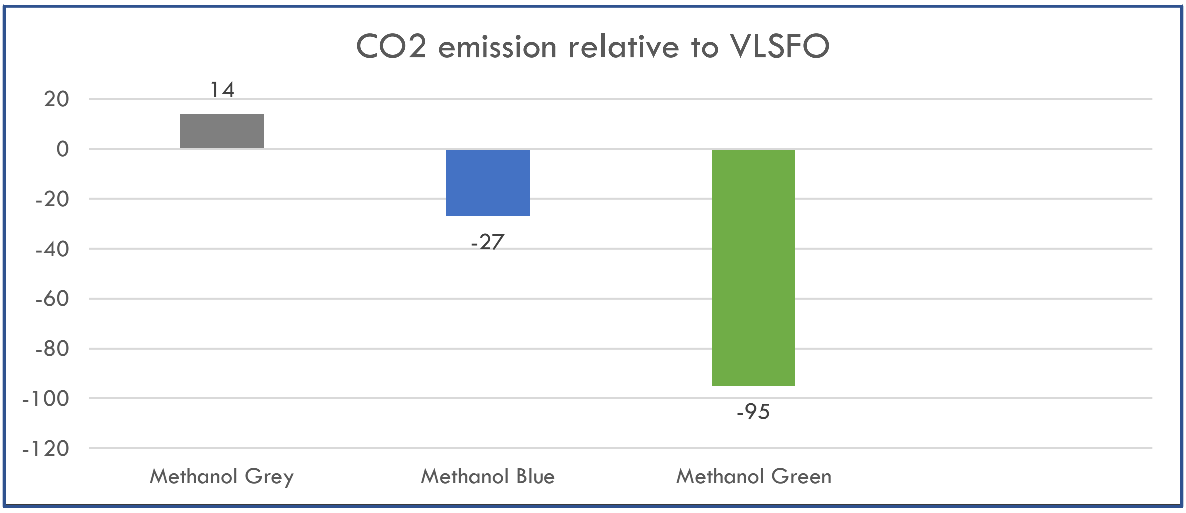
2.5.9 Methanol:

In November, 2020, the IMO Maritime Safety Committee (MSC) adopted MSC.1/Circ.1621, the Interim Guidelines for the Safety of Ships using Methyl/Ethyl Alcohol as fuel in internal combustion engines or in fuel cell operations.

Since methanol exists as a liquid under ambient conditions, the storage and handling is similar to the conventional fuel oils. Expertise in the handling and storage exists in the IBC code which were developed for chemical tankers. Modifications needed are minimal, with special zinc coating for the existing tanks and inert gas for the tank vapor space.(ABS, 2021a)

The use of fossil methanol, derived from LNG, dramatically reduces the SOx and PM10 emissions. NOx can be brought to levels well below the IMO Tier III requirement when water is introduced in the combustion chamber (MAN Energy solutions, 2020). The added advantage of using this system is that it eliminates the need to use a SCR or EGR, significantly reducing the CAPEX.

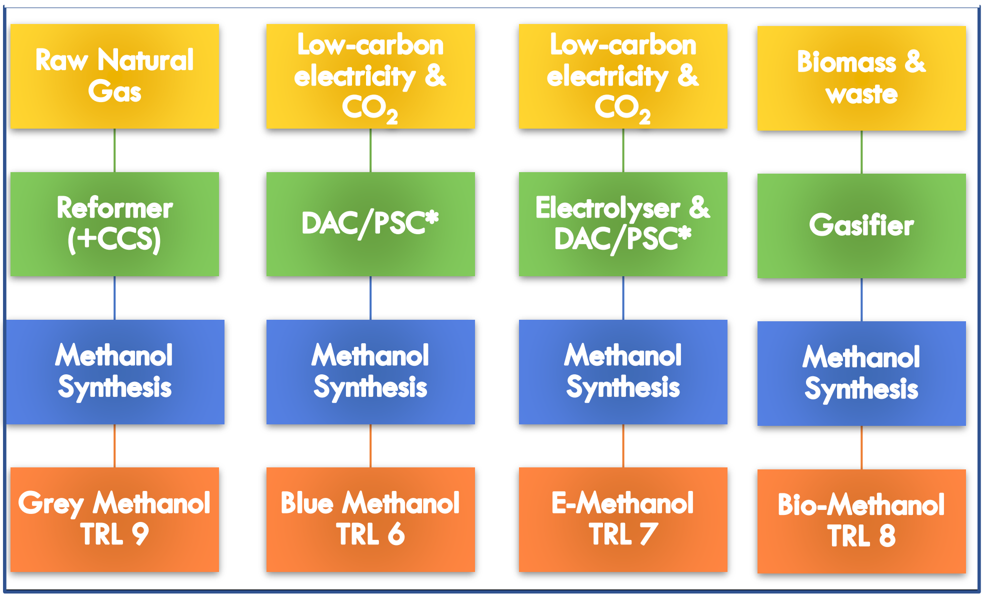
Figure 17: Well to Wake Emissions Relative to VLSFO



Source: Author's adaption from (ABS, 2021c)

The overall fuel and propulsion system size is less than that required by LNG. The MAN-LGIM ICE is also simpler than that needed to use LNG as a marine fuel. The safety aspects are however similar to those needed for LNG, primarily since methanol is a low flash point fuel.

Figure 18: Methanol production technologies and TRL level



Source: Author's adaptation from (IMO-Norway Green Voyage 2050 Project & E4Tech and Houlder, 2021)
**DAC = Direct air capture / PSC = Point source capture*

Although the use of methanol shows promising technological readiness levels in several areas, progress towards a position of widespread adoption would still be hampered by several commercial, policy and sustainability barriers. The recent orderbook of 8 methanol ready post-panamax ships from a Korean ship-yard ought to be a starting point of limited current use (Clarkson Research, 2021)

2.6 Chapter Summary:

We have discussed the data envelopment analysis as the frontier analysis method chosen and illustrated some of the advantages and disadvantages of this method. The initiatives taken by the international maritime organization and the European Commission have been discussed, highlighting some of the policies that are critical to achieving the decarbonization goals of the maritime industry.

We proceed with describing key parameters that are essential in selecting an alternative fuel. These parameters, although not directly linked to costs, have a significant role in determining the price of the fuel. Next, we describe the fuels that are most likely to be part of the maritime fuel mix in 2050. The current regulatory framework, production technologies, and emission potential are discussed.

3 Methodology

This section presents methodological framework used to evaluate efficiency, the criteria for selecting the variables, the treatment and arrangement of data, and the definition and implementation of the models.

3.1 Methodological Framework of DEA

The DEA technique will be used to compute the technical efficiency (TE) of utilizing various alternative fuels on container ships. The non-parametric linear programming approach of DEA, converts multiple incommensurable inputs and outputs of each decision-making unit (DMU) into a scalar measure of operational efficiency (Kumar & Gulati, 2008). In this paper, we will evaluate 2 types of efficiencies:

1. Economic efficiency (ECO)
2. Environmental efficiency (ENV)

For each individual DMU, DEA finds "peer" DMUs and then calculates the efficiency of the DMU by comparing its performance to that of the best practice DMUs selected from its peers. The DMU(s) that performs best among its (their) peers is given a score of 1. These units construct the efficient border by serving as 'standards' for referrals and 'enveloping' the other units. For each DMU, DEA necessitates the solution of a linear programming problem. The liner programming solution thus obtained contains information about the performance of each of these DMUs relative to its peers.

While evaluating the technical efficiency, considerations with respect to the orientation and the returns to scale must also be made.

3.1.1 Orientation:

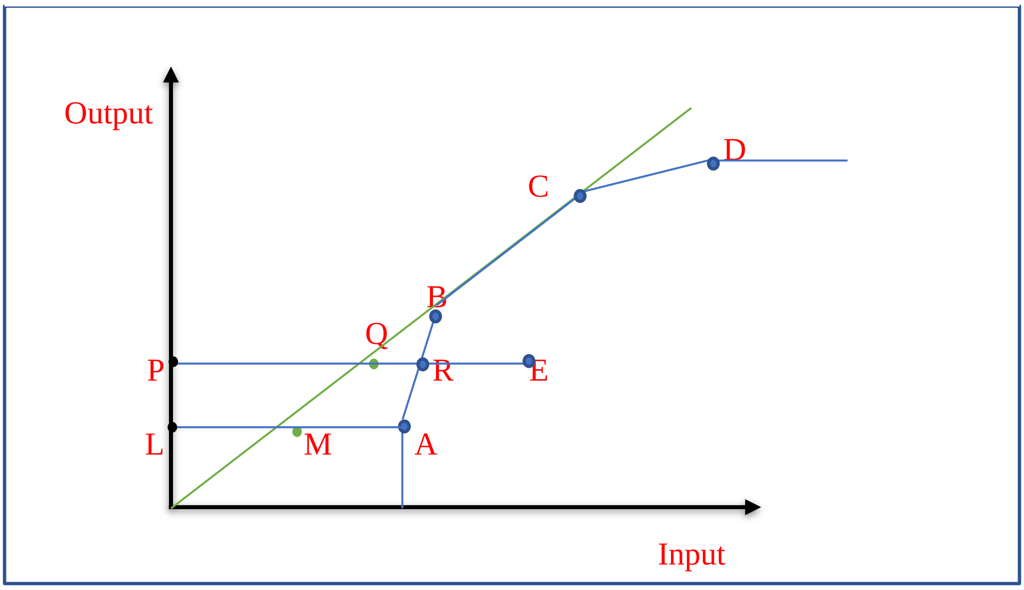
The input-oriented model aims to reduce the inputs while keeping the outputs constant. The output-oriented model tries to expand the output production while keeping constant the given set of inputs.

For instance, the TE for DMU "i" can be defined as
θ_i = Actual output_i / Max possible output_i in the case of an output-oriented model, or θ_i = Min possible input_i / Actual input_i. In this paper we benchmark the DMUs with input orientation.

3.1.2 Returns to Scale:

This is based on the fundamental economics concept of constant, increasing, and decreasing returns to scale. Increasing returns-to-scale (IRS) implies that a DMU can gain efficiency by increasing production and decreasing returns-to-scale (DRS) implies that a reduction in scale increases efficiency. The constant returns to scale (CRS) assumes that the output increases by the same proportion as the increase in input.
CRS does not appear to be an inferior method since proportional changes are expected to occur. We will evaluate both CRS and VRS efficiencies and determine whether the dataset reveals any major changes to the efficiency scores.

Figure 19: Comparison of VRS and CRS frontiers



Source: Author's representation of DEA frontier from (Cooper et al., 2007)

The BCC (Banker et al., 1984a) model varies from the CCR (Charnes et al., 1978) in that the BCC assumes VRS and CCR assumes CRS technology assumption. This paper will use the CRS and VRS terminologies, which refer to CCR and BCC respectively.

It can be seen above that M, Q, B, C are the efficient units as per the CRS technological assumption. However, A, R, B, C, and D are all units that form the efficient frontier in the VRS assumption. E is inefficient in both VRS and CRS.

VRS incorporates increasing returns to scale (IRTS) from A to B, constant returns to scale (CRS) from B to C, and decreasing returns to scale (DRTS) from C to D. Scale efficiency (SE) is calculated as a ratio of the CRS efficiency to the VRS efficiency. For instance, unit A is efficient in the VRS model but inefficient in the CRS model. The efficiency depicted by VRS refers to local or pure technical efficiency (PTE) and that depicted by CRS is the global technical efficiency (TE).

In the case of point E, the SE is less than unity. This is caused by both overall inefficient operation and a disadvantageous scale condition.

$$SE_E = \frac{\frac{PQ}{PE}}{\frac{PR}{PE}} = \frac{PQ}{PR},$$

which is equal to scale efficiency of input-oriented VRS projection of R
In the case of A, SE is less than one because the CRS value is less than 1, i.e.,

$$\frac{LM}{LA} < 1$$

Here the inefficiency is caused only due to scale inefficiency, although it is locally efficient. SE can never be greater than 1. In the case of point B, SE is 1. It shows that the given DMU is operating at the most productive scale, i.e., both VRS and CRS are 1.

3.2 Selection of variables:

The variables were determined based on previous studies (Gong et al., 2019) and the key environmental benefits expected from the use of alternative fuels. Unlike other studies which evaluate efficiencies based on empirical data, this study evaluates datasets populated from values proposed by manufacturers and naval architectural principles. We adopt this approach since many of the decision-making units (DMUs) studied are currently not in existence. The variables are chosen with the aim of comparing Economic Efficiency (ECO) and Environmental Efficiency (ENV). The table below depicts the inputs and outputs that will be used to evaluate ECO and ENV.

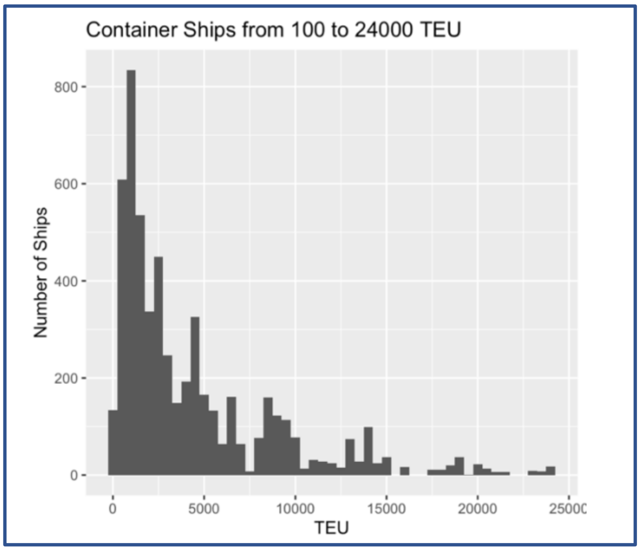
Table 8: Snapshot of the methodology used in this paper

Efficiency Measure	Variables					Returns To Scale		DEA Model	Orientation
	Input 1	Input 2	Input 3	Input 4	Output 1	CRS	VRS		
Economic efficiency (ECO)	Equivalent Fuel Cost	-	-	-	Teu-mile	-	Yes	BCC & Bootstrapped	Input oriented
Combined Economic and Environmental Efficiency (ENV)	Equivalent Fuel Cost	SOx (undesirable)	GWP100 (undesirable)	PM10 (undesirable)	Teu-mile	-	Yes	Bootstrapped & Slack-based measure	Input Oriented

Source: Author's compilation

It must be noted that we define Environmental Efficiency (ENV) as a combination of Economic Efficiency with the inclusion of emission factors. The decision-making units (DMUs) in this paper are container vessels. They are first categorized based on the TEU capacity. Capacities of 350, 1100, 3500, 6500, 10500, 14500, 18750 and 23500 were chosen due to the number of ships currently deployed in these ranges.

Figure 20: Histogram of world container fleet TEU capacity distribution



Source: Author's analysis from Clarkson's Database

Next, a DMU in each TEU capacity was further increased by a choice of 8 fuels – VLSFO, MGO, Methanol, Ammonia, LNG, LPG, H2 Liquid, and H2 Gas - which are assumed to be a significant part of the future fuel mix(DNV, 2019). This leads to a total of 8 DMUs within each TEU capacity. Finally, these 8 DMUs have been augmented to 48 units in a specified TEU capacity by choosing to deploy these vessels over a period of operation ranging from 1, 5, 10, 15, 20, and 30 days. We now have 48 DMUs for each TEU capacity. Table 25 illustrates the datasets grouped by the TEU capacity.

3.2.1 Input variables:

In this paper, we assume a MAN B&W LGI engine is used for the alternative fuels mentioned earlier. This engine follows the otto cycle principle and will require the use of a pilot fuel (assumed to be MGO) to initiate the combustion reaction. Energy requirement was calculated at 75% of maximum continuous rating (MCR) A volume of 5% of the total volume of fuel is assumed to be consumed as pilot oil (MAN Energy solutions, 2020). Details of the engine model assigned to various TEU ranges are adapted from (MAN Energy Solutions, 2019).

Fuel Cost: To compute the cost of alternative fuels used in DMUs that vary in sea-time, we first find the volume of fuel needed to provide the same energy input requirement. We use the methodology from (Mao et al., 2020) to determine this quantity:

$$V_{needed} = \frac{E_{required}}{D_{volumeteric} * \eta_{energy\ converter}} * fuel\ margin$$

Where:

V_{needed}	Volume needed to provide enough energy to complete sea-time, in m3
$D_{volumeteric}$	Volumetric density of a fuel system, in kWh/m3
$\eta_{energy\ converter}$	Efficiency of IC engine to turn fuel into energy. This is assumed to be 50 % for all fuels.
$E_{required}$	Energy output required to complete sea-time, in kWh at 75% load
$fuel\ margin$	Ships usually carry more fuel than needed onboard. We assume a fuel margin of 1.4 for all DMUs which includes a 20% allocated to fuel consumption from auxiliaries.

The cost of fuel is finally obtained from the below equation:

$$Fuel\ Cost = V_{needed} * Fuel\ density * \$_{per\ ton}$$

SOx and PM10: Values of sulphur oxides (SOx) and particulate matter (PM10), emitted by vessels are calculated based on the emissions data provided in (MAN Energy solutions, 2020) in g/Kwh and (van Lieshout et al., 2020). These variables will be considered as input variables as described in (Korhonen & Luptacik, 2004).

Table 9: Values of SOx and PM10 used in this paper

Fuel Type	Percentage reduction of SOx compared to HFO Tier II	Percentage reduction of PM10 compared to HFO Tier II	Value of SOx generated, g/KWh	Value of PM10 generated, g/KWh
VLSFO	0%	0%	2	0.74
MGO	18%	31%	0.36	0.23
Methanol*	90-97%	90%	0.1	0.074
Ammonia*	100%	90%	0.01	0.074
LNG*	90-99%	90%	0.1	0.074
LPG*	90-100%	90%	0.1	0.074
H2 Liq*	100%	100%	0.01	0.011
H2 Gas*	100%	100%	0.01	0.011

Source: (van Lieshout et al., 2020), (MAN Energy solutions, 2020)
**Values of emissions include a 5% consumption of MGO as pilot oil*

GWP100: Greenhouse gas emissions (GHGs) mentioned in this paper follow the same definition as mentioned the (European Commission, 2021) as the release of carbon-dioxide (CO_2), methane (CH_4), and nitrous oxides (N_2O) into the atmosphere. They are expressed as equivalent CO_2. 100-year Global Warming Potential (GWP100) of GHGs are also expressed as CO_2 equivalents. GWP100 values of GHGs generated by various fuels are referenced from (ABS, 2021c) and from (Lindstad et al., 2020).

Table 10: GWP100 values used in this paper

Fuel Type	GWP100 $CO_{2\ equivalent}$, in g/KWh
VLSFO	568
MGO	541
Methanol	533
Ammonia	102
LNG	492
LPG	500
H2 Liquid	27.5*
H2 Gas	27.5*

Source: (Lindstad et al., 2020) and (ABS, 2021c)
**Values of emissions include a 5% consumption of MGO as pilot oil*

3.2.2 Output Variables:

TEU- Mile: The measure of economic output for maritime transport has traditionally been ton-mile (Gong et al., 2019) and (Kim et al., 2020). Since this paper considers the use of alternative fuels on container ships, TEU-mile will be used as the measure of economic output. It has been calculated as:

$$TEU_{revised\ capacity} = TEU_{full\ capacity} - TEU_{lost\ capacity}$$

Speeds for the vessels of various sizes have been assumed as depicted in the table below. These values are based on statistical information provided in (MAN Engery Solutions, 2019) the economical speed and consumption at 75% load

Table 11: TEU capacity and corresponding speeds at 75% load

TEU capacity	Ship Speed
350	15
1100	15.5
3500	18
6500	20
10500	20
14500	21
18750	20
23500	20

Source: Authors compilation from (Man Energy Solutions, 2019)

$$TEU - Mile = TEU_{revised\ capacity} * Distance$$

Where:

$TEU_{full\ capacity}$	The design TEU capacity of the vessel, in TEU
$TEU_{lost\ capacity}$	Capacity lost due to volume occupied by fuel storage tanks, in TEU
$TEU_{revised\ capacity}$	Final available capacity after reductions due to fuel tank size, in TEU
$Distance$	Distance travelled by the vessel, in miles

3.3 Treatment of the Data

In this study we have emissions as undesirable variables. A prerequisite for the data set is the positive co-relation between the input and output variables. Thus, attaching a negative sign to the undesirable variables will not yield any useful result. (Sarkis, 2002) has suggested a few methods that could be used to treat this negative data. One is to take the absolute value of the undesired output and invert it. Another method is to add a large absolute value to the negative variables to make it a non-zero positive variable. Although this might overcome the problem of negative numbers, the issue of scale translation occurs. Scale translation can cause a high degree of variance in the efficiency evaluation as indicated by (Bowlin, 1998).

We follow the method used by (Korhonen & Luptacik, 2004) in their analysis of ecological efficiencies. Here the undesirable outputs are treated as inputs. Similarly, in this paper, we treat these variables as any other input variables in an input-oriented model. The output is kept constant and the inputs are reduced. This ensures that the scalar translation issues discussed earlier are eliminated.
Another consideration that is pertinent to this analysis is the choice of the DMUs. We can choose to either evaluate the efficiencies of using different types of alternate fuels on the most popular TEU ranges of container vessels as an entire data set, as shown in Table 26, or select the individual TEU ranges as in Table 27 and evaluate their efficiencies over varying periods of sea-time.

We present the reason of using the second method as follows. The table with 64 DMUs shows that one of the primary conditions of the data, i.e., positive correlation of the inputs and outputs is not satisfied. The importance of this condition is revealed when computing the efficiencies from constant returns to scale (CRS) and variable returns to scale (VRS). Scale efficiency (SE) defined as the ratio of CRS to VRS ranges widely for the dataset with 64 DMUs. This is due to the wide range of values and lack of correlation between the inputs and outputs. The table below presents the SE of the 2 datasets.

Table 12: Co-relation matrix with 64 DMUs and 48 DMUs

Correlation matrix with 64 DMUs	TEU-Mile Output 1	Correlation matrix with 48 DMUs	TEU-Mile Output 1
Fuel Cost	0.475131	Fuel Cost	0.811115
Input 1	<0.0001	Input 1	<0.0001
GWP100	-0.30914	GWP100	0.70704
Input 2	0.0129	Input 2	<0.0001
PM10	-0.3071	PM10	0.404827
Input 3	0.0136	Input 3	0.0043
Sox	-0.42355	Sox	0.311221
Input 4	0.0005	Input 4	0.0313

Source: Author's Calculation

Summary of section 3.2 and 3.3: The comparison of various TEU classes in our analysis will favor any one of the extreme sizes. Since our objective is to match the best fuel for each vessel class, the 48 DMU dataset is most appropriate for our evaluation. Addition of other input parameters such as operational cost, capital costs, and labor would make a cross sectional evaluation of various TEU classes more suited to use the 64-unit DMU data set.

3.4 Economic model and data description

Computation of DEA models is carried out using the R package “rDEA” by (Vicente Coll-Serrano et al., 2020). The codes can be found in R Code used in this paper.”
We use the bootstrap method created by (Simar & Wilson, 1998) for evaluating efficiencies in the DMUs. Bootstrapping is a procedure of sampling with replacement. Here, sampling with replacement mimics the data generating process of the underlying true model and produces statistically significant estimates. Bootstrapping differs in that the number of DMUs chosen to evaluate the efficiencies vary every time the sample efficiency is evaluated (Tone, 2007).

Resampling also re-distributes the randomness associated with the model observations. Deviation of the model’s variables from expected values, as calculated by the model (Dea et al., 2012), create a range of efficiency scores (confidence interval).

Advantages of bootstrapping are: Firstly, it accounts for the lack of statistical inference in the conventional CCR model. This is evidenced in the ability of the model to compute the 95% confidence interval for the efficiency score estimated. Secondly, the bias corrected scores, result in unique values which create the needed discrimination among the efficiency scores.

The bootstrap model is based on the basic CRS model (Charnes et al., 1978).

The basic model is as follows:

$$\theta = \frac{u_1 y_{1o} + u_2 y_{2o} + \cdots + u_s y_{so}}{v_1 x_{1o} + v_2 x_{2o} + \cdots + v_m x_{mo}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (3.1)$$

Fractional linear programing form,

$$\theta = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \ (3.2)$$

Subject to:

$$v_1 x_{1o} + v_2 x_{2o} + \cdots + v_m x_{mo} = 1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (3.3)$$

$$u_1 y_{1o} + \cdots + u_s y_{so} \leq v_1 x_{1o} + \cdots + v_m x_{mo} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (3.4)$$

$v_1, v_2, \ldots. v_m \geq 0$

$u_1, u_2, \ldots. u_s \geq 0$

Where:

$\theta = efficiency\ score$
$o =\ DMU\ under\ evaluation\ \ (1,2 \ldots., n)$
$u_r = output\ weights\ (r = 1,2\ldots., s)$
$v_i = input\ weights\ (i = 1,2\ldots., m)$
$y_{ro} = r^{th}\ output\ of\ DMU\ o$
$x_{io} = i^{th}\ input\ of\ DMU\ o$
$m = number\ of\ input\ performance\ measures$
$s = number\ of\ output\ performance\ measures$

Since we utilize an input-oriented VRS model as well (Banker et al., 1984a), equation (3.1) is modified as follows:

$\theta^* = \theta_{min}$ …………………… *(3.5)*

$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io}$ *(i=1, 2,…, m)*

$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro}$ *(r=1, 2,…, s)*

$\sum_{j=1}^{n} \lambda_j = 1$ ……………… (3.6)

$\lambda_j \geq 0 \quad (j = 1,2, \ldots, n)$

Where:

$\theta^* = input - oriented\ efficiency\ score$

$o = \ DMU\ under\ evaluation\ \ (1,2 \ldots., n)$

$j = number\ of\ DMUs\ (j = 1,2, \ldots, n)$

$u_r = output\ weights\ (r = 1,2 \ldots., s)$

$v_i = input\ weights\ (i = 1,2 \ldots., m)$

$y_{ro} = r^{th}\ \ output\ of\ DMUo$

$x_{io} = i^{th}\ \ input\ of\ DMUo$

$\lambda_j = non\ negative\ scalars\ \ of\ DMU\ j$

$m = number\ of\ input\ performance\ measures$

$s = number\ of\ output\ performance\ measures$

Additionally, following constraints must added in place of constraint equation (3.6) to evaluate the CRS model efficiency scores for equation (3.5):

$\sum_{j=1}^{n} \lambda_j \geq 0$ …..……….. (3.7)

The CCR model may not be entirely applicable in our evaluation of alternative fuels since some of these fuels are relatively expensive due to the maturity level of the underlying technology. In other words, the scale of operation of all these DMUs are not the same. It would be prudent to also compute the variable returns to scale (VRS) by incorporating the VRS model (Banker et al., 1984b) into the bootstrapping methodology. The composite unit is of a similar scale size as the DMU being measured. For this, the constraint in equation (3.6) will have to be adopted.

3.4.1 Choosing the number of DMUs:

In order to retain the discriminatory powers of the DEA, choosing a large number of inputs and outputs compared to the number of DMUs may lead to unsatisfactory results. (Golany & Roll, 1989) explain that there needs to be at least twice the number of DMUs as compared to the inputs and output, whereas (Banker et al., 1989) state that the number of DMUs should be at least 3 times the number of inputs and outputs combined.

$$Number\ of\ DMUs = 3 * (number\ of\ inputs + number\ of\ outputs)$$

Since DEA is not a form of regression model, but rather a frontier- based linear programming-based optimization technique, as pointed out by (Cook et al., 2014), applying a sample size requirement to DEA is meaningless.

However, we will use the more widely adopted rule of thumb (shown above) as proposed by (Banker et al., 1989) in our DEA analysis.

3.4.2 GHG intensity limit:

We also compute the effect of the GHG intensity limit proposed by the European Commission which is likely to come into effect by 2025. We use the formula as mentioned in the proposal (European Commission, 2021) :

$$\frac{\sum_i^{n\,fuel} M_i * CO_{2\,eq\,WtT,i} * LCV_i + \sum_k^c E_k * CO_{2\,eq\,electricity,k}}{\sum_i^{n\,fuel} M_i * LCV_i + \sum_k^c E_k} \qquad \text{.....} (3.7)$$

$$\frac{\sum_i^{n\,fuel} \sum_i^{n\,fuel} M_{i,j} * [(1 - \frac{1}{100} C_{engine\,slip\,j}) * CO_{2eq,TtW,j}) + (\frac{1}{100} C_{engine\,slip\,j} * CO_{2eq,TtW,slippage,j})]}{\sum_i^{n\,fuel} M_i * LCV_i + \sum_k^i E_k} \qquad \text{......}(3.8)$$

$$CO_{2eq,TtW,j} = (C_{f,co2,j} * GWP_{co2} + C_{f,CH4,j} * GWP_{CH4} + C_{f,N2O,j} * GWP_{N2O})_i \qquad \text{......}(3.9)$$

Where:

Term	**Explanation**	**Value used in this paper**
i	Index corresponding to the fuels delivered to the ship in the reference period	Each DMU is assumed to use only a single type of fuel
j	Index corresponding to the fuel combustion units on board the ship. The units considered are the main engine(s), auxiliary engine(s) and fired oil boilers	Fuel consumption is calculated for the main engine. An additional 40% is added to account for auxiliaries and additional fuel reserve
k	Index corresponding to the connection points (c) where electricity is supplied per connection point.	No shore connections considered. Value is 0
c	Index corresponding to the number of electrical charging points	No shore connections considered. Value is 0

m	Index corresponding to the number of energy consumers	Only 1 main engine is considered
$M_{i,j}$	Mass of the specific fuel i oxidized in consumer j [g Fuel]	Calculated for main engine
E_k	Electricity delivered to the ship per connection point k if more than one [MJ]	No shore connections considered. Value is 0
$CO_{2\ eq\ WtT,i}$	WtT GHG emission factor of fuel i [g CO2eq/MJ]	Only TtW emissions considered
$CO_{2\ eq\ electricity,k}$	WtT GHG emission factor associated to the electricity delivered to the ship at berth per connection point k [g CO2eq/MJ]	No shore connections considered. Value is 0
LCV_i	Lower Calorific Value of fuel i [MJ/g Fuel]	Values used as per Annex II of (European Commission, 2021)
$C_{engine\ slip\ j}$	Engine fuel slippage (non-combusted fuel) coefficient as a percentage of the mass of the fuel i used by combustion unit j [%]	Zero slip assumed
$C_{f,CO2,j}$, $C_{f,CH4,j}$, $C_{f,N2O,j}$	TtW GHG emission factors by combusted fuel in combustion unit j [gGHG/gFuel]	Values from (ABS, 2021c; Lindstad E, 2020) used to estimate $CO_{2eq,}$
$CO_{2eq,TtW,j}$	TtW CO2 equivalent emissions of combusted fuel i in combustion unit j [gCO2eq/gFuel]	Values from (ABS, 2021c; Lindstad E, 2020)
$C_{sf,CO2,j}$, $C_{sf,CH4,j}$, $C_{sf,N2O,j}$	TtW GHG emissions factors by slipped fuel towards combustion unit j [gGHG/gFuel]	Values used as per Annex II of (European Commission, 2021)
$CO_{2eq,TtW,slippage,j}$	TtW CO2 equivalent emissions of slipped fuel i towards combustion unit j [gCO2eq/gFuel]	Values used as per Annex II of (European Commission, 2021)
GWP_{co2}, GWP_{CH4}, GWP_{N2O}	CO2, CH4 , N2O Global Warming Potential over 100 years	Values from (ABS, 2021c; Lindstad E, 2020) to estimate $CO_{2eq,}$

3.4.3 Formula for calculating the ship's compliance balance:

$$Compliance\ balance\ [g\ CO_{2eq}/MJ]$$

$$= (GHGIE_{target} - GHGIE_{actual}) * [\sum_i^{n\ fuel} M_i * LCV_i + \sum_i^{n\ fuel} E_i]$$

Where:

$g\ CO_{2eq}$ = grams of CO2 equivalent
$GHGIE_{target}$ = Greenhouse gas intensity limit of the energy used on-board a ship according to Article 4(2) of (European Commission, 2021)
$GHGIE_{actual}$ = Yearly average of the greenhouse gas intensity of the energy used on-board a ship calculated for the relevant reporting period. We assume that the vessel will be in use for approximately 330 days in a year or 90% of the number of days in 1 year

Target refers to the reduction in the base line GHGIE calculated to the revised values of GHGIE, ie., $\text{GHGIE}_{\text{target}}$,according to the values mentioned below from (European Commission, 2021)

- -2% from 1 January 2025
- -6% from 1 January 2030
- -13% from 1 January 2035
- -26% from 1 January 2040
- -59% from 1 January 2045
- -75% from 1 January 2050.

3.4.4 Formula for calculating the ship's compliance balance:

$Penalty = \left\{ {}^{Compliance\ balance}/_{GHGIE_{actual}} \right\} * C$onversion factor from MJ to tones of VLSFO (41.0 MJ / kg) x EUR 2400

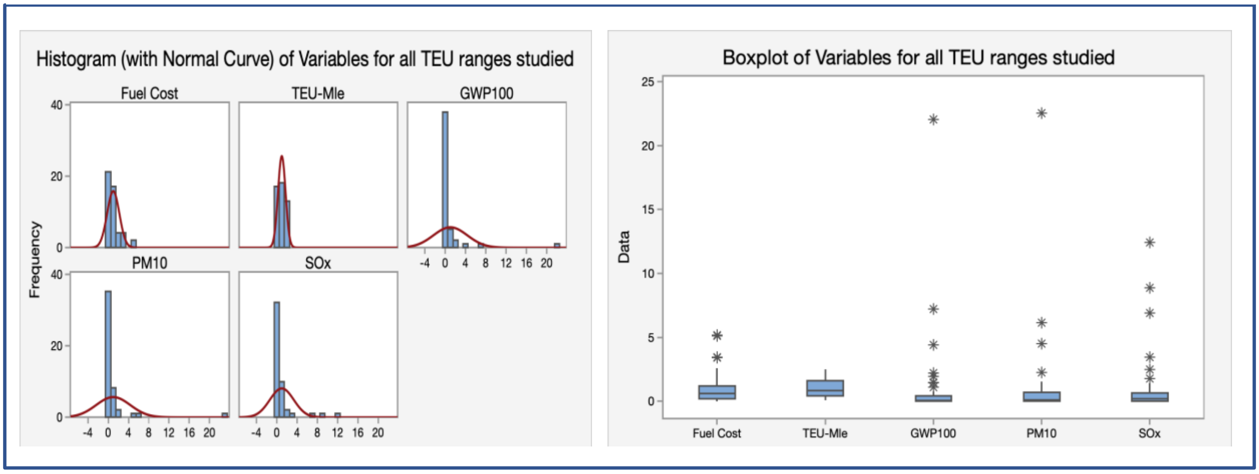
3.4.5 Data description:

Table 13: Descriptive statistics: Normalized values for all TEU classes

Variable	N	Mean	StDev	Minimum	Median	Maximum	Range
Fuel Cost	48	1.0000	1.2095	0.0278	0.6006	5.1741	5.1463
TEU-Mle	48	1.0000	0.7467	0.0836	0.8417	2.4936	2.4100
GWP100	48	1.0000	3.3461	0.0116	0.0769	22.0485	22.0368
PM10	48	1.0000	3.3712	0.0030	0.0966	22.5439	22.5409
SOx	48	1.0000	2.3638	0.0010	0.2014	12.4262	12.4251

Source: Author's calculation

Figure 21: Histogram and box-plot of normalized data



Source: Author's calculation

3.5 Chapter Summary

In this chapter we have seen that the non-parametric method of the DEA methodology is most suited for our analysis. Additionally, the bootstrapping technique helps to discriminate the results further, providing us with a benchmarking or ranking index of alternative fuels to be used on vessels. The choice of inputs are Fuel costs, SOx, GWP100, and PM10. The output chosen is the TEU-mile. These variables are be used to calculate the economic and environmental efficiencies of the DMUs. The details of database formulation are discussed with statistical evidence (a prerequisite for DEA analysis) backing the structure of the database.

Finally, the econometric model is highlighted with details of the constraints that play a key role determining efficiencies on the basis of CRS and VRS. The greenhouse gas intensity index model proposed by the EU commission is illustrated with additional formulae that calculate the penalty for exceeding the GHGIE.

4 Results and Analysis

The bootstrapped CCR results have been presented below. 3 types of efficiencies are assessed and the implication of each of these results is discussed further in this chapter. The analysis of the fuels across each of the 8 TEU classes is conducted for the years 2021 and 2050. It was found that ECO and ENV ranking order follow a similar pattern across TEU classes, with little to no change. Details of the table comparing the rank and efficiency results can be seen in the Figure 23 & Figure 24. Since the changes in ranks, if at all, are most prominent in the extreme classes, we have presented the detailed results of 350 TEU and 23500 TEU classes below. The corresponding table for the year 2021 can be found in the appendix Table 20

Table 14:Results of ECO,ENV, and Scale efficiencies for 2 ship classes - 350 & 23500 TEU

Days	Fuel type	350 TEU 2050 ECO	ECO Rank 2050	350 TEU 2050 ENV	ENV Rank 2050	SE 350	23500 TEU 2050 ECO	ECO Rank 2050	23500 TEU 2050 ENV	ENV Rank 2050	SE 23500
1 day	VLSFO	0.535	23	0.533	34	0.9999	0.539	25	0.538	43	1.0000
	MGO	0.546	19	0.533	35	0.9999	0.550	19	0.547	37	1.0000
	Methanol	0.458	32	0.654	28	0.9997	0.462	33	0.654	31	1.0000
	Ammonia	0.984	1	0.923	3	1.0000	0.994	1	0.958	5	1.0000
	LNG	0.610	7	0.774	14	0.9998	0.615	7	0.778	18	1.0000
	LPG	0.599	9	0.768	15	0.9997	0.604	12	0.771	21	1.0000
	H2 Liq	0.434	36	0.954	1	1.0000	0.439	40	0.981	1	1.0000
	H2 Gas	0.471	31	0.929	2	1.0000	0.485	31	0.959	4	1.0000
5 day	VLSFO	0.533	24	0.530	36	0.9789	0.538	26	0.538	44	0.9944
	MGO	0.543	20	0.530	37	0.9790	0.549	20	0.546	38	0.9944
	Methanol	0.452	33	0.645	29	0.9479	0.460	34	0.652	32	0.9824
	Ammonia	0.965	2	0.904	5	0.9799	0.988	2	0.952	6	0.9945
	LNG	0.604	8	0.767	16	0.9592	0.613	8	0.776	19	0.9867
	LPG	0.593	11	0.760	17	0.9585	0.602	13	0.769	23	0.9864
	H2 Liq	0.420	38	0.922	4	0.9668	0.435	41	0.972	2	0.9908
	H2 Gas	0.409	40	0.808	11	0.8699	0.468	32	0.926	12	0.9648
10 day	VLSFO	0.529	26	0.527	38	0.9518	0.537	27	0.537	45	0.9873
	MGO	0.540	21	0.526	39	0.9518	0.548	21	0.545	39	0.9873
	Methanol	0.444	34	0.634	30	0.9160	0.458	35	0.649	33	0.9643
	Ammonia	0.940	3	0.881	7	0.9549	0.981	3	0.946	8	0.9875
	LNG	0.596	10	0.757	18	0.9290	0.611	9	0.774	20	0.9754
	LPG	0.586	13	0.751	19	0.9280	0.600	15	0.766	25	0.9747
	H2 Liq	0.402	41	0.882	6	0.9252	0.430	42	0.961	3	0.9794
	H2 Gas	0.333	44	0.657	27	0.7073	0.446	39	0.883	15	0.9208
15 day	VLSFO	0.526	27	0.524	40	0.9234	0.536	28	0.536	46	0.9802
	MGO	0.536	22	0.523	41	0.9235	0.547	22	0.544	40	0.9802
	Methanol	0.436	35	0.623	31	0.8831	0.456	36	0.646	34	0.9474
	Ammonia	0.915	4	0.858	8	0.9298	0.975	4	0.939	9	0.9806
	LNG	0.588	12	0.747	20	0.8977	0.609	10	0.771	22	0.9610
	LPG	0.579	15	0.742	21	0.8965	0.598	16	0.764	26	0.9603
	H2 Liq	0.384	42	0.843	9	0.8837	0.425	43	0.950	7	0.9680
	H2 Gas	0.256	46	0.506	46	0.5446	0.425	44	0.841	16	0.8768
20 day	VLSFO	0.523	29	0.520	42	0.8910	0.536	29	0.535	47	0.9728
	MGO	0.532	25	0.519	43	0.8912	0.546	23	0.543	41	0.9728
	Methanol	0.428	37	0.612	32	0.8470	0.454	37	0.643	35	0.9340
	Ammonia	0.890	5	0.835	10	0.9047	0.968	5	0.933	11	0.9737
	LNG	0.581	14	0.737	22	0.8628	0.607	11	0.768	24	0.9481
	LPG	0.572	16	0.733	23	0.8612	0.596	17	0.761	28	0.9471
	H2 Liq	0.366	43	0.803	12	0.8421	0.420	45	0.938	10	0.9565
	H2 Gas	0.180	47	0.355	47	0.6070	0.404	47	0.799	17	0.8328
30 day	VLSFO	0.516	30	0.514	44	0.5245	0.534	30	0.533	48	0.5370
	MGO	0.525	28	0.513	45	0.5337	0.544	24	0.541	42	0.5474
	Methanol	0.413	39	0.590	33	0.7006	0.449	38	0.637	36	0.7490
	Ammonia	0.841	6	0.789	13	0.8545	0.954	6	0.919	13	0.9599
	LNG	0.565	17	0.718	25	0.7318	0.602	14	0.763	27	0.7682
	LPG	0.557	18	0.714	26	0.7272	0.592	18	0.756	29	0.7612
	H2 Liq	0.330	45	0.724	24	0.7590	0.410	46	0.916	14	0.9337
	H2 Gas	0.027	48	0.053	48	0.9258	0.361	48	0.714	30	0.7448

Efficiency Score	Symbol
>= 0.95	
>= 0.70 ; < 0.95	
< 0.70	

Source: Author's analysis
Note: ECO and ENV are bootstrapped CRS efficiency scores.

4.1 Economic Efficiency:

The variables considered here were the Fuel costs and the TEU-mile. Our analysis of efficiencies in 2050 has been conducted with the current price levels of all fuels. In 2050 however, we consider the compliance balance penalty proposed by EU commission in the *Fit for 55* package. The economic efficiencies of the 2021 datasets for both TEU classes show a higher standard deviation than the corresponding efficiencies in 2050. This can be interpreted as increased levels of competition. The lowest performance in all cases was recorded by H_2 gas. A common reason in both 2021 and 2050 for this was the low volumetric energy density of the fuel, resulting in a loss of TEU capacity. Another reason for the low efficiency of H_2 gas in 2021 was the high price compared to the price of existing fossil fuels. This effect is however minimized in 2050.

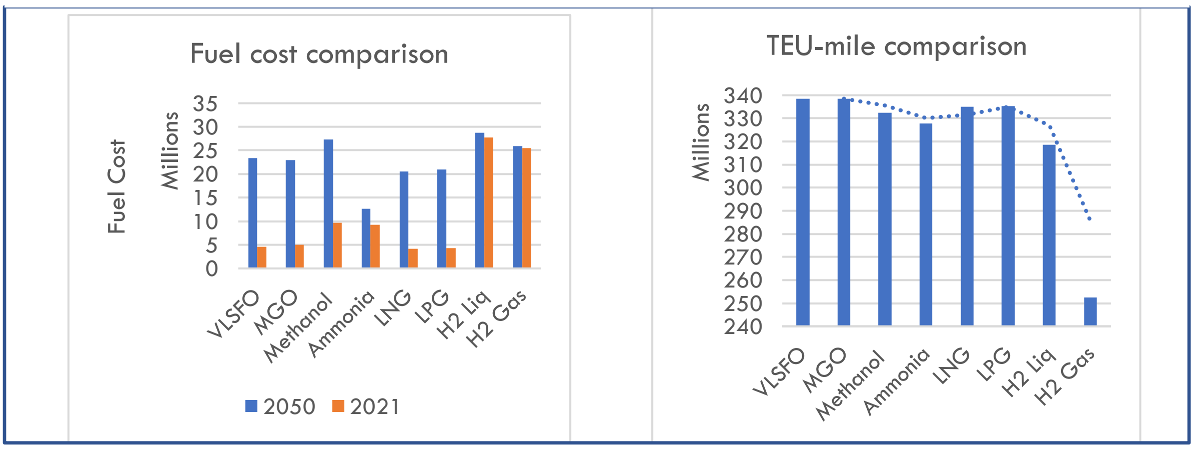
Table 15: Summary statistics of efficiency scores for 2 TEU classes in 2021 and 2050

Variable	N	Mean	Std Dev	Minimum	Median	Maximum	Range
350 TEU 2021 ECO	48	0.57373	0.33866	0.00879	0.60954	0.99114	0.98235
23500 TEU 2021 ECO	48	0.59621	0.33457	0.11848	0.62392	0.99629	0.87782
350 TEU 2050 ECO	48	0.53317	0.18814	0.02700	0.53250	0.98400	0.95700
23500 TEU 2050 ECO	48	0.57292	0.16910	0.36100	0.54150	0.99400	0.63300

Source: Author's calculation

The best performance in 2021 has was by vessels deployed on voyages of shorter duration running on LNG Figure 30. The higher energy density combined with prices comparable to VLSFO in the current 2021market, make LNG the best performing fuel from a purely economic perspective. In 2050, fossil-based fuels become considerably more expensive due to the compliance balance penalty. The reduction in mean efficiency score from 0.5845 to 0.553 (across TEU classes) suggests an overall decrease in vessel economic efficiency observed in 2050, due to the addition of applicable GHG penalties. However, higher levels of competition is evidenced from the reduction in standard deviation of efficiencies from an average (across TEU classes) of 0.336 in 2021 to 0.179 in 2050 Table 15. Our analysis shows that LNG has been displaced by Ammonia in 2050. Although ammonia does have N_20 emissions, the GWP100 is less than a fifth of most fossil equivalents. Hydrogen continues to perform poorly for due to cost to fuel and reduction in TEU-mile. The effects of this reduction for vessels of 23500 TEU class are depicted below.

Figure 22: 30 day Fuel Cost and TEU- mile comparison for 23500 TEU vessel



Source: Author's analysis

4.2 Environmental Efficiency:

The variables included are the same those for economic efficiency with the addition of emissions – SOx, GWP100, and PM10 as input variables.

The 2021 range of ENV scores vary in much higher proportion depending on the size of the vessel. Smaller vessel classes have a range of 0.928 due to the high efficiencies attained in voyages of shorter duration. The loss of TEU capacity owing to low volumetric energy densities of fuels leads to inefficient performance over longer voyages for smaller vessels. In the same period, large vessels, such as the 23500 TEU class, show higher performance due to lower TEU capacity losses. The range, 0.255, is also much narrower due to the increased benefits of reduced emission from zero-carbon fuels compared to the loss in cargo. Voyages of shorter duration have a number of fuel types that perform well – ammonia, LNG, LPG, H_2 liquid, and H_2 gas.

Table 16: Summary statistics of efficiency scores for 2 TEU classes in 2021 and 2050

Variable	N	Mean	Std Dev	Minimum	Median	Maximum	Range
350 TEU 2021 ENV	48	0.85089	0.16220	0.05539	0.87613	0.98347	0.92808
23500 TEU 2021 ENV	48	0.920538	0.065771	0.737434	0.949319	0.992875	0.255441
350 TEU 2050 ENV	48	0.68008	0.17339	0.05300	0.72100	0.95400	0.90100
23500 TEU 2050 ENV	48	0.75142	0.15786	0.53300	0.76700	0.98100	0.44800

Source: Author's calculation

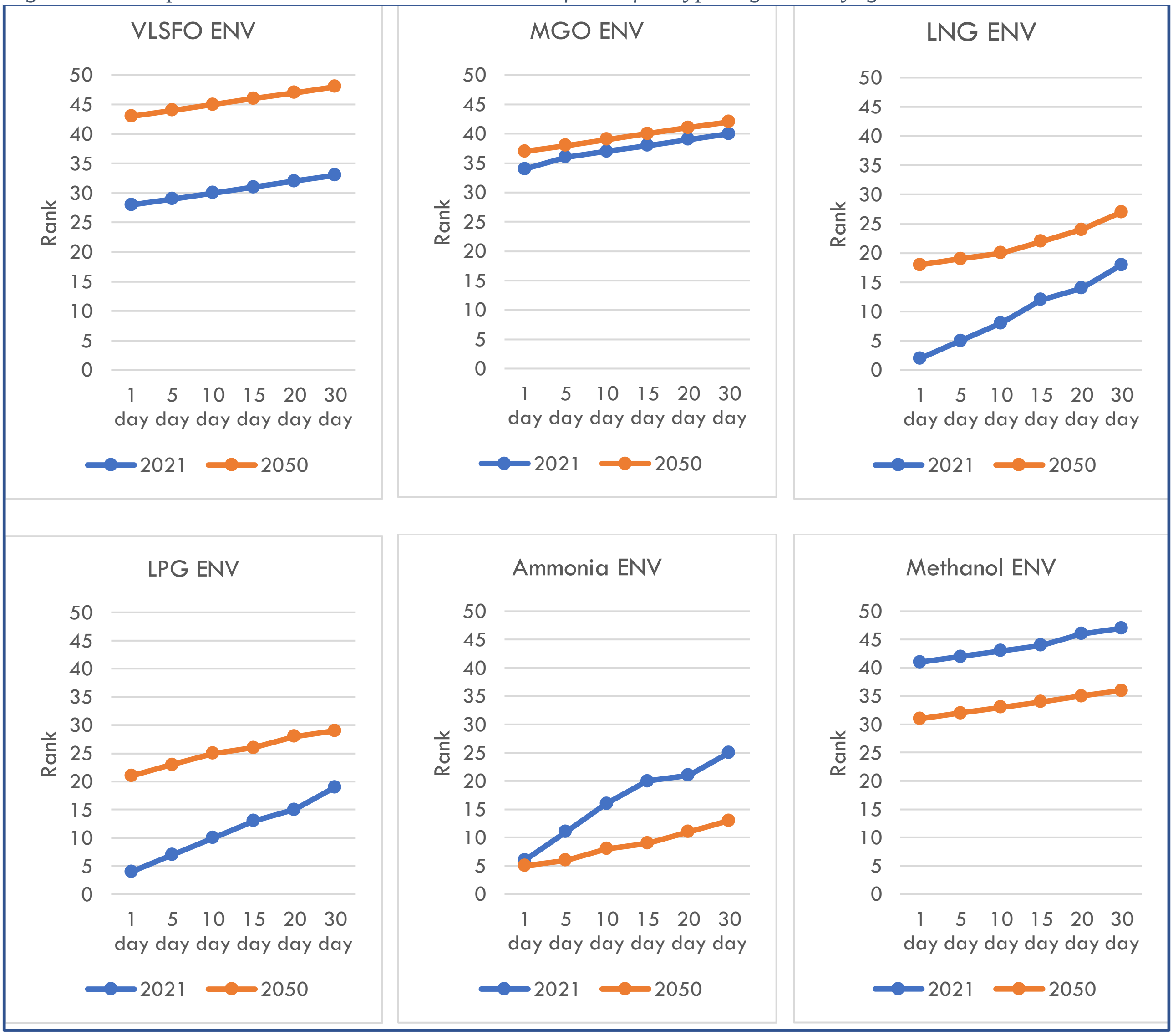
In the 2050, ammonia, H_2 liquid, and H_2 gas remain as the best performing fuels for shorter durations irrespective of vessel size. The mean (across TEU classes) efficiency score for 2050 suffers a reduction from an average of 0.885 in 2021 to 0.7155 in 2050. Zero carbon fuels are elevated and fossil fuels are penalized for breaching the GHG intensity limit. The penalty imposed in conjunction with the combustion emissions results in VLSFO achieving in the lowest efficiency. Larger vessels on longer voyages perform best with ammonia.

The efficiencies can also be interpreted as ranks for the purpose of benchmarking the best performers. The ranking of various fuels in both periods is shown in the figures below. Longer duration voyages emit more compared to shorter voyages of the same vessel class and are consequently allotted lower ENV efficiencies/ranks.

As indicated by the Figure 23 and Figure 24 below, rankings of each fuel type show a range of variations. The effect of the *Fit for 55* package is clearly seen in that zero-carbon fuels improve rankings by much wider margins. Methanol, which is a poor performer in 2021 improves its rankings by 10 places in 2050. The high GWP100 and cost of the fuel (excluding compliance balance penalties), make it a poor choice.

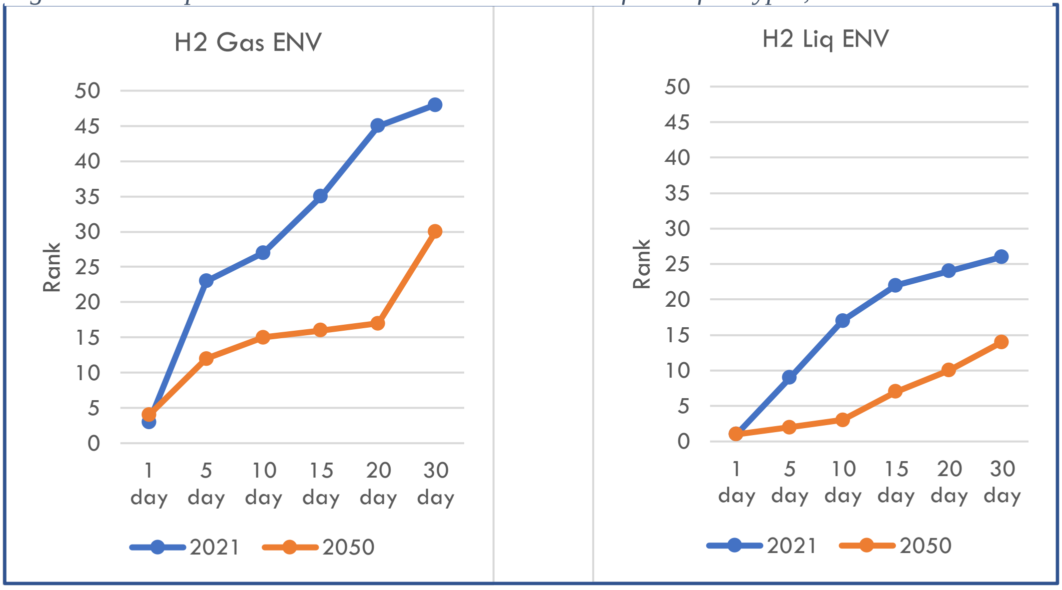
A comparison of the economic and environmental efficiencies for 2021 and 2050 are presented in Figure 30, Figure 31, Figure 32, and Figure 33. We notice that the overall ENV efficiency of container shipping drops in 2050 compared to the 2021 levels. This is evidenced by the value of efficiency scores in both periods. Although we expect the zero and low carbon fuels such as ammonia and hydrogen to perform better in 2050 compared to 2021, there appears to be a marginal drop in efficiencies. This is due to the minimal compliance balance penalty that these fuels will have to pay as a result of using pilot fuels in the internal combustion engines. Since the usage of pilot fuel is assumed to be 5%, the negative impact to the overall efficiency score of DMUs with ammonia and hydrogen fuels is minimal. Methanol is severely taxed due to the cost of the fuel itself and the emissions from TtW. If green methanol is used, the penalty may be reduced or eliminated. However, procuring green methanol at such large scale will require improvements in the TRL levels of e-methanol, blue, and green methanol.

Figure 23: Comparison between 2021 and 2050 ranks for all fuel types against voyage duration



Source: Author's analysis
Note: The rankings shown are for 23500 TEU vessels. Other classes also follow similar trends.

Figure 24: Comparison between 2021 and 2050 ranks for all fuel types, continued



Source: Author's analysis
Note: The rankings shown are for 23500 TEU vessels. Other classes also follow similar trends.

4.3 Scale efficiencies:

In order to further understand the source of inefficiency, we compare the bootstrapped CCR and VRS model scores. The source of inefficiency can be caused either by the inefficient use of the resources or simply because of the disadvantageous operating conditions of the DMU (Cooper et al., 2007).

The efficiency frontier in the basic CRS model has fewer efficient DMUs. This can be seen in Table 24. In a VRS assumption, since the scale effects are considered, the number of efficient DMUs are more such that an envelope is created. This envelop is the efficiency frontier and as shown in Figure 19 all inefficient units fall within it. By using the bootstrapped method for our analysis, we have discriminated the results to achieve unique scores for each DMU. When computing the scale efficiency (SE), we compute the ratio of CRS efficiency to VRS efficiency of the basic model (Table 24).

A SE value of 1 indicates that the vessel with the fuel of choice is operating at the optimal scale and that the resources are efficiently consumed. Referring to Table 14 for our evaluation of environmental efficiencies (ENV), we notice that voyages of shorter duration are operating at the optimal scale. However, the CRS scores show that the resource utilization of fossil-based fuels is subpar. With CRS scores above 0.95 and SE at 1, the performance of zero carbon fuels w.r.t resource utilization and scale of operation is nearly optimal for short voyages (1 to 5 days).

Longer voyage durations are found to have SE scores that have a wider range – 0.537 for VLSFO to 0.996 for Ammonia. The VRS score of 1 (e.g., Table 29)for vessels on longer voyages cannot be interpreted as an efficient DMU on absolute terms. This is because the DMU under consideration is experiencing decreasing returns to scale (Table 21) and continues to be projected as efficient in order to form the envelop. Firms or vessels that are operating on constant returns to scale, such as ammonia on short voyages, need not make any adjustments to vessel operation scale. Any adjustments here after will result in a reduction in efficiencies. This is why ammonia is both scale efficient and resource efficient in shorter voyages, but is impacted negatively (although to a much lesser extent than fossil fuels) in longer voyages.

Table 17: Environmental CRS and VRS efficiency comparison for 23500 TEU in 2050

ENV **CRS** scores for 23500 TEU								
Days	VLSFO	MGO	Methanol	Ammonia	LNG	LPG	H2 Liq	H2 Gas
1	0.542	0.553	0.660	1.000	0.784	0.776	1.000	1.000
5	0.542	0.552	0.658	0.994	0.782	0.774	0.991	0.965
10	0.541	0.551	0.654	0.988	0.779	0.772	0.979	0.921
15	0.540	0.550	0.651	0.981	0.776	0.769	0.968	0.877
20	0.539	0.549	0.648	0.974	0.774	0.766	0.957	0.833
30	0.537	0.547	0.642	0.960	0.768	0.761	0.934	0.745
ENV **VRS** scores for 23500 TEU								
Days	VLSFO	MGO	Methanol	Ammonia	LNG	LPG	H2 Liq	H2 Gas
1	0.542	0.553	0.660	1.000	0.784	0.776	1.000	1.000
5	0.545	0.555	0.669	1.000	0.792	0.785	1.000	1.000
10	0.548	0.558	0.679	1.000	0.799	0.792	1.000	1.000
15	0.551	0.561	0.688	1.000	0.808	0.801	1.000	1.000
20	0.554	0.565	0.694	1.000	0.816	0.809	1.000	1.000
30	1.000	1.000	0.857	1.000	1.000	1.000	1.000	1.000

Source: Author's calculation

4.4 Comparison and interpretation of slacks:

Slacks are calculated for input and output variables. The slacks identified for any DMU indicate the input excess in the case of input variable slacks and output shortfalls in the case of output variables. CRS slacks were calculated in the analysis and the results are shown in the tables below.

The interpretation of an input variable slack is the quantity by which these variables must be reduced to in order to become efficient DMUs.

For instance, in the case of 350 TEU vessels in 2050, we find that all the fossil fuel options have input slacks. VLSFO, MGO, and Methanol also have output slacks. In order to reach the efficiency frontier, these three fuels have to overcome the challenges of both reducing the emissions and increasing economic output, which is measured as TEU mile in the analysis. The slacks clearly show that the objectives of the *Fit for 55* package are leveling the field for the use of zero- carbon fuels.

Table 18: Slacks for 350 TEU vessel in 1 Day voyage

1 day	Fuel Cost	SOx	GWP100	PM10	TEU-mile
VLSFO	0	0.248216	47.56547	0.075585	103461.3
MGO	0	0.042828	44.64537	0.012036	99028.256
Methanol	0	0.011202	65.5735	0.007812	3413.284
Ammonia	0	0	0	0	0
LNG	0	0.011251	55.37333	0.004406	0
LPG	0	0.01125	56.67988	0.004612	0
H2 Liq	0	0	0	0	0
H2 Gas	0	0	0	0	0

Source: Author's analysis
Note: Emissions values in Tons

Table 19: Slacks for 23500 TEU vessel in 30 Day voyage

30 day	Fuel Cost	SOx	GWP100	PM10	TEU-mile
VLSFO	0	142.8346	27371.28	43.49502	291960300
MGO	0	24.64524	25690.93	6.925808	279834100
Methanol	0	6.445922	37733.9	4.495542	26131840
Ammonia	0	0.028729	550.9307	0.387297	0
LNG	0	6.498219	32319.09	2.85512	0
LPG	0	6.49741	33066.93	2.970688	0
H2 Liq	2842807.3	0	1333.527	0	20437730
H2 Gas	0	0	0	9.79E-14	86550900

Source: Author's analysis
Note: Fuel cost in Euros and Emissions in Tons

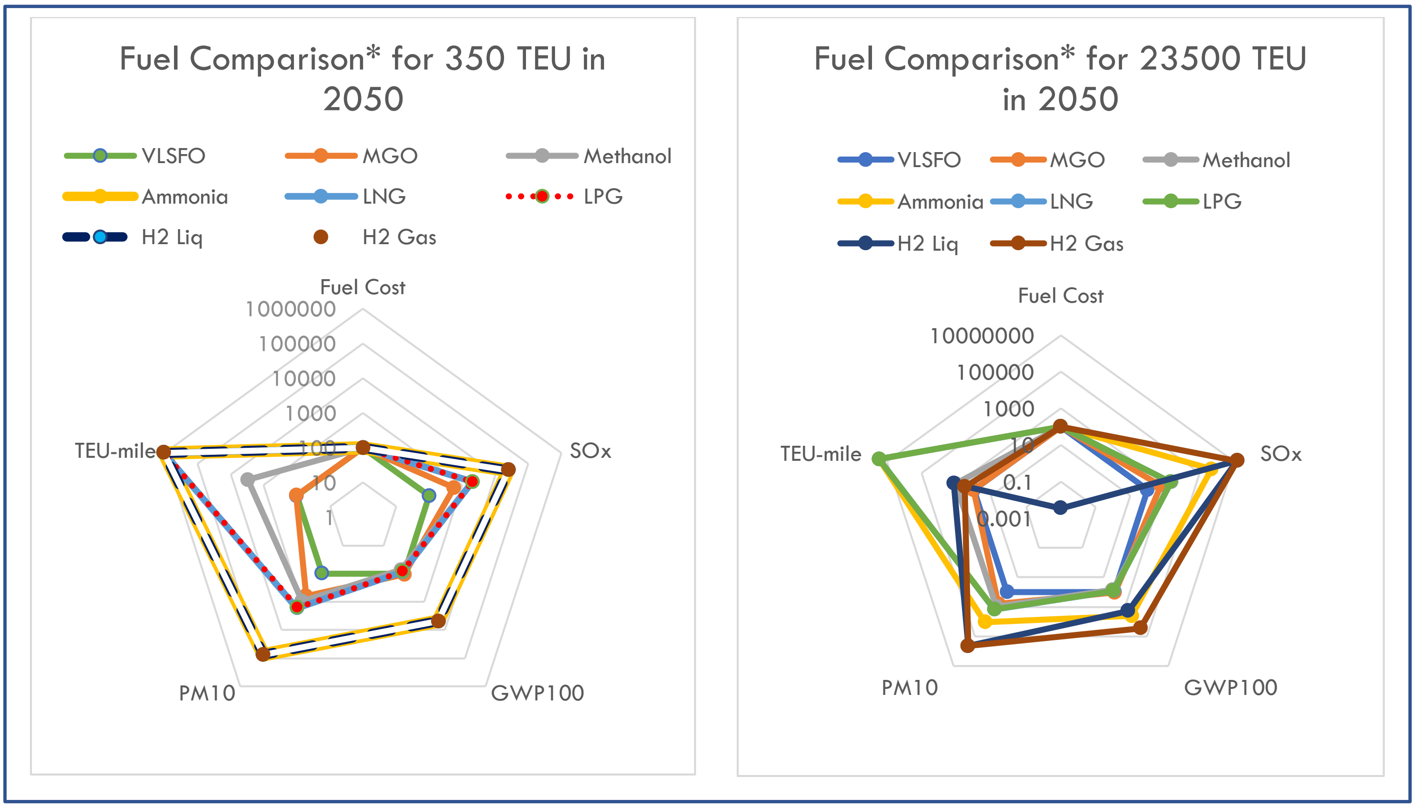
Cost over-runs or input excesses due to fuel costs have been found to be zero for all fuel types. Excess in emission factors is seen, with GWP100 contributing to a considerable amount in the case of methanol. Output shortfalls are noted in the TEU-mile for VLSFO, MGO, and Methanol. This can be interpreted as the TEU-mile target that these 3 fuels have fallen short by for the same levels of input. Vessels deployed with VLSFO in the given scenario need to cover the largest ground in order to stay competitive. However, VLSFO fueled vessels with output slacks are unlikely to improve efficiencies so long as the compliance balance penalty is in place.

For the 23500 TEU vessel category, the fuel costs of H2 liquid continue to make H2 an unlikely fuel choice. Emissions are clearly produced in excess for the fossil or carbon-based fuels. The marginal emissions on account of ammonia and H2 liq are due to the usage of pilot fuel. VLSFO, MGO, and Methanol once again suffer output shortfalls. In order to arrive at the best possible efficiencies, the DEA model has allotted significantly higher values of TEU-mile that need to be achieved to improve ENV efficiencies in 2050. This outputs slacks have been computed keeping inputs constant. In other words, to improve efficiencies, the excess emissions need to be compensated by a disproportionately large TEU-mile output. Since the possibility of lowering emissions further is unlikely, the usage of these fuels needs to be minimized as much as possible.

LNG and LPG show better results. Although the GWP100 emissions generated are higher than those of VLSFO and MGO, the PM10 and SOx emissions have reduced. Comparable costs of fuel and higher energy densities have contributed to zero slacks in the TEU-mile and Fuel cost variables.

The clear winner for both short sea shipping and deep-sea shipping appears to be Ammonia. Low emissions and fuel costs make ammonia a highly competitive fuel in 2050. Using the slacks from the DMUs tested above, we have computed the performance of the fuels against the variables used in the analysis. The fig below shows that short sea shipping has a few options that can be equally viable- H2 liq, H2 gas, and Ammonia, while ammonia shows the best all-around performance for deep sea shipping, followed by LNG and LPG.

Figure 25: Slack-based comparison of Fuels for 350 and 23500 TEU vessels in 2050

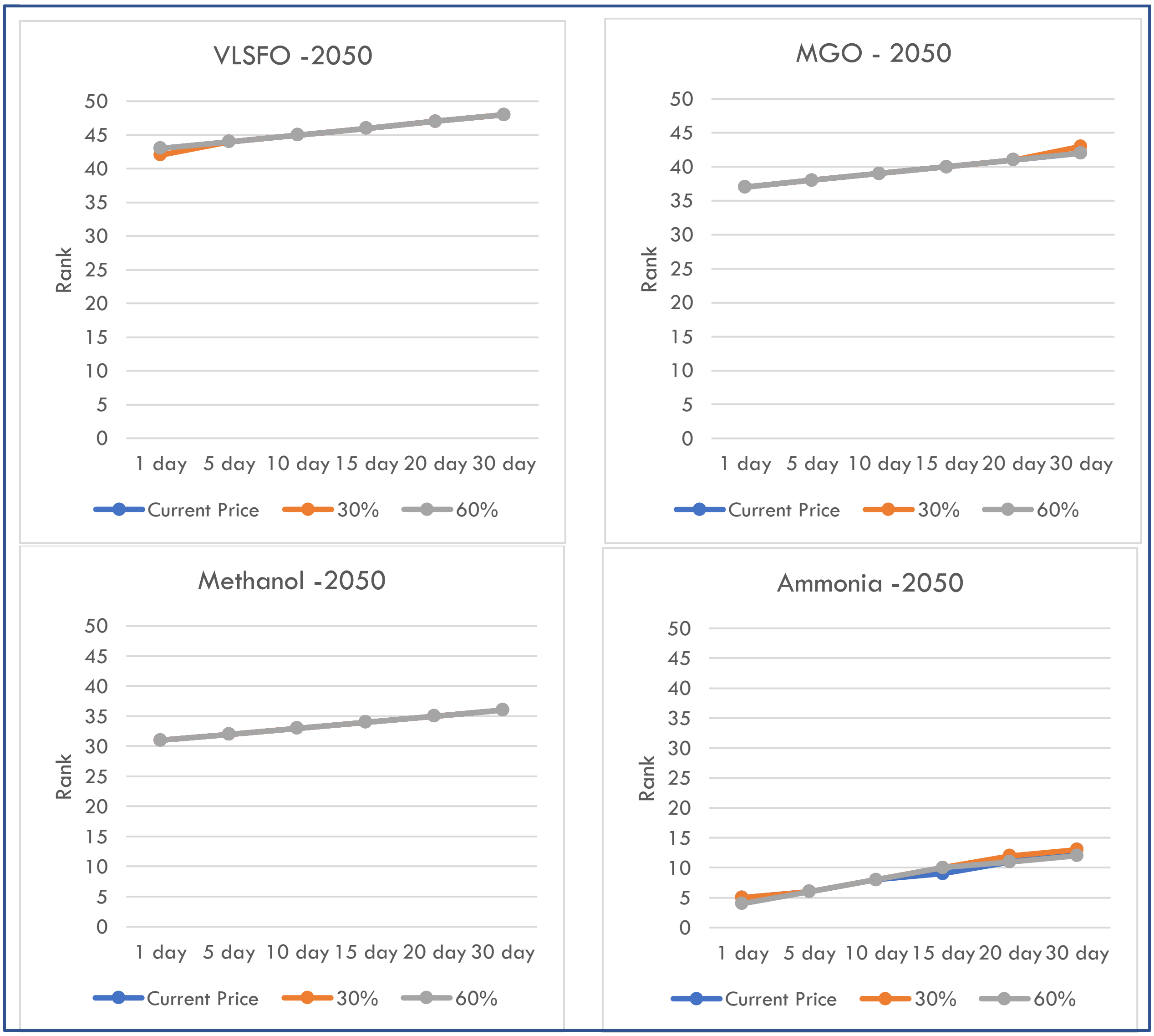


Source: Author's analysis
**Log scale used with normalized values*

4.5 Sensitivity Analysis:

Among the variables chosen, the most dynamic element is the price of the fuel. Since VLSFO, MGO, LNG, and LPG are currently at the highest levels of technological readiness levels (TRL), we assume further reductions in prices are unlikely (IMO-Norway Green Voyage 2050 Project & E4Tech and Houlder, 2021). An increase will not affect the rankings either since the analysis presented earlier shows that the compliance balance penalty imposed is sufficient to award low ranks to these fossil fuels. Thus, we assume the same price levels as 2021 for these 4 fossil fuels. For the rest of the fuels – ammonia, methanol, H_2 liq, and H_2gas – we assume 2 scenarios. The first scenario considers a conservative change in TRL levels, resulting in a reduction in prices for ammonia and methanol by 30% and H2 by 20% by 2050. In the second scenario, we consider an accelerated improvement in TRLs with the effect of reducing 60% for ammonia and methanol, and 40% for H_2 fuels. Presented below are the changes in ranks in these 2 scenarios. They are also compared with ranks obtained with the current fuel price. Since the comparison of all ranking scenarios are in 2050, penalties are added where ever applicable.

Figure 26: Scenario Environmental Rank Comparison for all fuels in 2050 (a)

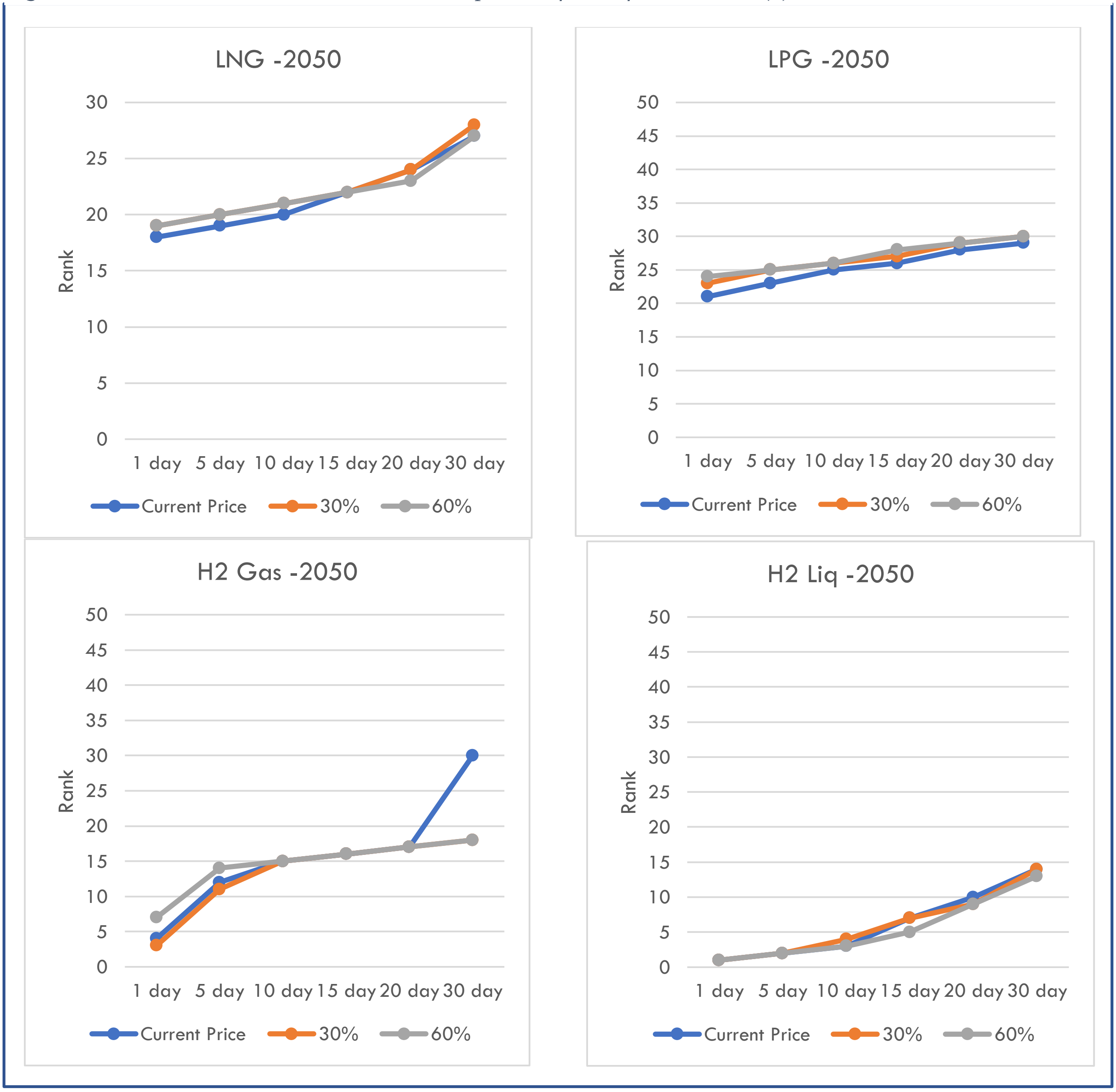


Source: Author's calculations

Note: 30% refers to the conservative scenario where prices reduce by a maximum of 30% from 2021 levels

60% refers to the accelerated scenario where prices reduce by a maximum of 60% from 2021 levels

Figure 27: Scenario Environmental Rank Comparison for all fuels in 2050 (b)



Source: Author's calculations
Note: 30% refers to the conservative scenario where prices reduce by a maximum of 30% from 2021 levels
60% refers to the accelerated scenario where prices reduce by a maximum of 60% from 2021 levels

On analyzing the CRS efficiencies of the vessels, we find that fuels that have not been awarded a price reduction in any of the scenarios suffer the greatest change in efficiency scores (Table 22). VLSFO is impacted the most with a reduction in efficiency by 55% on average. In both scenarios, we see the reduction in prices making H2 liq the best performing fuel in 2050. This is due to the combined effects of reduced emission and cost reductions. Ammonia continues to hold a strong position with efficiencies of over 91% under all scenarios and voyage durations. The reduction in price makes H2 based fuels nearly twice as efficient as VLSFO and MGO. The overall range of efficiencies is found to be large in the scenario where the maximum price reductions are awarded to alternative fuels.

Table 23 shows that the scale efficiencies have little to no changes for most voyage durations. The largest TEU class of 23500 however, shows 10-30 % changes in the scale efficiency as compared to the present-day prices. This implies that the decreasing returns to scale experienced by the vessels even in the current scenario is further compounded. The effects are worst experienced for VLSFO, MGO, LNG, and LPG. Methanol experiences these effects as well, but to a less extent.

To conclude, we see that even with the reduction in prices for the two stated scenarios, the ranking order doesn't change much from the current levels of pricing so long as the penalty is in place. However, the competitiveness of the fuels erodes significantly with vessels powered by fossil fuels becoming increasingly inefficient.

5 Conclusion and Recommendation:

This study differs from existing studies in that we simulate the performance of alternative fuels on vessels that are currently not in existence. Conventional efficiency analysis in the maritime industry is carried out through empirical analysis of firms that are currently operating in the market.

In this research, we compare and analyze economic efficiency (ECO) and environmental efficiency (ENV) of container ships using 8 fuel types (VLSFO, MGO, Methanol, Ammonia, LNG, LPG, H_2 liq, and H_2 gas) deployed on 6 different voyage durations. Further, these specifications are extended to 8 TEU classes. Since the efficiencies are calculated using the bootstrapped DEA methodology, we are able to discriminate between the efficiencies of each of the DMUs tested. These unique efficiencies are then equated to ranks. We find that the ranking order of both ECO and ENV efficiencies vary marginally across TEU classes. The deviations in ranking order are greatest in the 2 extreme classes – 350 and 23500 TEU. Further analysis is carried out with these two classes.

The variables chosen to analyze the economic efficiency are fuel cost as input and TEU-mile as output. The economic efficiencies computed revealed that the average efficiency of vessels was higher in 2021 than in 2050. It is also noted that zero- emission fuels are not nearly as competitive as fossil fuels in 2021 as they are in 2050. This was a result of the compliance balance penalties imposed from the *Fit for 55* package. Vessels running on ammonia are found to be the most economically efficient, irrespective of vessel size and voyage duration. LNG and LPG are the next best options. However, these fossil options have a much lower efficiency score than ammonia. This indicates that ammonia fueled vessels are not just the best economic option, but they are so by a wide margin.

Next, we evaluated the environmental efficiency by considering emissions, SOx, GWP100, and PM10, as inputs, in addition to fuel costs. TEU-mile continues to be the output variable. 2021 environmental efficiency results show that a number of options exist for shorter voyage durations - Ammonia, LNG, LPG, H_2 liquid, and H_2 gas. For longer voyages, LNG and LPG are assessed to be the best options. Zero emission fuels do not perform well mainly due to the current price of fuels. Loss of cargo carriage capacity is also a factor. In 2050, we find that the list of fuels that perform best on shorter voyages have been reduced to 3 – Ammonia, H_2 liquid, and H_2 gas. The best performance for deep sea shipping is by ammonia.

The FuelEU measures indeed bridge the gap between fossil and zero carbon fuel, making ammonia the most efficient option both economically and environmentally, irrespective of vessel size and voyage duration. We anticipate maturity of the underlying technology in zero-carbon fuel production and distribution, contributing to a reduction is the fuel cost. Fossil fuel costs were not altered since we assume the current TRL levels cannot be surpassed.

Efficiencies and ranks in 2 price scenarios were evaluated. The first considers a conservative level of development and the second scenario shows a higher TRL level being attained by 2050. In both cases, ammonia is joined by H_2 liquid as the two best performing fuels of 2050. The next most viable option is LNG, but it comes at a distant third.

The results from this study can provide meaningful insights to policy makers, ship owners, and investors. For policy makers, the study shows that without the help of measures such as the FuelEU, fossil fuels will continue to dominate the shipping landscape. LNG has the best economic efficiency today and this is reflected in the orderbook. A concerted, global application of such packages as the Fit for 55 will help achieve the goals set out in the IMO GHG strategy. Access to capital for ventures that support initiatives which lower the carbon foot print of the industry must be available.

For ship owners, greater collaboration among stakeholders in the value chain that focus on these fuels will be crucial in distributing the risks that are involved in eliminating the chicken and egg problem.

Investors have become increasingly conscious about the environmental footprint of their actions. In this regard, accelerating the efforts of companies that work on ammonia and H_2 based fuels will help make these fuels a lot more competitive within the time frame needed.

5.1 Scope for future work:

Future work can extend our study in various directions. Firstly, since the study covers an analysis of only container ships, other vessel types can be analyzed. Secondly, the study does not include emissions from Well to Tank. Thirdly, to expand the definition of economic efficiency, an inclusion of operational and capital costs may be considered. Lastly, an ex-post analysis of the results can be carried out to verify the methodology used and suggest necessary modifications to the DEA model.

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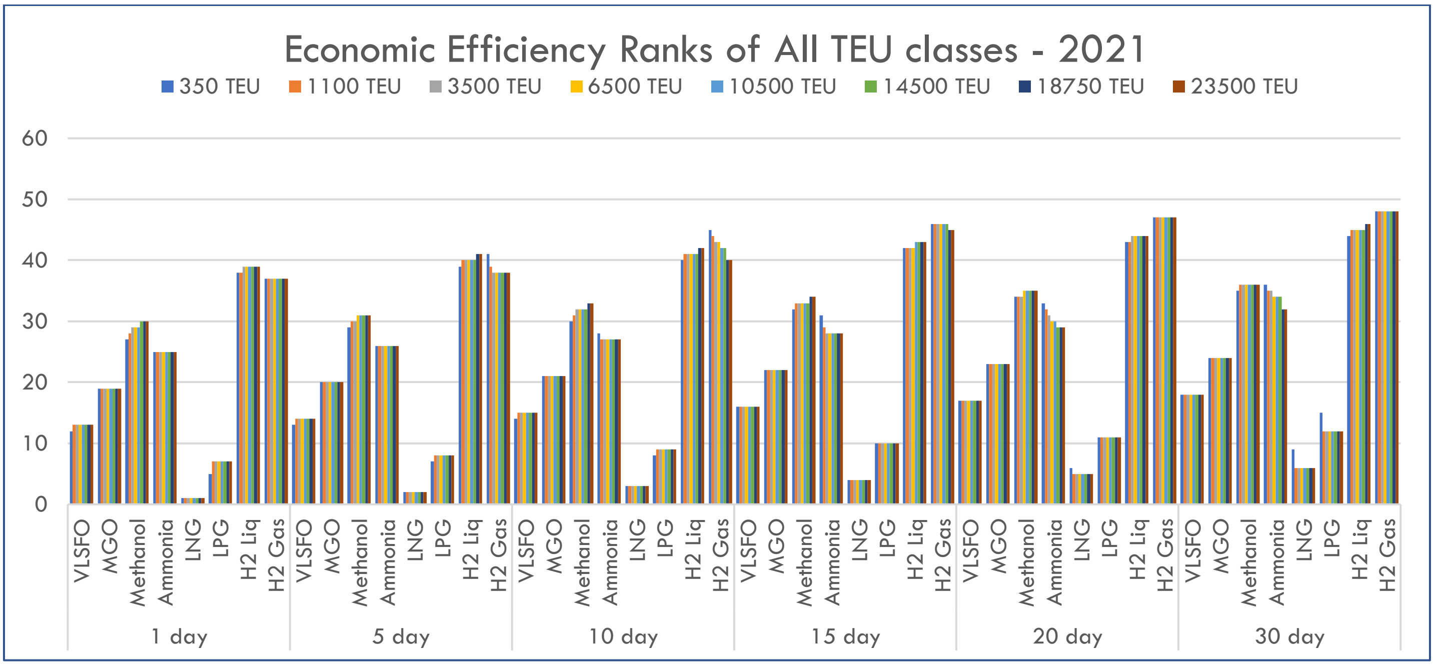
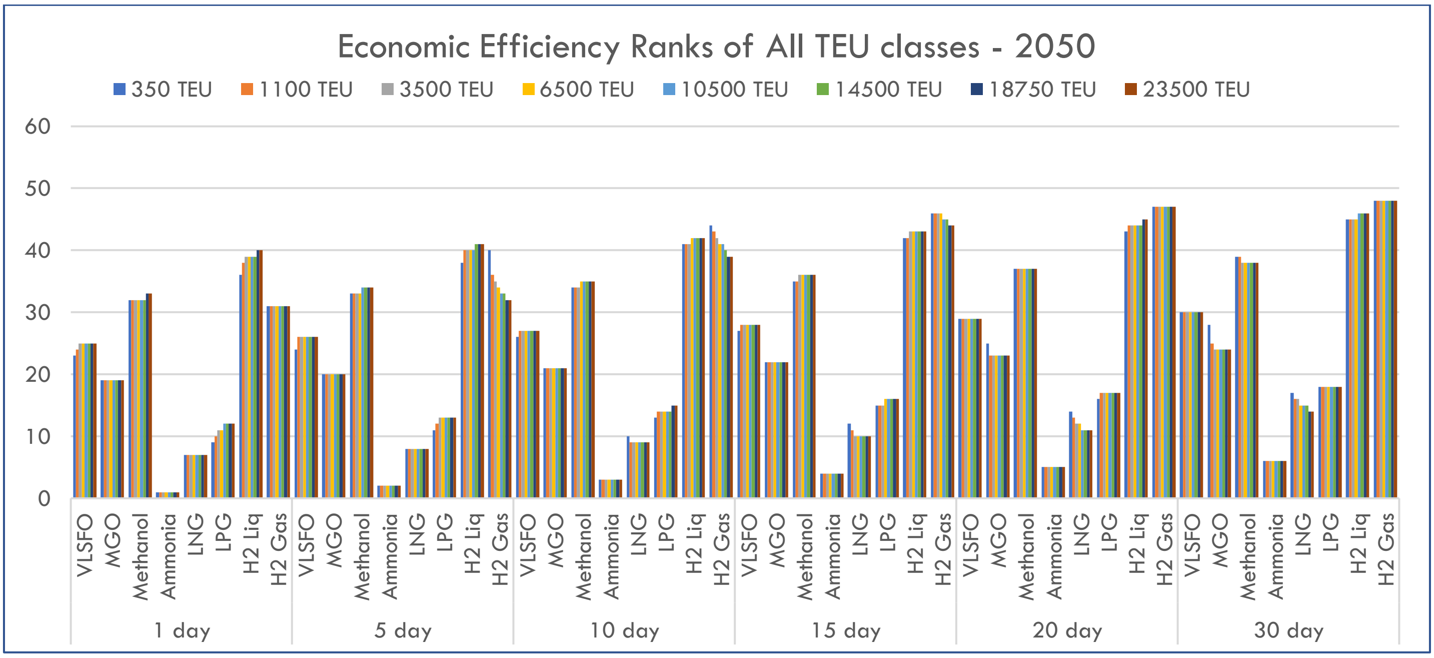
7 Appendix:

Figure 28: 2021 Economic Efficiency ranks of all TEU classes



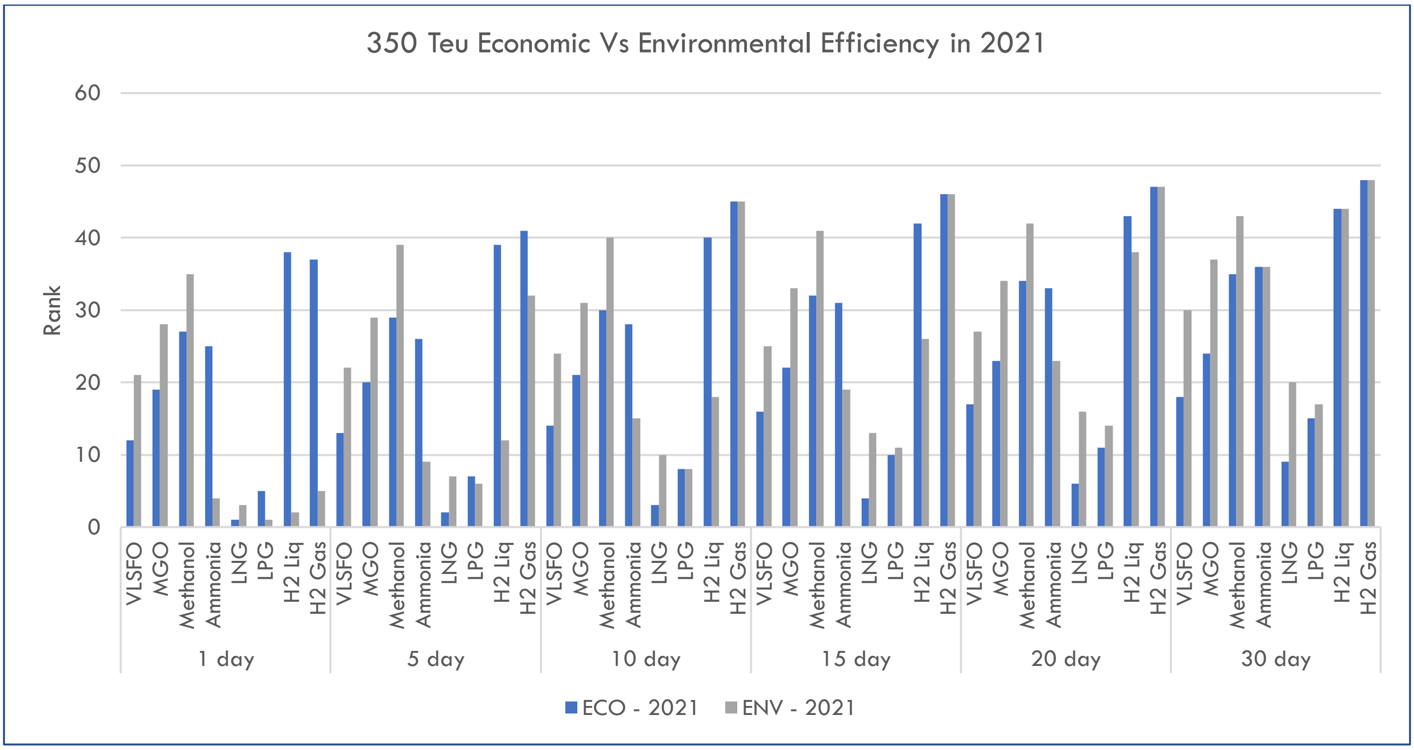
Source: Author's calculation

Figure 29: 2050 Economic Efficiency ranks of all TEU classes



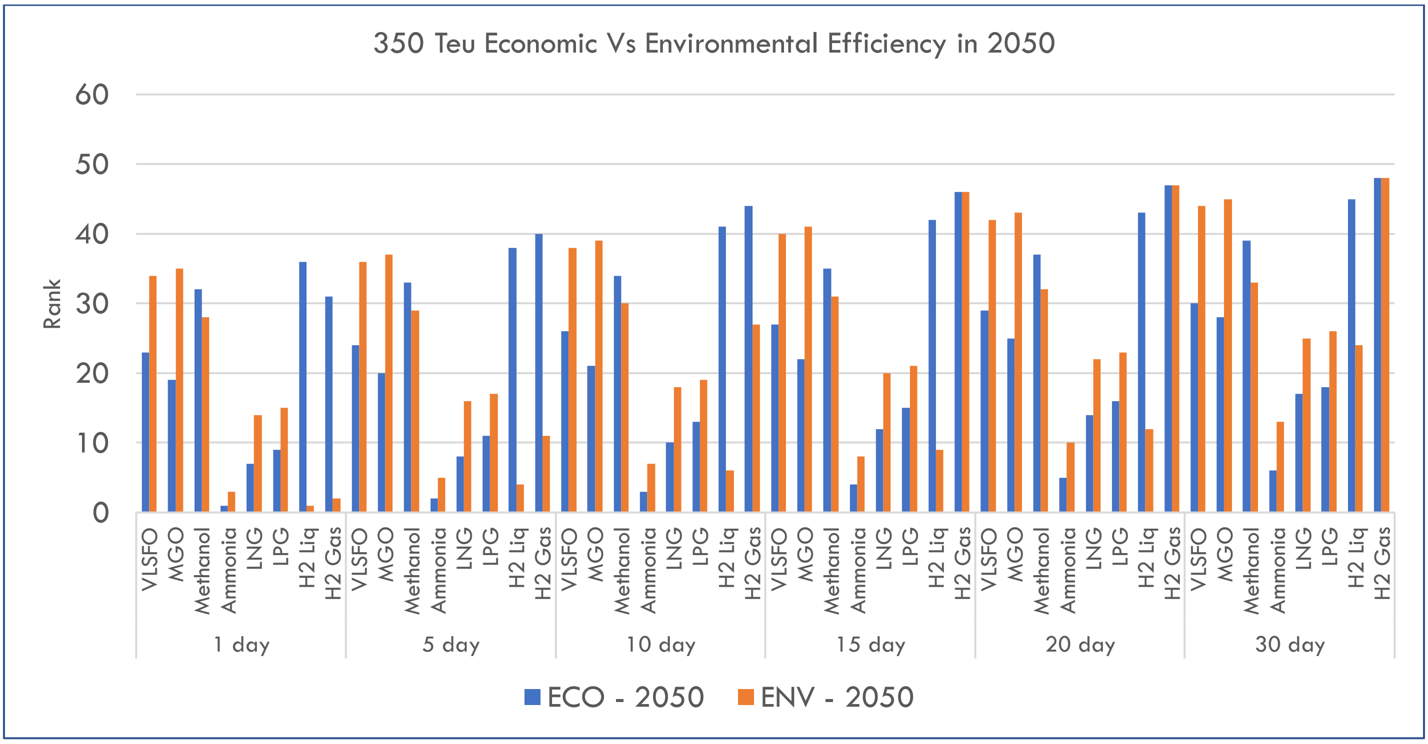
Source: Author's calculation

Figure 30: ECO and ENV Efficiency comparison in 2021 for 350 TEU class vessels



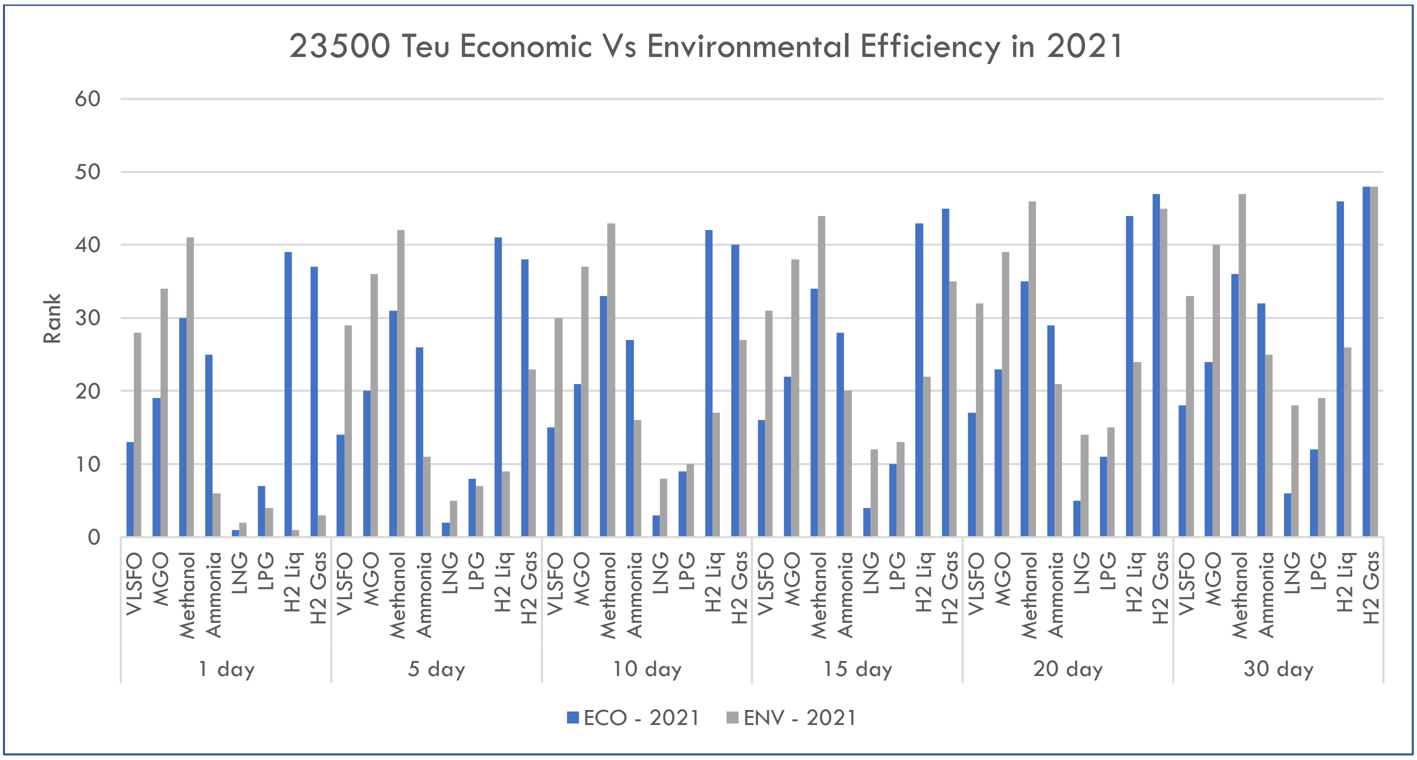
Source: Author's analysis

Figure 31: ECO and ENV Efficiency comparison in 2050 for 350 TEU class vessels



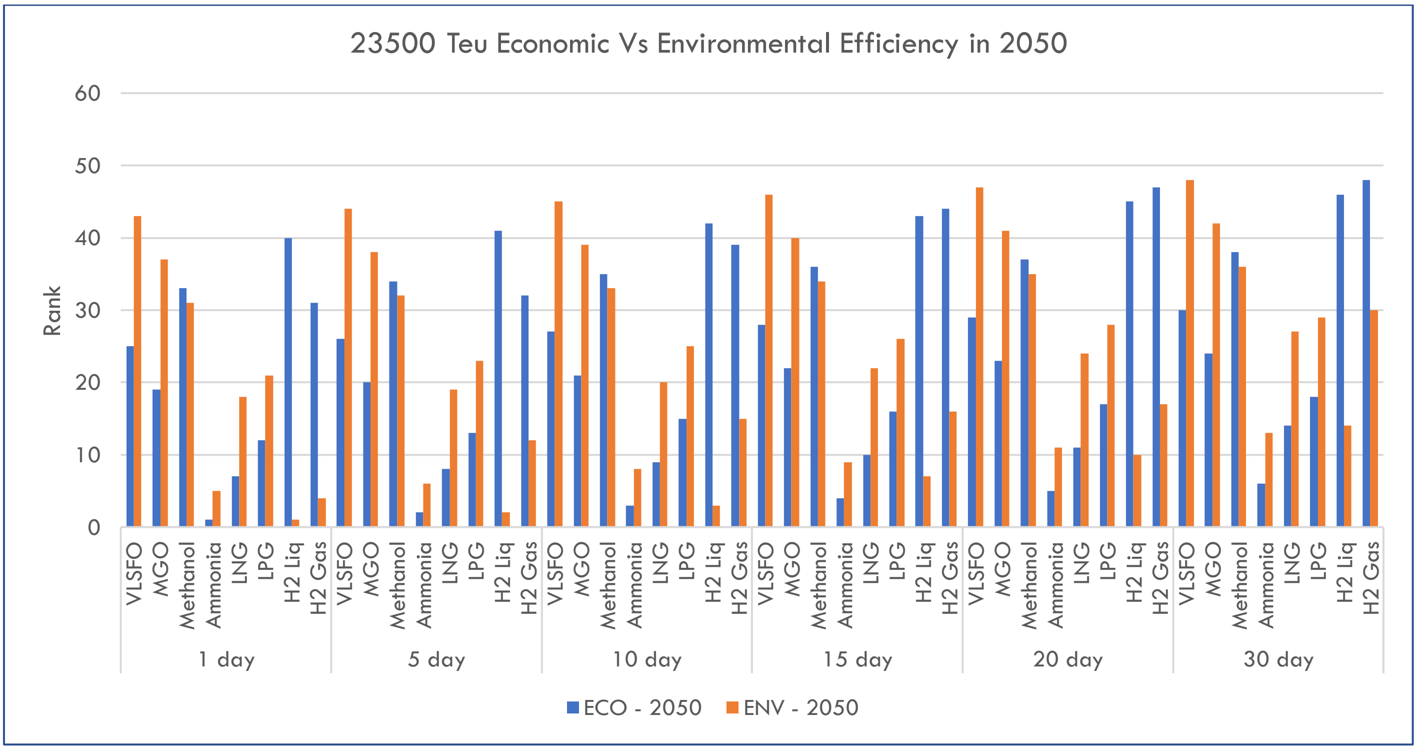
Source: Author's analysis

Figure 32: ECO and ENV Efficiency comparison in 2021 for 23500 TEU class vessels



Source: Author's analysis

Figure 33: ECO and ENV Efficiency comparison in 2050 for 23500 TEU class vessels



Source: Author's analysis

Table 20: Results of ECO, ENV, and Scale efficiencies (SE) for 2 ship classes – 350 & 23500 TEU for year 2021

Days	Fuel type	350 TEU 2021 ECO	ECO Rank 2021	350 TEU 2021 ENV	SE 350 Env	ENV Rank 2021	23500 TEU 2021 ECO	ECO Rank 2021	23500 TEU 2021 ENV	ENV Rank 2021	SE 23500 Env
1 day	VLSFO	0.89071	12	0.888635	🟢 0.99998	21	0.894507	13	0.893415	28	🟢 1
	MGO	0.813084	19	0.864905	🟢 0.99998	28	0.816598	19	0.868175	34	🟢 1
	Methanol	0.422218	27	0.838354	🟢 0.99994	35	0.42468	30	0.839268	41	🟢 1
	Ammonia	0.436723	25	0.977297	🟢 1	4	0.439787	25	0.988595	6	🟢 1
	LNG	0.991142	1	0.979409	🟢 1	3	0.996293	1	0.991352	2	🟢 1
	LPG	0.944894	5	0.983467	🟢 1	1	0.949728	7	0.989205	4	🟢 1
	H2 Liq	0.145899	38	0.982441	🟢 1	2	0.147271	39	0.992875	1	🟢 1
	H2 Gas	0.154903	37	0.976316	🟢 1	5	0.159081	37	0.990158	3	🟢 1
5 day	VLSFO	0.886351	13	0.884287	🟢 0.98979	22	0.893296	14	0.892205	29	🟢 0.99721
	MGO	0.808845	20	0.860396	🟢 0.98927	29	0.81542	20	0.866923	36	🟢 0.99707
	Methanol	0.416501	29	0.827002	🟢 0.97741	39	0.423091	31	0.836128	42	🟢 0.99189
	Ammonia	0.427962	26	0.95769	🟢 0.97994	9	0.437352	26	0.983122	11	🟢 0.99446
	LNG	0.981184	2	0.969569	🟢 0.98995	7	0.993526	2	0.988599	5	🟢 0.99722
	LPG	0.935823	7	0.974026	🟢 0.9894	6	0.947207	8	0.98658	7	🟢 0.99702
	H2 Liq	0.14105	39	0.949787	🟢 0.96676	12	0.145924	41	0.98379	9	🟢 0.99085
	H2 Gas	0.134749	41	0.849292	🟡 0.86989	32	0.153481	38	0.955299	23	🟢 0.9648
10 day	VLSFO	0.880903	14	0.878851	🟢 0.97689	24	0.891782	15	0.890693	30	🟢 0.99371
	MGO	0.803547	21	0.85476	🟢 0.97571	31	0.813947	21	0.865358	37	🟢 0.99339
	Methanol	0.409354	30	0.812811	🟢 0.96062	40	0.421105	33	0.832203	43	🟢 0.98637
	Ammonia	0.417009	28	0.933181	🟢 0.95486	15	0.434308	27	0.976281	16	🟢 0.98754
	LNG	0.968737	3	0.957269	🟢 0.97739	10	0.990067	3	0.985157	8	🟢 0.99375
	LPG	0.924484	8	0.962225	🟢 0.97662	8	0.944057	9	0.983298	10	🟢 0.99343
	H2 Liq	0.134988	40	0.90897	🟡 0.92522	18	0.144239	42	0.972434	17	🟢 0.97941
	H2 Gas	0.109557	45	0.690512	🟡 0.70726	45	0.14648	40	0.911726	27	🟡 0.92079
15 day	VLSFO	0.875455	16	0.873416	🟢 0.9638	25	0.890268	16	0.889181	31	🟢 0.9902
	MGO	0.798248	22	0.849123	🟢 0.96196	33	0.812475	22	0.863792	38	🟢 0.98971
	Methanol	0.402207	32	0.798621	🟡 0.94544	41	0.419119	34	0.828279	44	🟢 0.97771
	Ammonia	0.406057	31	0.908672	🟡 0.92978	19	0.431265	28	0.969439	20	🟢 0.98062
	LNG	0.95629	4	0.944969	🟢 0.96484	13	0.986608	4	0.981715	12	🟢 0.99028
	LPG	0.913146	10	0.950423	🟢 0.96388	11	0.940906	10	0.980016	13	🟢 0.98984
	H2 Liq	0.128927	42	0.868154	🟡 0.88367	26	0.142555	43	0.961078	22	🟢 0.96797
	H2 Gas	0.084365	46	0.531731	🔴 0.54463	46	0.13948	45	0.868153	35	🟡 0.87678
20 day	VLSFO	0.870007	17	0.867981	🟢 0.95013	27	0.888754	17	0.887669	32	🟢 0.98665
	MGO	0.792949	23	0.843487	🟡 0.94761	34	0.811002	23	0.862227	39	🟢 0.98598
	Methanol	0.39506	34	0.78443	🟡 0.928	42	0.417133	35	0.824354	46	🟢 0.97075
	Ammonia	0.395105	33	0.884163	🟡 0.9047	23	0.428222	29	0.962598	21	🟢 0.9737
	LNG	0.943842	6	0.932669	🟢 0.95228	16	0.983149	5	0.978273	14	🟢 0.98681
	LPG	0.901807	11	0.938622	🟢 0.95098	14	0.937755	11	0.976735	15	🟢 0.9861
	H2 Liq	0.122865	43	0.827337	🟡 0.84212	38	0.14087	44	0.949722	24	🟢 0.95654
	H2 Gas	0.059173	47	0.372951	🔴 0.60701	47	0.132479	47	0.82458	45	🟡 0.83278
30 day	VLSFO	0.859111	18	0.85711	🟡 0.86679	30	0.885726	18	0.884645	33	🟡 0.88902
	MGO	0.782352	24	0.832214	🟡 0.84061	37	0.808057	24	0.859096	40	🟡 0.86366
	Methanol	0.380767	35	0.756049	🟡 0.88881	43	0.413162	36	0.816504	47	🟢 0.95567
	Ammonia	0.373201	36	0.835146	🟡 0.85455	36	0.422135	32	0.948915	25	🟢 0.95986
	LNG	0.918948	9	0.90807	🟡 0.92716	20	0.976232	6	0.97139	18	🟢 0.97986
	LPG	0.87913	15	0.915019	🟡 0.92435	17	0.931453	12	0.970171	19	🟢 0.97414
	H2 Liq	0.110742	44	0.745703	🟡 0.75903	44	0.137501	46	0.92701	26	🟡 0.93366
	H2 Gas	0.008788	48	0.055391	🟡 0.92583	48	0.118478	48	0.737434	48	🟡 0.74476

Efficiency Score	Symbol
>= 0.95	🟢
>= 0.70 ; < 0.95	🟡
< 0.70	🔴

Source: Author's calculation

Table 21: Returns to scale (RTS) for ENV efficiency of 2 ship classes – 350 & 23500 TEU for year 2050

Voyage Duration	Fuel	Lambda sum 350	RTS - 350 TEU	Lambda sum 23500	RTS - 23500 TEU
1 day	VLSFO	1.0038	Decreasing	1.001	Decreasing
	MGO	1.0037	Decreasing	1.001	Decreasing
	Methanol	1.0125	Decreasing	1.0034	Decreasing
	Ammonia	1	Constant	1	Constant
	LNG	1.0094	Decreasing	1.0026	Decreasing
	LPG	1.0098	Decreasing	1.0027	Decreasing
	H2 Liq	1	Constant	1	Constant
	H2 Gas	1	Constant	1	Constant
5 day	VLSFO	4.9944	Decreasing	4.9984	Decreasing
	MGO	4.9924	Decreasing	4.9979	Decreasing
	Methanol	4.9938	Decreasing	4.9983	Decreasing
	Ammonia	4.8997	Decreasing	4.9723	Decreasing
	LNG	4.9962	Decreasing	4.999	Decreasing
	LPG	5.0003	Decreasing	5	Decreasing
	H2 Liq	4.8338	Decreasing	4.9542	Decreasing
	H2 Gas	4.3495	Decreasing	4.824	Decreasing
10 day	VLSFO	9.9274	Decreasing	9.98	Decreasing
	MGO	9.9193	Decreasing	9.9777	Decreasing
	Methanol	9.8162	Decreasing	9.9497	Decreasing
	Ammonia	9.5486	Decreasing	9.8754	Decreasing
	LNG	9.8657	Decreasing	9.9631	Decreasing
	LPG	9.8793	Decreasing	9.9669	Decreasing
	H2 Liq	9.2522	Decreasing	9.7941	Decreasing
	H2 Gas	7.0726	Decreasing	9.2079	Decreasing
15 day	VLSFO	14.7989	Decreasing	14.9445	Decreasing
	MGO	14.7809	Decreasing	14.9395	Decreasing
	Methanol	14.4673	Decreasing	14.8542	Decreasing
	Ammonia	13.9467	Decreasing	14.7093	Decreasing
	LNG	14.6084	Decreasing	14.8924	Decreasing
	LPG	14.6373	Decreasing	14.9005	Decreasing
	H2 Liq	13.2551	Decreasing	14.5196	Decreasing
	H2 Gas	8.1695	Decreasing	13.1517	Decreasing
20 day	VLSFO	19.6091	Decreasing	19.8921	Decreasing
	MGO	19.577	Decreasing	19.8833	Decreasing
	Methanol	18.9469	Decreasing	19.7117	Decreasing
	Ammonia	18.0941	Decreasing	19.4741	Decreasing
	LNG	19.2243	Decreasing	19.787	Decreasing
	LPG	19.2741	Decreasing	19.8007	Decreasing
	H2 Liq	16.8425	Decreasing	19.1307	Decreasing
	H2 Gas	7.64	Decreasing	16.6555	Decreasing
30 day	VLSFO	29.0453	Decreasing	29.7366	Decreasing
	MGO	28.9731	Decreasing	29.7166	Decreasing
	Methanol	27.3921	Decreasing	29.286	Decreasing
	Ammonia	25.6364	Decreasing	28.7959	Decreasing
	LNG	28.0759	Decreasing	29.4717	Decreasing
	LPG	28.1841	Decreasing	29.5015	Decreasing
	H2 Liq	22.7709	Decreasing	28.0099	Decreasing
	H2 Gas	1.702	Decreasing	22.3429	Decreasing

Source: Author's calculation

Table 22: Comparison of CRS efficiency scores for 23500 TEU class vessel under 3 different fuel pricing scenarios.

Comparison of CRS efficiencies under varying scenarios								
Voyage Duration	Fuel type	2050 ENV CRS for 23500 TEU	30% Scenario ENV CRS for 23500 TEU	% change in CRS eficiencies		2050 ENV CRS for 23500 TEU	60% Scenario ENV CRS for 23500 TEU	% change in CRS eficiencies
1 day	VLSFO	0.8934147	0.4193474	-53.0624		0.8934147	0.380611	-57.39817
	MGO	0.8681754	0.423283	-51.24453		0.8681754	0.386009	-55.5379
	Methanol	0.8392679	0.6066994	-27.71088		0.8392679	0.5219116	-37.81347
	Ammonia	0.9885952	0.960986	-2.792771		0.9885952	0.9599857	-2.893955
	LNG	0.9913519	0.6777227	-31.63652		0.9913519	0.5426661	-45.25999
	LPG	0.9892054	0.670557	-32.21256		0.9892054	0.5349965	-45.91654
	H2 Liq	0.9928753	0.9867252	-0.619423		0.9928753	0.986725	-0.619443
	H2 Gas	0.9901578	0.9701978	-2.01584		0.9901578	0.9490162	-4.155055
5 day	VLSFO	0.8922051	0.4187796	-53.06241		0.8922051	0.3800956	-57.39818
	MGO	0.8669231	0.4226724	-51.24453		0.8669231	0.3854522	-55.5379
	Methanol	0.8361281	0.6044297	-27.71087		0.8361281	0.5199591	-37.81346
	Ammonia	0.9831221	0.9556657	-2.792776		0.9831221	0.9546709	-2.893964
	LNG	0.9885985	0.6758404	-31.63651		0.9885985	0.5411588	-45.26
	LPG	0.9865799	0.6687773	-32.21256		0.9865799	0.5335766	-45.91653
	H2 Liq	0.9837904	0.9776966	-0.619421		0.9837904	0.9776964	-0.619441
	H2 Gas	0.9552993	0.9360421	-2.015829		0.9552993	0.9156062	-4.155043
10 day	VLSFO	0.890693	0.4180699	-53.0624		0.890693	0.3794515	-57.39817
	MGO	0.8653576	0.4219092	-51.24453		0.8653576	0.3847562	-55.5379
	Methanol	0.8322033	0.6015925	-27.71087		0.8322033	0.5175184	-37.81346
	Ammonia	0.9762806	0.9490154	-2.792763		0.9762806	0.9480275	-2.893953
	LNG	0.9851567	0.6734875	-31.63651		0.9851567	0.5392748	-45.26
	LPG	0.9832982	0.6665527	-32.21256		0.9832982	0.5318017	-45.91654
	H2 Liq	0.9724343	0.9664109	-0.619415		0.9724343	0.9664107	-0.619435
	H2 Gas	0.9117263	0.8933474	-2.015835		0.9117263	0.8738437	-4.155041
15 day	VLSFO	0.8891809	0.4173601	-53.06241		0.8891809	0.3788073	-57.39817
	MGO	0.8637922	0.4211459	-51.24454		0.8637922	0.3840601	-55.53791
	Methanol	0.8282786	0.5987554	-27.71087		0.8282786	0.5150777	-37.81347
	Ammonia	0.9694392	0.942365	-2.792769		0.9694392	0.9413841	-2.893951
	LNG	0.981715	0.6711346	-31.63651		0.981715	0.5373908	-45.26
	LPG	0.9800164	0.664328	-32.21256		0.9800164	0.5300268	-45.91654
	H2 Liq	0.9610783	0.9551251	-0.619429		0.9610783	0.9551249	-0.61945
	H2 Gas	0.8681533	0.8506528	-2.015831		0.8681533	0.8320811	-4.15505
20 day	VLSFO	0.8876688	0.4166504	-53.0624		0.8876688	0.3781631	-57.39818
	MGO	0.8622267	0.4203827	-51.24453		0.8622267	0.3833641	-55.5379
	Methanol	0.8243538	0.5959182	-27.71087		0.8243538	0.5126371	-37.81346
	Ammonia	0.9625978	0.9357147	-2.792766		0.9625978	0.9347407	-2.89395
	LNG	0.9782732	0.6687817	-31.63651		0.9782732	0.5355068	-45.25999
	LPG	0.9767346	0.6621034	-32.21256		0.9767346	0.5282519	-45.91654
	H2 Liq	0.9497222	0.9438394	-0.619423		0.9497222	0.9438392	-0.619444
	H2 Gas	0.8245802	0.8079581	-2.015826		0.8245802	0.7903185	-4.155048
30 day	VLSFO	0.8846447	0.4152309	-53.06241		0.8846447	0.3768748	-57.39817
	MGO	0.8590958	0.4188562	-51.24453		0.8590958	0.381972	-55.5379
	Methanol	0.8165043	0.5902439	-27.71086		0.8165043	0.5077557	-37.81347
	Ammonia	0.948915	0.922414	-2.792769		0.948915	0.9214539	-2.893947
	LNG	0.9713897	0.6640759	-31.63651		0.9713897	0.5317388	-45.25999
	LPG	0.970171	0.6576541	-32.21256		0.970171	0.5247021	-45.91653
	H2 Liq	0.92701	0.9212679	-0.619422		0.92701	0.9212677	-0.619443
	H2 Gas	0.7374342	0.7225687	-2.015841		0.7374342	0.7067934	-4.155055

Source: Author's calculations

Table 23: Comparison of CRS efficiency scores for 23500 TEU class vessel under 3 different fuel pricing scenarios

Comparison of Scale efficiencies under varying scenarios						
2050 SE for 23500 TEU	2050 SE - 30% scenario for 23500 TEU	% change		2050 SE for 23500 TEU	2050 SE - 60% scenario for 23500 TEU	% change
1	1	0.000		1	1	0.000
1	1	0.000		1	1	0.000
1	1	0.000		1	1	-0.001
1	1	0.000		1	1	0.000
1	1	-0.001		1	1	-0.001
1	1	-0.001		1	1	-0.001
1	1	0.000		1	1	0.000
1	1	0.000		1	1	0.000
0.9944	0.9944	0.000		0.9944	0.9944	0.000
0.9944	0.9944	0.000		0.9944	0.9944	0.000
0.9824	0.9806	-0.177		0.9824	0.9776	-0.487
0.9945	0.9945	0.000		0.9945	0.9945	0.000
0.9867	0.9831	-0.365		0.9867	0.9783	-0.855
0.9864	0.9829	-0.363		0.9864	0.978	-0.855
0.9908	0.9908	0.000		0.9908	0.9908	0.000
0.9648	0.9648	0.000		0.9648	0.9648	0.000
0.9873	0.9873	0.000		0.9873	0.9873	0.000
0.9873	0.9873	0.000		0.9873	0.9873	0.000
0.9643	0.9598	-0.468		0.9643	0.9518	-1.289
0.9875	0.9875	0.000		0.9875	0.9875	0.000
0.9754	0.9662	-0.938		0.9754	0.9537	-2.227
0.9747	0.9655	-0.938		0.9747	0.9529	-2.232
0.9794	0.9794	0.000		0.9794	0.9794	0.000
0.9208	0.9208	0.000		0.9208	0.9208	0.000
0.9802	0.9802	0.000		0.9802	0.9802	0.000
0.9802	0.9802	0.000		0.9802	0.9802	0.000
0.9474	0.9414	-0.626		0.9474	0.9288	-1.966
0.9806	0.9806	0.000		0.9806	0.9806	0.000
0.961	0.9497	-1.174		0.961	0.9315	-3.068
0.9603	0.9488	-1.193		0.9603	0.9303	-3.116
0.968	0.968	0.000		0.968	0.968	0.000
0.8768	0.8768	0.000		0.8768	0.8768	0.000
0.9728	0.9728	0.000		0.9728	0.9728	0.000
0.9728	0.9728	0.000		0.9728	0.9728	0.000
0.934	0.927	-0.744		0.934	0.9103	-2.532
0.9737	0.9737	0.000		0.9737	0.9737	0.000
0.9481	0.9354	-1.333		0.9481	0.913	-3.696
0.9471	0.9345	-1.333		0.9471	0.9119	-3.722
0.9565	0.9565	0.000		0.9565	0.9565	0.000
0.8328	0.8328	0.000		0.8328	0.8328	0.000
0.537	0.4189	-22.000		0.537	0.3795	-29.333
0.5474	0.4269	-22.000		0.5474	0.3868	-29.333
0.749	0.6888	-8.031		0.749	0.5756	-23.156
0.9599	0.9599	0.000		0.9599	0.9599	0.000
0.7682	0.6701	-12.764		0.7682	0.537	-30.098
0.7612	0.6622	-13.012		0.7612	0.5282	-30.616
0.9337	0.9337	0.000		0.9337	0.9337	0.000
0.7448	0.7448	0.000		0.7448	0.7448	0.000

Source: Author's calculation

Table 24: Environmental CRS and VRS efficiency comparison for 23500 TEU in 2050

ENV **CRS** scores for 23500 TEU								
Days	VLSFO	MGO	Methanol	Ammonia	LNG	LPG	H2 Liq	H2 Gas
1	0.542	0.553	0.660	1.000	0.784	0.776	1.000	1.000
5	0.542	0.552	0.658	0.994	0.782	0.774	0.991	0.965
10	0.541	0.551	0.654	0.988	0.779	0.772	0.979	0.921
15	0.540	0.550	0.651	0.981	0.776	0.769	0.968	0.877
20	0.539	0.549	0.648	0.974	0.774	0.766	0.957	0.833
30	0.537	0.547	0.642	0.960	0.768	0.761	0.934	0.745

ENV **VRS** scores for 23500 TEU								
Days	VLSFO	MGO	Methanol	Ammonia	LNG	LPG	H2 Liq	H2 Gas
1	0.542	0.553	0.660	1.000	0.784	0.776	1.000	1.000
5	0.545	0.555	0.669	1.000	0.792	0.785	1.000	1.000
10	0.548	0.558	0.679	1.000	0.799	0.792	1.000	1.000
15	0.551	0.561	0.688	1.000	0.808	0.801	1.000	1.000
20	0.554	0.565	0.694	1.000	0.816	0.809	1.000	1.000
30	1.000	1.000	0.857	1.000	1.000	1.000	1.000	1.000

Source: Author's calculation

Table 25: Final DMU matrix chosen

Dataset	**1 day**	**5 days**	**10 days**	**15 days**	**20 days**	**30 days**	**Total DMUs**
350 TEU 1. VLSFO 2. MGO 3. Methanol 4. Ammonia 5. LNG 6. LPG 7. H2 Liq 8. H2 Gas	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	48
1100 TEU	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	48
3500 TEU	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	48
6500 TEU	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	48
10500 TEU	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	48
14500 TEU	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	48
18750 TEU	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	48
23500 TEU	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	48

Source: Author's representation

Table 26: 64 DMU dataset for evaluation

Dataset	**1 day**	**5, 10, 15, 20 days**	**30 Days**
350 TEU 1. VLSFO 2. MGO 3. Methanol 4. Ammonia 5. LNG 6. LPG 7. H2 Liq 8. H2 Gas	8 DMUs	. . . .	. . . .
. . .	. . .	. . . .	. . . .
18750 TEU	8 DMUs	. . . .	. . . .
23500 TEU	8 DMUs	. . . .	. . . .
Total DMUs	**64 DMUs (1st dataset)**	**. . . . . . .**	**64 DMUs (6th dataset)**

Source: Author's illustration

Table 27: 48 DMU dataset for evaluation

Dataset	**1 day**	**5 days**	**10 days**	**15 days**	**20 days**	**30 days**	**Total DMUs**
350 TEU **1. VLSFO** **2. MGO** **3. Methanol** **4. Ammonia** **5. LNG** **6. LPG** **7. H2 Liq** **8. H2 Gas**	8 DMUs	8DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	**48 DMUs** **(1st dataset)**
. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
23500 TEU	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	8 DMUs	**48 DMUs (8th dataset)**

Source: Author's illustration

Table 28: Comparison of scale efficiency of possible datasets

Scale Efficiency - 48 DMUs	Scale Efficiency - 64 DMUs
0.8890214	0.202767334
0.894127544	0.202360706
0.979968363	0.190657867
0.980167179	0.180369372
0.9798637	0.196184908
0.971182667	0.196759127
0.980584575	0.159685673
0.984482557	0.011655851
0.986654959	0.464793632
0.986664475	0.464436475
0.986858788	0.455014446
0.986956228	0.447448185
0.9868073	0.459000399
0.986794017	0.459506771
0.98715768	0.431633558
0.98885996	0.288258943
0.990203459	0.781769182
0.990208264	0.781557041
0.990304788	0.775931192
0.990352704	0.771371831
0.990279	0.778318165
0.990272454	0.778620664
0.990451882	0.761720284
0.991248591	0.665958164
0.993713215	0.901375765
0.993715565	0.90125254
0.993759147	0.897979659
0.993775061	0.895320273
0.9937508	0.899369448
0.993747555	0.899545461
0.99380701	0.889670078
0.994056956	0.8320488
0.997210185	0.946531112
0.997210941	0.946452889
0.997223422	0.944378608
0.997224902	0.942698133
0.9972226	0.945258591
0.997221466	0.945370125
0.99722829	0.939142519
0.997251357	0.903993705
0.999998775	0.975556708
0.99999878	0.975501685
0.99975936	0.974042829
0.999311113	0.972860909
1	0.974661729
0.999999895	0.974740173
0.998410289	0.970360112
0.991964161	0.945632081
	0.990365562
	0.990330301
	0.989398984
	0.988649715
	0.9897932
	0.989843261
	0.987079656
	0.9725967
	0.907290824
	0.912501918
	0.999685769
	0.99908878
	1
	0.991140521
	0.997838805
	0.986371942

Legend	
(green)	> 0.9
(yellow)	>= 0.8 & < =0.9
(red)	< 0.8

Source: Author's calculation

8 R Code used in this paper

R Code for Bootstrapped ECO Efficiency 2021

```
## Economic Efficiency Bootstrapped with 350 TEU
## Inputs : Fuel Costs 2021
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                sheet = " 350 BS ECO 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                     ni = 1,
                     no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "crs",
                        B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "vrs",
                        B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 1100 TEU
## Inputs : Fuel Costs 2021
## Outputs:  Teu-mile
```

```
data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                sheet = "1100 BS ECO 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                     ni = 1,
                     no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "crs",
                        B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "vrs",
                        B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 3500 TEU
## Inputs : Fuel Costs 2021
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                sheet = "3500 BS ECO 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                     ni = 1,
                     no = 1
)
```

```
result_crs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "crs",
                         B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "vrs",
                         B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 6500 TEU
## Inputs : Fuel Costs 2021
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                  sheet = "6500 BS ECO 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                      ni = 1,
                      no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "crs",
                         B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "vrs",
                         B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)
```

```
result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 10500 TEU
## Inputs : Fuel Costs 2021
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA Analysis.xlsx",
              sheet = "10500 BS ECO 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                  ni = 1,
                  no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                       orientation = "io",
                       rts = "crs",
                       B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                       orientation = "io",
                       rts = "vrs",
                       B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 14500 TEU
## Inputs : Fuel Costs 2021
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                 sheet = "14500 BS ECO 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                      ni = 1,
                      no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                          orientation = "io",
                          rts = "crs",
                          B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                          orientation = "io",
                          rts = "vrs",
                          B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 18750 TEU
## Inputs : Fuel Costs 2021
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                 sheet = "18750 BS ECO 2021")
data15 <- na.omit(data15)
```

```
data_example <- read_data(data15, dmus = 1,
                    ni = 1,
                    no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                       orientation = "io",
                       rts = "crs",
                       B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                       orientation = "io",
                       rts = "vrs",
                       B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 23500 TEU
## Inputs : Fuel Costs 2021
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
               sheet = "23500 BS ECO 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                    ni = 1,
                    no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                       orientation = "io",
                       rts = "crs",
                       B = 100)
```

```
result_vrs <- bootstrap_basic(datadea = data_example,
                              orientation = "io",
                              rts = "vrs",
                              B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

R Code for Bootstrapped ECO Efficiency 2050

```
## Economic Efficiency Bootstrapped with 350 TEU
## Inputs : Fuel Costs 2050
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
            sheet = "350 BS ECO 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                          ni = 1,
                          no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                              orientation = "io",
                              rts = "crs",
                              B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                              orientation = "io",
                              rts = "vrs",
                              B = 100)
```

```
result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 1100 TEU
## Inputs : Fuel Costs 2050
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                sheet = "1100 BS ECO 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                     ni = 1,
                     no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "crs",
                        B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "vrs",
                        B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 3500 TEU
## Inputs : Fuel Costs 2050
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                 sheet = "3500 BS ECO 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                      ni = 1,
                      no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                          orientation = "io",
                          rts = "crs",
                          B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                          orientation = "io",
                          rts = "vrs",
                          B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 6500 TEU
## Inputs : Fuel Costs 2050
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                 sheet = "6500 BS ECO 2050")
data15 <- na.omit(data15)
```

```
data_example <- read_data(data15, dmus = 1,
                      ni = 1,
                      no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                          orientation = "io",
                          rts = "crs",
                          B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                          orientation = "io",
                          rts = "vrs",
                          B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 10500 TEU
## Inputs : Fuel Costs 2050
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                 sheet = "10500 BS ECO 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                      ni = 1,
                      no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                          orientation = "io",
                          rts = "crs",
                          B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
```

```
                        orientation = "io",
                        rts = "vrs",
                        B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 14500 TEU
## Inputs : Fuel Costs 2050
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA Analysis.xlsx",
                sheet = "14500 BS ECO 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                    ni = 1,
                    no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "crs",
                        B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "vrs",
                        B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
```

```
view(result_combined)
```

```
## Economic Efficiency Bootstrapped with 18750 TEU
## Inputs : Fuel Costs 2050
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                sheet = "18750 BS ECO 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                     ni = 1,
                     no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "crs",
                        B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "vrs",
                        B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
# Economic Efficiency Bootstrapped with 23500 TEU
```

```
## Inputs : Fuel Costs 2050
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA Analysis.xlsx",
                 sheet = "23500 BS ECO 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                     ni = 1,
                     no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "crs",
                         B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "vrs",
                         B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)

result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

R Code Environmental Efficiency Bootstrapped 2021

```
## Environmental Efficiency Bootstrapped with 350 TEU
## Inputs : Fuel Costs 2021, SOx, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA Analysis.xlsx",
                 sheet = "350 BS ENV 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                     ni = 4,
                     no = 1
```

```
)


result_crs <- bootstrap_basic(datadea = data_example,
                              orientation = "io",
                              rts = "crs",
                              B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                              orientation = "io",
                              rts = "vrs",
                              B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Environmental Efficiency Bootstrapped with 1100 TEU
## Inputs : Fuel Costs 2021, SOx, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA Analysis.xlsx",
                    sheet = "1100 BS ENV 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                          ni = 4,
                          no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                              orientation = "io",
                              rts = "crs",
                              B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                              orientation = "io",
```

```
                    rts = "vrs",
                    B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
# Economic Efficiency Bootstrapped with 3500 TEU
## Inputs : Fuel Costs 2021, SOX, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
             sheet = "3500 BS ENV 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                 ni = 4,
                 no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                    orientation = "io",
                    rts = "crs",
                    B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                    orientation = "io",
                    rts = "vrs",
                    B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)

result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Environmental Efficiency Bootstrapped with 6500 TEU
## Inputs : Fuel Costs 2021, SOx, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                sheet = "6500 BS ENV 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                     ni = 4,
                     no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "crs",
                        B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "vrs",
                        B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Environmental Efficiency Bootstrapped with 10500 TEU
## Inputs : Fuel Costs 2021, SOx, GWP, PM10
## Outputs:  Teu-mile
```

```
data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                 sheet = "10500 BS ENV 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                      ni = 4,
                      no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "crs",
                         B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "vrs",
                         B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Environmental Efficiency Bootstrapped with 14500 TEU
## Inputs : Fuel Costs 2021, SOx, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                 sheet = "14500 BS ENV 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                      ni = 4,
                      no = 1
)
```

```
result_crs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "crs",
                        B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "vrs",
                        B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Environmental Efficiency Bootstrapped with 18750 TEU
## Inputs : Fuel Costs 2021, SOx, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA 
Analysis.xlsx",
                sheet = "18750 BS ENV 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                     ni = 4,
                     no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "crs",
                        B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "vrs",
```

```
                        B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
# Economic Efficiency Bootstrapped with 23500 TEU
## Inputs : Fuel Costs 2021, SOX, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                sheet = "23500 BS ENV 2021")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                    ni = 4,
                    no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "crs",
                        B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "vrs",
                        B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)

result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

R Code for Environmental Efficiency Bootstrapped 2050

```
## Environmental Efficiency Bootstrapped with 350 TEU
## Inputs : Fuel Costs 2050, SOx, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA Analysis.xlsx",
                    sheet = "350 BS ENV 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                          ni = 4,
                          no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                              orientation = "io",
                              rts = "crs",
                              B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                              orientation = "io",
                              rts = "vrs",
                              B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Environmental Efficiency Bootstrapped with 1100 TEU
## Inputs : Fuel Costs 2050, SOx, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                 sheet = "1100 BS ENV 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                      ni = 4,
                      no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "crs",
                         B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "vrs",
                         B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
# Economic Efficiency Bootstrapped with 3500 TEU
## Inputs : Fuel Costs 2050, SOX, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                 sheet = "3500 BS ENV 2050")
data15 <- na.omit(data15)
```

```
data_example <- read_data(data15, dmus = 1,
                    ni = 4,
                    no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "crs",
                        B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "vrs",
                        B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)

result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Environmental Efficiency Bootstrapped with 6500 TEU
## Inputs : Fuel Costs 2050, SOx, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
               sheet = "6500 BS ENV 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                    ni = 4,
                    no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "crs",
                        B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                        orientation = "io",
                        rts = "vrs",
```

```
                         B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
## Environmental Efficiency Bootstrapped with 10500 TEU
## Inputs : Fuel Costs 2050, SOx, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                sheet = "10500 BS ENV 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                     ni = 4,
                     no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "crs",
                         B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "vrs",
                         B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
```

```
view(result_combined)
```

```
## Environmental Efficiency Bootstrapped with 14500 TEU
## Inputs : Fuel Costs 2050, SOx, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                sheet = "14500 BS ENV 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                     ni = 4,
                     no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                          orientation = "io",
                          rts = "crs",
                          B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                          orientation = "io",
                          rts = "vrs",
                          B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)



result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
# Environmental Efficiency Bootstrapped with 18750 TEU
## Inputs : Fuel Costs 2050, SOX, GWP, PM10
## Outputs:  Teu-mile
```

```
data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                 sheet = "18750 BS ENV 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                      ni = 4,
                      no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "crs",
                         B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "vrs",
                         B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)

result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

```
# Environmental Efficiency Bootstrapped with 23500 TEU
## Inputs : Fuel Costs 2050, SOX, GWP, PM10
## Outputs:  Teu-mile

data15<- read_excel("Downloads/Thesis/Data Collection /Final Data SET for DEA
Analysis.xlsx",
                 sheet = "23500 BS ENV 2050")
data15 <- na.omit(data15)

data_example <- read_data(data15, dmus = 1,
                      ni = 4,
                      no = 1
)


result_crs <- bootstrap_basic(datadea = data_example,
```

```
                         orientation = "io",
                         rts = "crs",
                         B = 100)

result_vrs <- bootstrap_basic(datadea = data_example,
                         orientation = "io",
                         rts = "vrs",
                         B = 100)

result_crs <- data.frame(result_crs$score,result_crs$score_bc,result_crs$bias,result_crs$CI)
result_vrs <- data.frame(result_vrs$score,result_vrs$score_bc,result_vrs$bias,result_vrs$CI)

result_combined <- cbind(result_crs,result_vrs)
summary(result_combined)
view(result_combined)
```

350 TEU dataset							
Days	FUEL	Fuelcost 2021	Fuelcost 2050	SOx	GWP100	PM10	TEU-Mle
1 day	VLSFO	7964.460	40732.524	0.251	71.150	0.093	123329.132
	MGO	8724.131	39934.558	0.045	67.768	0.029	123319.269
	Methanol	16765.596	47514.501	0.013	66.766	0.009	123063.390
	Ammonia	16182.446	22066.852	0.001	12.777	0.009	122863.760
	LNG	7148.227	35707.410	0.013	61.630	0.009	123170.633
	LPG	7498.935	36344.061	0.013	62.632	0.009	123184.362
	H2 Liquid	48281.103	49867.585	0.001	3.445	0.001	122462.428
	H2 compressed	44408.178	44927.390	0.001	1.127	0.001	119590.162
5 day	VLSFO	39822.300	203662.620	1.253	355.750	0.463	613628.291
	MGO	43620.656	199672.792	0.225	338.840	0.144	613381.715
	Methanol	83827.978	237572.504	0.063	333.829	0.046	606984.762
	Ammonia	80912.232	110334.261	0.006	63.885	0.046	601993.997
	LNG	35741.133	178537.051	0.063	308.150	0.046	609665.833
	LPG	37494.674	181720.307	0.063	313.160	0.046	610009.048
	H2 Liquid	241405.514	249337.924	0.006	17.224	0.007	591960.699
	H2 compressed	222040.888	224636.949	0.006	5.637	0.007	520154.048
10 day	VLSFO	79644.600	407325.240	2.505	711.500	0.927	1219713.164
	MGO	87241.312	399345.584	0.451	677.679	0.288	1218726.861
	Methanol	167655.957	475145.008	0.125	667.658	0.093	1193139.049
	Ammonia	161824.464	220668.523	0.013	127.769	0.093	1173175.988
	LNG	71482.265	357074.103	0.125	616.300	0.093	1203863.332
	LPG	74989.347	363440.615	0.125	626.321	0.093	1205236.192
	H2 Liquid	482811.028	498675.848	0.013	34.448	0.014	1133042.797
	H2 compressed	444081.776	449273.898	0.013	11.274	0.014	845816.192
15 day	VLSFO	119466.900	610987.860	3.758	1067.251	1.390	1818254.620
	MGO	130861.968	599018.375	0.676	1016.519	0.432	1816035.437
	Methanol	251483.935	712717.512	0.188	1001.487	0.139	1758462.860
	Ammonia	242736.696	331002.784	0.019	191.654	0.139	1713545.973
	LNG	107223.398	535611.154	0.188	924.450	0.139	1782592.497
	LPG	112484.021	545160.922	0.188	939.481	0.139	1785681.433
	H2 Liquid	724216.543	748013.772	0.019	51.671	0.021	1623246.294
	H2 compressed	666122.663	673910.848	0.019	16.911	0.021	976986.431
20 day	VLSFO	159289.200	814650.480	5.011	1423.001	1.854	2409252.657
	MGO	174482.624	798691.167	0.902	1355.358	0.576	2405307.443
	Methanol	335311.913	950290.016	0.251	1335.316	0.185	2302956.196
	Ammonia	323648.929	441337.046	0.025	255.539	0.185	2223103.952
	LNG	142964.530	714148.206	0.251	1232.599	0.185	2345853.328
	LPG	149978.694	726881.229	0.251	1252.642	0.185	2351344.769
	H2 Liquid	965622.057	997351.696	0.025	68.895	0.028	2062571.189
	H2 compressed	888163.551	898547.797	0.025	22.548	0.028	913664.767
30 day	VLSFO	238933.800	1221975.720	7.516	2134.501	2.781	3568618.479
	MGO	261723.936	1198036.751	1.353	2033.037	0.864	3559741.746
	Methanol	502967.870	1425435.023	0.376	2002.974	0.278	3329451.442
	Ammonia	485473.393	662005.569	0.038	383.308	0.278	3149783.893
	LNG	214446.796	1071222.309	0.376	1848.899	0.278	3425969.987
	LPG	224968.041	1090321.844	0.376	1878.962	0.278	3438325.731
	H2 Liquid	1448433.085	1496027.544	0.038	103.343	0.041	2788585.176
	H2 compressed	1332245.327	1347821.695	0.038	33.821	0.041	203545.726

Source: Author’s Calculations

1100 TEU dataset							
Days	FUEL	Fuelcost 2021	Fuelcost 2050	SOx	GWP100	PM10	TEU-Mle
1 day	VLSFO	14275.170	73007.298	0.449	127.526	0.166	404084.576
	MGO	15636.773	71577.057	0.081	121.464	0.052	404066.309
	Methanol	30049.963	85163.034	0.022	119.668	0.017	403592.396
	Ammonia	29004.750	39551.717	0.002	22.901	0.017	403222.659
	LNG	12812.187	64000.491	0.022	110.463	0.017	403791.021
	LPG	13440.782	65141.599	0.022	112.259	0.017	403816.448
	H2 Liquid	86537.060	89380.605	0.002	6.174	0.002	402479.351
	H2 compressed	79595.388	80526.003	0.002	2.021	0.002	397159.615
5 day	VLSFO	71375.850	365036.490	2.245	637.632	0.831	2014834.402
	MGO	78183.867	357885.286	0.404	607.322	0.258	2014377.718
	Methanol	150249.815	425815.169	0.112	598.341	0.083	2002529.896
	Ammonia	145023.752	197758.585	0.011	114.504	0.083	1993286.479
	LNG	64060.934	320002.456	0.112	552.315	0.083	2007495.518
	LPG	67203.908	325707.993	0.112	561.296	0.083	2008131.188
	H2 Liquid	432685.299	446903.023	0.011	30.871	0.012	1974703.767
	H2 compressed	397976.940	402630.014	0.011	10.103	0.012	1841710.374
10 day	VLSFO	142751.700	730072.980	4.490	1275.264	1.661	4015697.610
	MGO	156367.734	715770.573	0.808	1214.644	0.516	4013870.873
	Methanol	300499.630	851630.338	0.225	1196.683	0.166	3966479.582
	Ammonia	290047.503	395517.170	0.022	229.009	0.166	3929505.915
	LNG	128121.867	640004.912	0.225	1104.630	0.166	3986342.070
	LPG	134407.816	651415.985	0.225	1122.592	0.166	3988884.751
	H2 Liquid	865370.597	893806.047	0.022	61.743	0.025	3855175.068
	H2 compressed	795953.880	805260.027	0.022	20.207	0.025	3323201.495
15 day	VLSFO	214127.550	1095109.470	6.736	1912.896	2.492	6002589.622
	MGO	234551.601	1073655.859	1.212	1821.966	0.775	5998479.464
	Methanol	450749.445	1277445.507	0.337	1795.024	0.249	5891849.060
	Ammonia	435071.255	593275.755	0.034	343.513	0.249	5808658.309
	LNG	192182.801	960007.368	0.337	1656.945	0.249	5936539.658
	LPG	201611.725	977123.978	0.337	1683.887	0.249	5942260.689
	H2 Liquid	1298055.896	1340709.070	0.034	92.614	0.037	5641413.903
	H2 compressed	1193930.820	1207890.041	0.034	30.310	0.037	4444473.363
20 day	VLSFO	285503.400	1460145.960	8.981	2550.528	3.323	7975510.439
	MGO	312735.468	1431541.145	1.617	2429.288	1.033	7968203.492
	Methanol	600999.259	1703260.676	0.449	2393.365	0.332	7778638.328
	Ammonia	580095.006	791034.339	0.045	458.017	0.332	7630743.660
	LNG	256243.735	1280009.824	0.449	2209.260	0.332	7858088.281
	LPG	268815.633	1302831.971	0.449	2245.183	0.332	7868259.003
	H2 Liquid	1730741.195	1787612.094	0.045	123.485	0.049	7333420.272
	H2 compressed	1591907.761	1610520.055	0.045	40.413	0.049	5205525.979
30 day	VLSFO	428255.100	2190218.940	13.471	3825.792	4.984	11879438.488
	MGO	469103.201	2147311.718	2.425	3643.932	1.549	11862997.856
	Methanol	901498.889	2554891.014	0.674	3590.048	0.498	11436476.239
	Ammonia	870142.510	1186551.509	0.067	687.026	0.498	11103713.235
	LNG	384365.602	1920014.736	0.674	3313.890	0.498	11615238.633
	LPG	403223.449	1954247.956	0.674	3367.775	0.498	11638122.756
	H2 Liquid	2596111.792	2681418.140	0.067	185.228	0.074	10434735.612
	H2 compressed	2387861.641	2415780.082	0.067	60.620	0.074	5646973.454

Source: Author’s Calculations

3500 TEU dataset							
Days	FUEL	Fuelcost 2021	Fuelcost 2050	SOx	GWP100	PM10	TEU-Mle
1 day	VLSFO	35582.085	181976.949	1.119	317.870	0.414	1493911.175
	MGO	38975.998	178411.951	0.201	302.760	0.129	1493858.298
	Methanol	74902.109	212276.163	0.056	298.283	0.041	1492486.502
	Ammonia	72296.827	98586.045	0.006	57.082	0.041	1491416.257
	LNG	31935.474	159526.711	0.056	275.339	0.041	1493061.445
	LPG	33502.301	162371.019	0.056	279.816	0.041	1493135.046
	H2 Liquid	215701.040	222788.820	0.006	15.390	0.006	1489264.665
	H2 compressed	198398.328	200717.965	0.006	5.037	0.006	1473866.074
5 day	VLSFO	177910.425	909884.745	5.596	1589.352	2.071	7453379.380
	MGO	194879.991	892059.757	1.007	1513.802	0.644	7452057.454
	Methanol	374510.544	1061380.813	0.280	1491.417	0.207	7417762.561
	Ammonia	361484.133	492930.226	0.028	285.412	0.207	7391006.422
	LNG	159677.369	797633.555	0.280	1376.693	0.207	7432136.129
	LPG	167511.503	811855.094	0.280	1399.078	0.207	7433976.149
	H2 Liquid	1078505.200	1113944.098	0.028	76.949	0.031	7337216.613
	H2 compressed	991991.641	1003589.826	0.028	25.183	0.031	6952251.851
10 day	VLSFO	355820.850	1819769.490	11.193	3178.705	4.141	14866317.519
	MGO	389759.982	1784119.514	2.015	3027.605	1.287	14861029.818
	Methanol	749021.088	2122761.625	0.560	2982.834	0.414	14723850.244
	Ammonia	722968.267	985860.452	0.056	570.824	0.414	14616825.688
	LNG	319354.738	1595267.109	0.560	2753.385	0.414	14781344.514
	LPG	335023.005	1623710.188	0.560	2798.156	0.414	14788704.597
	H2 Liquid	2157010.400	2227888.195	0.056	153.899	0.062	14401666.452
	H2 compressed	1983983.282	2007179.651	0.056	50.367	0.062	12861807.404
15 day	VLSFO	533731.275	2729654.235	16.789	4768.057	6.212	22238814.418
	MGO	584639.972	2676179.271	3.022	4541.407	1.931	22226917.090
	Methanol	1123531.632	3184142.438	0.839	4474.251	0.621	21918263.049
	Ammonia	1084452.400	1478790.678	0.084	856.236	0.621	21677457.797
	LNG	479032.107	2392900.664	0.839	4130.078	0.621	22047625.157
	LPG	502534.508	2435565.282	0.839	4197.234	0.621	22064185.342
	H2 Liquid	3235515.600	3341832.293	0.084	230.848	0.092	21193349.517
	H2 compressed	2975974.923	3010769.477	0.084	75.550	0.092	17728666.659
20 day	VLSFO	711641.700	3639538.980	22.385	6357.410	8.283	29570870.076
	MGO	779519.963	3568239.027	4.029	6055.209	2.574	29549719.271
	Methanol	1498042.176	4245523.251	1.119	5965.668	0.828	29001000.977
	Ammonia	1445936.534	1971720.904	0.112	1141.648	0.828	28572902.750
	LNG	638709.476	3190534.218	1.119	5506.771	0.828	29230978.057
	LPG	670046.010	3247420.376	1.119	5596.312	0.828	29260418.386
	H2 Liquid	4314020.801	4455776.391	0.112	307.797	0.123	27712265.808
	H2 compressed	3967966.564	4014359.302	0.112	100.734	0.123	21552829.616
30 day	VLSFO	1067462.550	5459308.470	33.578	9536.115	12.424	44113657.672
	MGO	1169279.945	5352358.541	6.044	9082.814	3.861	44066068.360
	Methanol	2247063.264	6368284.876	1.679	8948.502	1.242	42831452.197
	Ammonia	2168904.800	2957581.356	0.168	1712.471	1.242	41868231.189
	LNG	958064.214	4785801.327	1.679	8260.156	1.242	43348900.627
	LPG	1005069.015	4871130.564	1.679	8394.467	1.242	43415141.369
	H2 Liquid	6471031.201	6683664.586	0.168	461.696	0.185	39931798.069
	H2 compressed	5951949.845	6021538.953	0.168	151.100	0.185	26073066.635

Source: Author’s Calculations

6500 TEU dataset							
Days	FUEL	Fuelcost 2021	Fuelcost 2050	SOx	GWP100	PM10	TEU-Mle
1 day	VLSFO	62796.989	321161.743	1.975	560.993	0.731	3161133.941
	MGO	68786.731	314870.062	0.356	534.326	0.227	3161030.252
	Methanol	132190.873	374635.264	0.099	526.425	0.073	3158340.239
	Ammonia	127592.945	173989.433	0.010	100.742	0.073	3156241.549
	LNG	56361.273	281540.474	0.099	485.931	0.073	3159467.669
	LPG	59126.484	286560.247	0.099	493.832	0.073	3159611.996
	H2 Liquid	380679.654	393188.511	0.010	27.161	0.011	3152022.399
	H2 compressed	350142.989	354236.797	0.010	8.889	0.011	3121826.645
5 day	VLSFO	313984.944	1605808.714	9.877	2804.966	3.654	15773948.521
	MGO	343933.656	1574350.310	1.778	2671.632	1.136	15771356.301
	Methanol	660954.366	1873176.319	0.494	2632.125	0.365	15704105.978
	Ammonia	637964.725	869947.163	0.049	503.709	0.365	15651638.721
	LNG	281806.363	1407702.370	0.494	2429.654	0.365	15732291.721
	LPG	295632.421	1432801.233	0.494	2469.161	0.365	15735899.897
	H2 Liquid	1903398.268	1965942.553	0.049	135.804	0.054	15546159.985
	H2 compressed	1750714.944	1771183.983	0.049	44.445	0.054	14791266.121
10 day	VLSFO	627969.888	3211617.427	19.753	5609.933	7.309	31468594.085
	MGO	687867.313	3148700.621	3.556	5343.263	2.272	31458225.205
	Methanol	1321908.732	3746352.638	0.988	5264.250	0.731	31189223.913
	Ammonia	1275929.450	1739894.325	0.099	1007.417	0.731	30979354.884
	LNG	563612.726	2815404.740	0.988	4859.308	0.731	31301966.886
	LPG	591264.843	2865602.465	0.988	4938.321	0.731	31316399.586
	H2 Liquid	3806796.537	3931885.106	0.099	271.608	0.109	30557439.938
	H2 compressed	3501429.889	3542367.966	0.099	88.890	0.109	27537864.485
15 day	VLSFO	941954.832	4817426.141	29.630	8414.899	10.963	47083936.690
	MGO	1031800.969	4723050.931	5.333	8014.895	3.407	47060606.711
	Methanol	1982863.099	5619528.957	1.481	7896.375	1.096	46455353.805
	Ammonia	1913894.175	2609841.488	0.148	1511.126	1.096	45983148.488
	LNG	845419.088	4223107.111	1.481	7288.962	1.096	46709025.493
	LPG	886897.264	4298403.698	1.481	7407.482	1.096	46741499.069
	H2 Liquid	5710194.805	5897827.659	0.148	407.411	0.163	45033839.861
	H2 compressed	5252144.833	5313551.949	0.148	133.335	0.163	38239795.091
20 day	VLSFO	1255939.776	6423234.854	39.507	11219.865	14.617	62619976.338
	MGO	1375734.626	6297401.241	7.111	10686.527	4.543	62578500.820
	Methanol	2643817.465	7492705.276	1.975	10528.500	1.462	61502495.652
	Ammonia	2551858.901	3479788.651	0.198	2014.835	1.462	60663019.535
	LNG	1127225.451	5630809.481	1.975	9718.616	1.462	61953467.542
	LPG	1182529.686	5731204.931	1.975	9876.642	1.462	62011198.344
	H2 Liquid	7613593.073	7863770.212	0.198	543.215	0.217	58975359.753
	H2 compressed	7002859.778	7084735.932	0.198	177.780	0.217	46897057.940
30 day	VLSFO	1883909.664	9634852.282	59.260	16829.798	21.926	93454146.761
	MGO	2063601.939	9446101.862	10.667	16029.790	6.815	93360826.844
	Methanol	3965726.197	11239057.914	2.963	15792.751	2.193	90939815.218
	Ammonia	3827788.351	5219682.976	0.296	3022.252	2.193	89050993.954
	LNG	1690838.177	8446214.221	2.963	14577.924	2.193	91954501.971
	LPG	1773794.528	8596807.396	2.963	14814.963	2.193	92084396.274
	H2 Liquid	11420389.610	11795655.318	0.296	814.823	0.326	85253759.445
	H2 compressed	10504289.667	10627103.898	0.296	266.669	0.326	58077580.365

Source: Author’s Calculations

10500 TEU dataset							
Days	FUEL	Fuelcost 2021	Fuelcost 2050	SOx	GWP100	PM10	TEU-Mle
1 day	VLSFO	85252.136	436003.779	2.682	761.595	0.992	4845846.793
	MGO	93383.709	427462.299	0.483	725.392	0.308	4845706.027
	Methanol	179460.106	508598.531	0.134	714.666	0.099	4842054.110
	Ammonia	173218.036	236205.126	0.013	136.765	0.099	4839204.964
	LNG	76515.115	382214.611	0.134	659.691	0.099	4843584.690
	LPG	80269.120	389029.370	0.134	670.418	0.099	4843780.626
	H2 Liquid	516804.293	533786.107	0.013	36.873	0.015	4833477.117
	H2 compressed	475348.231	480905.915	0.013	12.068	0.015	4792483.869
5 day	VLSFO	426260.678	2180018.894	13.408	3807.975	4.961	24186169.819
	MGO	466918.546	2137311.494	2.414	3626.962	1.542	24182650.665
	Methanol	897300.528	2542992.656	0.670	3573.329	0.496	24091352.758
	Ammonia	866090.178	1181025.632	0.067	683.827	0.496	24020124.092
	LNG	382575.577	1911073.055	0.670	3298.457	0.496	24129617.249
	LPG	401345.602	1945146.848	0.670	3352.091	0.496	24134515.647
	H2 Liquid	2584021.466	2668930.535	0.067	184.365	0.074	23876927.934
	H2 compressed	2376741.155	2404529.577	0.067	60.338	0.074	22852096.726
10 day	VLSFO	852521.355	4360037.787	26.817	7615.950	9.922	48264679.278
	MGO	933837.091	4274622.989	4.827	7253.924	3.084	48250602.661
	Methanol	1794601.055	5085985.313	1.341	7146.658	0.992	47885411.033
	Ammonia	1732180.355	2362051.264	0.134	1367.653	0.992	47600496.369
	LNG	765151.154	3822146.109	1.341	6596.915	0.992	48038468.996
	LPG	802691.203	3890293.696	1.341	6704.182	0.992	48058062.587
	H2 Liquid	5168042.933	5337861.070	0.134	368.730	0.147	47027711.738
	H2 compressed	4753482.309	4809059.154	0.134	120.675	0.147	42928386.904
15 day	VLSFO	1278782.033	6540056.681	40.225	11423.925	14.883	72235528.375
	MGO	1400755.637	6411934.483	7.241	10880.887	4.626	72203855.987
	Methanol	2691901.583	7628977.969	2.011	10719.986	1.488	71382174.824
	Ammonia	2598270.533	3543076.896	0.201	2051.480	1.488	70741116.831
	LNG	1147726.731	5733219.164	2.011	9895.372	1.488	71726555.240
	LPG	1204036.805	5835440.544	2.011	10056.272	1.488	71770640.820
	H2 Liquid	7752064.399	8006791.605	0.201	553.095	0.221	69452351.410
	H2 compressed	7130223.464	7213588.731	0.201	181.013	0.221	60228870.533
20 day	VLSFO	1705042.710	8720075.574	53.633	15231.900	19.844	96098717.110
	MGO	1867674.183	8549245.978	9.654	14507.849	6.168	96042410.644
	Methanol	3589202.111	10171970.626	2.682	14293.315	1.984	94581644.132
	Ammonia	3464360.711	4724102.528	0.268	2735.306	1.984	93441985.478
	LNG	1530302.308	7644292.218	2.682	13193.829	1.984	95193875.983
	LPG	1605382.406	7780587.392	2.682	13408.363	1.984	95272250.347
	H2 Liquid	10336085.866	10675722.140	0.268	737.460	0.295	91150846.952
	H2 compressed	9506964.618	9618118.308	0.268	241.351	0.295	74753547.615
30 day	VLSFO	2557564.065	13080113.361	80.450	22847.851	29.767	143502113.498
	MGO	2801511.274	12823868.966	14.481	21761.773	9.252	143375423.949
	Methanol	5383803.166	15257955.939	4.023	21439.973	2.977	140088699.297
	Ammonia	5196541.066	7086153.792	0.402	4102.959	2.977	137524467.325
	LNG	2295453.462	11466438.328	4.023	19790.744	2.977	141466220.961
	LPG	2408073.609	11670881.088	4.023	20112.545	2.977	141642563.282
	H2 Liquid	15504128.798	16013583.210	0.402	1106.190	0.442	132369405.641
	H2 compressed	14260446.927	14427177.462	0.402	362.026	0.442	95475482.134

Source: Author’s Calculations

14500 TEU dataset							
Days	FUEL	Fuelcost 2021	Fuelcost 2050	SOx	GWP100	PM10	TEU-Mle
1 day	VLSFO	115592.495	591173.043	3.636	1032.639	1.345	7103334.513
	MGO	126618.012	579591.739	0.654	983.552	0.418	7103134.106
	Methanol	243328.113	689603.522	0.182	969.008	0.135	7097934.931
	Ammonia	234864.554	320268.104	0.018	185.439	0.135	7093878.646
	LNG	103746.059	518240.863	0.182	894.469	0.135	7100113.993
	LPG	108836.075	527480.925	0.182	909.013	0.135	7100392.944
	H2 Liquid	700729.631	723755.097	0.018	49.996	0.020	7085724.001
	H2 compressed	644519.782	652055.389	0.018	16.362	0.020	7027362.561
5 day	VLSFO	577962.473	2955865.217	18.180	5163.194	6.727	35455362.822
	MGO	633090.058	2897958.693	3.272	4917.761	2.091	35450352.658
	Methanol	1216640.565	3448017.612	0.909	4845.040	0.673	35320373.269
	Ammonia	1174322.772	1601340.519	0.091	927.193	0.673	35218966.142
	LNG	518730.294	2591204.317	0.909	4472.344	0.673	35374849.820
	LPG	544180.377	2637404.624	0.909	4545.065	0.673	35381823.592
	H2 Liquid	3503648.154	3618775.487	0.091	249.979	0.100	35015100.033
	H2 compressed	3222598.909	3260276.945	0.091	81.811	0.100	33556064.023
10 day	VLSFO	1155924.945	5911730.433	36.361	10326.389	13.453	70757451.287
	MGO	1266180.116	5795917.386	6.545	9835.522	4.181	70737410.631
	Methanol	2433281.130	6896035.224	1.818	9690.079	1.345	70217493.076
	Ammonia	2348645.545	3202681.037	0.182	1854.387	1.345	69811864.568
	LNG	1037460.587	5182408.634	1.818	8944.689	1.345	70435399.281
	LPG	1088360.754	5274809.247	1.818	9090.131	1.345	70463294.367
	H2 Liquid	7007296.307	7237550.974	0.182	499.957	0.200	68996400.132
	H2 compressed	6445197.818	6520553.891	0.182	163.622	0.200	63160256.092
15 day	VLSFO	1733887.418	8867595.650	54.541	15489.583	20.180	105906265.396
	MGO	1899270.175	8693876.079	9.817	14753.282	6.272	105861173.919
	Methanol	3649921.695	10344052.836	2.727	14535.119	2.018	104691359.421
	Ammonia	3522968.317	4804021.556	0.273	2781.580	2.018	103778695.278
	LNG	1556190.881	7773612.951	2.727	13417.033	2.018	105181648.381
	LPG	1632541.131	7912213.871	2.727	13635.196	2.018	105244412.326
	H2 Liquid	10510944.461	10856326.462	0.273	749.936	0.300	101943900.297
	H2 compressed	9667796.727	9780830.836	0.273	245.434	0.300	88812576.207
20 day	VLSFO	2311849.890	11823460.866	72.721	20652.777	26.907	140901805.149
	MGO	2532360.233	11591834.772	13.090	19671.043	8.363	140821642.522
	Methanol	4866562.260	13792070.447	3.636	19380.159	2.691	138741972.303
	Ammonia	4697291.089	6405362.074	0.364	3708.773	2.691	137119458.272
	LNG	2074921.175	10364817.269	3.636	17889.378	2.691	139613597.122
	LPG	2176721.508	10549618.494	3.636	18180.262	2.691	139725177.468
	H2 Liquid	14014592.615	14475101.949	0.364	999.914	0.400	133857600.528
	H2 compressed	12890395.635	13041107.781	0.364	327.245	0.400	110513024.368
30 day	VLSFO	3467774.835	17735191.299	109.082	30979.166	40.360	210433061.585
	MGO	3798540.349	17387752.157	19.635	29506.565	12.544	210252695.675
	Methanol	7299843.391	20688105.671	5.454	29070.238	4.036	205573437.683
	Ammonia	7045936.634	9608043.112	0.545	5563.160	4.036	201922781.113
	LNG	3112381.762	15547225.903	5.454	26834.066	4.036	207534593.526
	LPG	3265082.262	15824427.741	5.454	27270.393	4.036	207785649.304
	H2 Liquid	21021888.922	21712652.923	0.545	1499.872	0.600	194583601.189
	H2 compressed	19335593.453	19561661.672	0.545	490.867	0.600	142058304.827

Source: Author’s Calculations

18750 TEU dataset							
Days	FUEL	Fuelcost 2021	Fuelcost 2050	SOx	GWP100	PM10	TEU-Mle
1 day	VLSFO	126489.384	646902.850	3.979	1129.986	1.472	9172005.266
	MGO	138554.275	634229.777	0.716	1076.271	0.458	9171796.410
	Methanol	266266.623	754612.357	0.199	1060.356	0.147	9166378.028
	Ammonia	257005.206	350459.736	0.020	202.920	0.147	9162150.723
	LNG	113526.186	567095.363	0.199	978.790	0.147	9168648.964
	LPG	119096.038	577206.483	0.199	994.706	0.147	9168939.675
	H2 Liquid	766787.322	791983.397	0.020	54.709	0.022	9153652.264
	H2 compressed	705278.578	713524.566	0.020	17.905	0.022	9092830.202
5 day	VLSFO	632446.920	3234514.248	19.894	5649.928	7.361	45796131.662
	MGO	692771.376	3171148.884	3.581	5381.357	2.288	45790910.260
	Methanol	1331333.114	3773061.786	0.995	5301.781	0.736	45655450.709
	Ammonia	1285026.028	1752298.682	0.099	1014.600	0.736	45549768.077
	LNG	567630.931	2835476.813	0.995	4893.952	0.736	45712224.089
	LPG	595480.191	2886032.416	0.995	4973.528	0.736	45719491.887
	H2 Liquid	3833936.612	3959916.984	0.099	273.544	0.109	45337306.610
	H2 compressed	3526392.891	3567622.831	0.099	89.524	0.109	43816755.042
10 day	VLSFO	1264893.840	6469028.496	39.788	11299.856	14.722	91432526.647
	MGO	1385542.752	6342297.768	7.162	10762.715	4.576	91411641.041
	Methanol	2662666.228	7546123.572	1.989	10603.562	1.472	90869802.836
	Ammonia	2570052.056	3504597.364	0.199	2029.199	1.472	90447072.308
	LNG	1135261.863	5670953.626	1.989	9787.903	1.472	91096896.354
	LPG	1190960.382	5772064.832	1.989	9947.056	1.472	91125967.547
	H2 Liquid	7667873.224	7919833.968	0.199	547.088	0.219	89597226.438
	H2 compressed	7052785.782	7135245.662	0.199	179.047	0.219	83515020.168
15 day	VLSFO	1897340.760	9703542.744	59.682	16949.784	22.082	136909184.957
	MGO	2078314.128	9513446.652	10.743	16144.072	6.863	136862192.342
	Methanol	3993999.341	11319185.358	2.984	15905.343	2.208	135643056.381
	Ammonia	3855078.084	5256896.046	0.298	3043.799	2.208	134691912.692
	LNG	1702892.794	8506430.439	2.984	14681.855	2.208	136154016.797
	LPG	1786440.572	8658097.248	2.984	14920.584	2.208	136219426.982
	H2 Liquid	11501809.835	11879750.953	0.298	820.632	0.328	132779759.486
	H2 compressed	10579178.673	10702868.493	0.298	268.571	0.328	119094795.378
20 day	VLSFO	2529787.680	12938056.992	79.576	22599.712	29.443	182226106.590
	MGO	2771085.504	12684595.536	14.324	21525.430	9.151	182142564.164
	Methanol	5325332.455	15092247.144	3.979	21207.124	2.944	179975211.343
	Ammonia	5140104.112	7009194.728	0.398	4058.399	2.944	178284289.230
	LNG	2270523.725	11341907.251	3.979	19575.807	2.944	180883585.418
	LPG	2381920.763	11544129.665	3.979	19894.113	2.944	180999870.190
	H2 Liquid	15335746.447	15839667.937	0.398	1094.176	0.438	174884905.753
	H2 compressed	14105571.564	14270491.324	0.398	358.094	0.438	150556080.672
30 day	VLSFO	3794681.520	19407085.488	119.365	33899.568	44.165	272380739.827
	MGO	4156628.256	19026893.303	21.486	32288.145	13.727	272192769.369
	Methanol	7987998.683	22638370.716	5.968	31810.686	4.416	267316225.523
	Ammonia	7710156.169	10513792.093	0.597	6087.598	4.416	263511650.768
	LNG	3405785.588	17012860.877	5.968	29363.710	4.416	269360067.190
	LPG	3572881.145	17316194.497	5.968	29841.169	4.416	269621707.927
	H2 Liquid	23003619.671	23759501.905	0.597	1641.264	0.657	255863037.943
	H2 compressed	21158357.346	21405736.986	0.597	537.141	0.657	201123181.512

Source: Author’s Calculations

23500 TEU dataset							
Days	FUEL	Fuelcost 2021	Fuelcost 2050	SOx	GWP100	PM10	TEU-Mle
1 day	VLSFO	152770.118	781310.030	4.806	1364.763	1.778	11399021.496
	MGO	167341.734	766003.869	0.865	1299.889	0.553	11398769.246
	Methanol	321588.911	911398.371	0.240	1280.667	0.178	11392225.085
	Ammonia	310403.247	423274.851	0.024	245.081	0.178	11387119.471
	LNG	137113.553	684920.919	0.240	1182.154	0.178	11394967.853
	LPG	143840.654	697132.830	0.240	1201.376	0.178	11395318.966
	H2 Liquid	926102.932	956534.001	0.024	66.076	0.026	11376855.286
	H2 compressed	851814.499	861773.758	0.024	21.625	0.026	11303396.206
5 day	VLSFO	763850.588	3906550.148	24.028	6823.815	8.890	56917937.396
	MGO	836708.672	3830019.345	4.325	6499.444	2.763	56911631.142
	Methanol	1607944.555	4556991.853	1.201	6403.333	0.889	56748027.123
	Ammonia	1552016.233	2116374.253	0.120	1225.403	0.889	56620386.782
	LNG	685567.763	3424604.597	1.201	5910.769	0.889	56816596.323
	LPG	719203.271	3485664.151	1.201	6006.879	0.889	56825374.154
	H2 Liquid	4630514.658	4782670.006	0.120	330.378	0.132	56363782.138
	H2 compressed	4259072.495	4308868.791	0.120	108.124	0.132	54527305.161
10 day	VLSFO	1527701.175	7813100.295	48.055	13647.630	17.780	113642949.583
	MGO	1673417.344	7660038.689	8.650	12998.887	5.526	113617724.568
	Methanol	3215889.109	9113983.706	2.403	12806.667	1.778	112963308.493
	Ammonia	3104032.467	4232748.506	0.240	2450.807	1.778	112452747.128
	LNG	1371135.527	6849209.193	2.403	11821.539	1.778	113237585.293
	LPG	1438406.542	6971328.303	2.403	12013.759	1.778	113272696.616
	H2 Liquid	9261029.316	9565340.012	0.240	660.757	0.264	111426328.553
	H2 compressed	8518144.990	8617737.582	0.240	216.248	0.264	104080420.642
15 day	VLSFO	2291551.763	11719650.443	72.083	20471.445	26.671	170175036.561
	MGO	2510126.016	11490058.034	12.975	19498.331	8.289	170118280.278
	Methanol	4823833.664	13670975.559	3.604	19210.000	2.667	168645844.108
	Ammonia	4656048.700	6349122.759	0.360	3676.210	2.667	167497081.039
	LNG	2056703.290	10273813.790	3.604	17732.308	2.667	169262966.909
	LPG	2157609.813	10456992.454	3.604	18020.638	2.667	169341967.385
	H2 Liquid	13891543.973	14348010.019	0.360	991.135	0.396	165187639.244
	H2 compressed	12777217.485	12926606.373	0.360	324.371	0.396	148659346.445
20 day	VLSFO	3055402.350	15626200.590	96.110	27295.260	35.561	226514198.330
	MGO	3346834.688	15320077.378	17.300	25997.774	11.053	226413298.272
	Methanol	6431778.218	18227967.412	4.806	25613.334	3.556	223795633.971
	Ammonia	6208064.933	8465497.011	0.481	4901.614	3.556	221753388.513
	LNG	2742271.053	13698418.386	4.806	23643.078	3.556	224892741.172
	LPG	2876813.084	13942656.605	4.806	24027.518	3.556	225033186.462
	H2 Liquid	18522058.631	19130680.025	0.481	1321.513	0.529	217647714.211
	H2 compressed	17036289.980	17235475.164	0.481	432.495	0.529	188264082.568
30 day	VLSFO	4583103.525	23439300.885	144.165	40942.890	53.341	338613746.243
	MGO	5020252.033	22980116.068	25.950	38996.661	16.579	338386721.112
	Methanol	9647667.328	27341951.118	7.208	38420.001	5.334	332496976.434
	Ammonia	9312097.400	12698245.517	0.721	7352.420	5.334	327901924.154
	LNG	4113406.580	20547627.580	7.208	35464.616	5.334	334965467.636
	LPG	4315219.626	20913984.908	7.208	36041.277	5.334	335281469.540
	H2 Liquid	27783087.947	28696020.037	0.721	1982.270	0.793	318664156.976
	H2 compressed	25554434.970	25853212.745	0.721	648.743	0.793	252550985.779

Source: Author’s Calculations

350 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2021

350 TEU		BS Model	ECO Eff 2021	In: Fuel cost 2021	Out: TEU-mile										
Day	Fuel	DMUs	result_crs.score	result_crs.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	result_vrs.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1 day	VLSFO	1	0.89867	0.89071	−0.00995	0.86912	0.89818	0.898685	0.869999	−0.03669	0.82579	0.897736	0.999984	12	17
	MGO	2	0.820351	0.813084	−0.01089	0.793377	0.819904	0.820364	0.794168	−0.04021	0.753817	0.819498	0.999985	19	22
	Methanol	3	0.425992	0.422218	−0.02098	0.411984	0.425759	0.426363	0.412777	−0.0772	0.392003	0.425956	0.999129	27	32
	Ammonia	4	0.440627	0.436723	−0.02028	0.426138	0.440386	0.441727	0.427887	−0.07323	0.406639	0.441405	0.997509	25	26
	LNG	5	1	0.991142	−0.00894	0.967118	0.999454	1	0.967739	−0.03334	0.918796	0.998725	1	1	5
	LPG	6	0.953339	0.944894	−0.00937	0.921991	0.952818	0.95334	0.922621	−0.03492	0.875932	0.952175	0.999999	5	11
	H2 Liq	7	0.147203	0.145899	−0.06071	0.142363	0.147123	0.148054	0.143495	−0.21459	0.136475	0.147999	0.99425	38	38
	H2 Gas	8	0.156287	0.154903	−0.05719	0.151148	0.156202	0.160966	0.156282	−0.18622	0.148377	0.160941	0.970931	37	37
5 day	VLSFO	9	0.894273	0.886351	−0.00999	0.864868	0.893785	0.903501	0.891598	−0.01478	0.876035	0.902925	0.989787	13	15
	MGO	10	0.816074	0.808845	−0.01095	0.78924	0.815629	0.824487	0.813622	−0.0162	0.799414	0.823966	0.989797	20	21
	Methanol	11	0.420223	0.416501	−0.02127	0.406405	0.419994	0.424483	0.418859	−0.03163	0.411501	0.424238	0.989964	29	29
	Ammonia	12	0.431787	0.427962	−0.0207	0.417589	0.431551	0.436154	0.430384	−0.03074	0.422801	0.435916	0.989985	26	25
	LNG	13	0.989953	0.981184	−0.00903	0.957402	0.989413	1	0.986734	−0.01344	0.969436	0.999444	0.989953	2	3
	LPG	14	0.944187	0.935823	−0.00947	0.91314	0.943671	0.953783	0.941139	−0.01409	0.924645	0.953258	0.989939	7	8
	H2 Liq	15	0.14231	0.14105	−0.0628	0.137631	0.142233	0.143744	0.14184	−0.09338	0.139118	0.143638	0.990029	39	39
	H2 Gas	16	0.135953	0.134749	−0.06574	0.131483	0.135879	0.137273	0.135333	−0.10444	0.132539	0.137091	0.990387	41	41
10 day	VLSFO	17	0.888776	0.880903	−0.01006	0.859552	0.888291	0.909806	0.899138	−0.01304	0.884924	0.908777	0.976886	14	14
	MGO	18	0.810728	0.803547	−0.01102	0.78407	0.810286	0.829884	0.820151	−0.0143	0.807174	0.828962	0.976917	21	20
	Methanol	19	0.413013	0.409354	−0.02164	0.399432	0.412787	0.422515	0.417564	−0.02807	0.410857	0.422193	0.977509	30	30
	Ammonia	20	0.420736	0.417009	−0.02124	0.406902	0.420507	0.430321	0.425339	−0.02722	0.418473	0.429924	0.977728	28	27
	LNG	21	0.977395	0.968737	−0.00914	0.945256	0.976861	1	0.988172	−0.01197	0.972375	0.999187	0.977395	3	1
	LPG	22	0.932747	0.924484	−0.00958	0.902076	0.932238	0.954363	0.943087	−0.01253	0.928021	0.953606	0.97735	8	7
	H2 Liq	23	0.136195	0.134988	−0.06562	0.131716	0.13612	0.139231	0.137647	−0.08265	0.135415	0.13907	0.978191	40	40
	H2 Gas	24	0.110536	0.109557	−0.08086	0.106901	0.110476	0.112469	0.11119	−0.10235	0.109121	0.112355	0.98281	45	45
15 day	VLSFO	25	0.88328	0.875455	−0.01012	0.854236	0.882798	0.916457	0.905155	−0.01362	0.879795	0.916146	0.963798	16	12
	MGO	26	0.805382	0.798248	−0.0111	0.7789	0.804943	0.835579	0.825288	−0.01492	0.802217	0.835286	0.963861	22	18
	Methanol	27	0.405802	0.402207	−0.02202	0.392458	0.40558	0.420437	0.41544	−0.02861	0.404482	0.42017	0.96519	32	31
	Ammonia	28	0.409686	0.406057	−0.02182	0.396215	0.409463	0.42416	0.419302	−0.02732	0.408594	0.423932	0.965877	31	28
	LNG	29	0.964836	0.95629	−0.00926	0.933111	0.96431	1	0.987825	−0.01233	0.961278	0.999531	0.964836	4	2
	LPG	30	0.921307	0.913146	−0.0097	0.891012	0.920804	0.954975	0.943342	−0.01291	0.917888	0.954413	0.964745	10	6
	H2 Liq	31	0.130079	0.128927	−0.06871	0.125802	0.130008	0.134466	0.132977	−0.08329	0.129875	0.134362	0.967374	42	42
	H2 Gas	32	0.085119	0.084365	−0.105	0.08232	0.085072	0.086824	0.085855	−0.13008	0.084338	0.086722	0.980358	46	46
20 day	VLSFO	33	0.877783	0.870007	−0.01018	0.84892	0.877304	0.923856	0.904615	−0.02302	0.865183	0.921923	0.950129	17	13
	MGO	34	0.800036	0.792949	−0.01117	0.773729	0.799599	0.841913	0.824502	−0.02508	0.788709	0.840144	0.95026	23	19
	Methanol	35	0.398591	0.39506	−0.02242	0.385485	0.398374	0.418245	0.410415	−0.04562	0.394496	0.417153	0.953009	34	33
	Ammonia	36	0.398636	0.395105	−0.02242	0.385528	0.398419	0.417661	0.410405	−0.04234	0.394984	0.416515	0.954449	33	34
	LNG	37	0.952278	0.943842	−0.00939	0.920965	0.951758	1	0.980304	−0.02009	0.940997	0.997729	0.952278	6	4
	LPG	38	0.909867	0.901807	−0.00982	0.879949	0.90937	0.955655	0.936778	−0.02109	0.899087	0.9533	0.952087	11	9
	H2 Liq	39	0.123963	0.122865	−0.0721	0.119887	0.123896	0.129439	0.127486	−0.11834	0.123222	0.129243	0.957696	43	43
	H2 Gas	40	0.059701	0.059173	−0.1497	0.057738	0.059669	0.06083	0.06015	−0.18584	0.059051	0.060762	0.981452	47	47
30 day	VLSFO	41	0.86679	0.859111	−0.01031	0.838288	0.866316	1	0.710127	−0.4082	0.508529	0.994555	0.86679	18	24
	MGO	42	0.789344	0.782352	−0.01132	0.763389	0.788913	0.907101	0.787395	−0.1676	0.529138	0.905445	0.870183	24	23
	Methanol	43	0.38417	0.380767	−0.02326	0.371538	0.38396	0.413663	0.390476	−0.14355	0.293316	0.412453	0.928703	35	35
	Ammonia	44	0.376536	0.373201	−0.02374	0.364155	0.37633	0.404077	0.386868	−0.11009	0.349897	0.402902	0.931841	36	36
	LNG	45	0.927161	0.918948	−0.00964	0.896674	0.926655	1	0.931798	−0.07319	0.664332	0.995658	0.927161	9	10
	LPG	46	0.886987	0.87913	−0.01008	0.857821	0.886503	0.96266	0.889445	−0.08551	0.63668	0.960957	0.921392	15	16
	H2 Liq	47	0.111732	0.110742	−0.07999	0.108058	0.111671	0.118932	0.11519	−0.27311	0.107752	0.118518	0.939462	44	44
	H2 Gas	48	0.008867	0.008788	−1.00796	0.008575	0.008862	0.008911	0.0087	−2.72746	0.008416	0.008886	0.995003	48	48

350 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2050

350 TEU	**ECO Eff 2050**	In: Fuel cost 2050	Out: TEU-mile										
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.543802	0.535255	−0.02936	0.516656	0.543436	0.543855	0.515803	−0.1	0.397189	0.543351	0.999903	23	31
2	0.554624	0.545907	−0.02879	0.526938	0.55425	0.554677	0.526062	−0.09807	0.405086	0.554139	0.999905	19	30
3	0.465178	0.457867	−0.03433	0.441957	0.464865	0.465198	0.440902	−0.11846	0.339589	0.464231	0.999958	32	37
4	1	0.984283	−0.01597	0.950081	0.999326	1	0.946966	−0.056	0.729737	0.996581	1	1	5
5	0.619534	0.609797	−0.02577	0.588608	0.619117	0.619574	0.58744	−0.08829	0.452365	0.618594	0.999936	7	19
6	0.60875	0.599182	−0.02623	0.578362	0.608339	0.60879	0.577236	−0.08979	0.444502	0.60786	0.999933	9	21
7	0.441064	0.434131	−0.0362	0.419046	0.440766	0.442509	0.419382	−0.12462	0.323104	0.441454	0.996734	36	40
8	0.47808	0.470566	−0.0334	0.454215	0.477758	0.491167	0.466924	−0.10571	0.358633	0.490685	0.973356	31	33
9	0.541141	0.532636	−0.02951	0.514128	0.540777	0.552785	0.546392	−0.02117	0.532236	0.552361	0.978936	24	28
10	0.551732	0.543061	−0.02894	0.524191	0.551361	0.563592	0.557071	−0.02077	0.54262	0.563165	0.978957	20	26
11	0.458879	0.451667	−0.0348	0.435972	0.45857	0.468481	0.462932	−0.02559	0.450586	0.468162	0.979503	33	35
12	0.979937	0.964536	−0.01629	0.93102	0.979277	1	0.987816	−0.01233	0.960936	0.99896	0.979937	2	1
13	0.61331	0.603671	−0.02604	0.582695	0.612897	0.626291	0.618967	−0.01889	0.602628	0.625894	0.979273	8	15
14	0.602906	0.59343	−0.02648	0.57281	0.602499	0.615685	0.608496	−0.01919	0.592456	0.6153	0.979243	11	18
15	0.426404	0.419702	−0.03745	0.405118	0.426116	0.435096	0.429773	−0.02846	0.417292	0.434634	0.980023	38	38
16	0.415879	0.409343	−0.0384	0.395119	0.415599	0.42405	0.418291	−0.03247	0.404781	0.423519	0.980731	40	41
17	0.537815	0.529362	−0.02969	0.510968	0.537453	0.565078	0.557714	−0.02337	0.54557	0.564403	0.951753	26	25
18	0.548118	0.539503	−0.02913	0.520757	0.547749	0.575865	0.568366	−0.02291	0.555983	0.575186	0.951817	21	22
19	0.451005	0.443917	−0.0354	0.428492	0.450701	0.473002	0.46674	−0.02837	0.456639	0.47217	0.953495	34	34
20	0.954859	0.939852	−0.01672	0.907194	0.954216	1	0.986204	−0.01399	0.96535	0.997462	0.954859	3	2
21	0.60553	0.596013	−0.02637	0.575302	0.605122	0.635539	0.627273	−0.02073	0.613571	0.634749	0.952782	10	12
22	0.595601	0.58624	−0.02681	0.565869	0.595199	0.625177	0.617052	−0.02106	0.60357	0.624445	0.952692	13	16
23	0.408079	0.401666	−0.03913	0.387709	0.407804	0.426963	0.42132	−0.03137	0.412917	0.426177	0.955772	41	39
24	0.338128	0.332814	−0.04722	0.321249	0.3379	0.350416	0.3467	−0.03059	0.340151	0.350043	0.964932	44	44
25	0.534489	0.526088	−0.02987	0.507808	0.534129	0.578858	0.568106	−0.03269	0.531941	0.577932	0.92335	27	23
26	0.544504	0.535946	−0.02933	0.517323	0.544137	0.589623	0.578755	−0.03185	0.542229	0.588719	0.923478	22	20
27	0.443131	0.436167	−0.03603	0.421011	0.442833	0.47807	0.469555	−0.03793	0.448921	0.477261	0.926918	35	32
28	0.929781	0.915168	−0.01717	0.883368	0.929154	1	0.981675	−0.01867	0.950105	0.996435	0.929781	4	3
29	0.597749	0.588355	−0.02671	0.56791	0.597346	0.645904	0.634522	−0.02777	0.600943	0.645492	0.925446	12	11
30	0.588296	0.57905	−0.02714	0.558929	0.587899	0.635816	0.624616	−0.0282	0.59089	0.635438	0.925261	15	14
31	0.389755	0.383629	−0.04097	0.370299	0.389492	0.41786	0.410674	−0.04187	0.397669	0.417185	0.93274	42	42
32	0.260377	0.256285	−0.06133	0.247379	0.260202	0.271209	0.268118	−0.04252	0.262909	0.270752	0.960059	46	46
33	0.531163	0.522815	−0.03006	0.504648	0.530805	0.596163	0.55613	−0.12075	0.463654	0.595555	0.890969	29	27
34	0.540889	0.532388	−0.02952	0.513889	0.540525	0.606899	0.566892	−0.11628	0.472181	0.606378	0.891234	25	24
35	0.435257	0.428416	−0.03669	0.41353	0.434964	0.484433	0.461281	−0.10361	0.38092	0.483251	0.898488	37	36
36	0.904703	0.890484	−0.01765	0.859541	0.904093	1	0.957146	−0.04477	0.793955	0.995217	0.904703	5	4
37	0.589969	0.580696	−0.02707	0.560518	0.589571	0.658921	0.624644	−0.08328	0.515712	0.658382	0.895356	14	13
38	0.580991	0.57186	−0.02748	0.551989	0.580599	0.649177	0.614724	−0.08634	0.507795	0.648629	0.894965	16	17
39	0.37143	0.365593	−0.04299	0.352889	0.37118	0.407657	0.394445	−0.08217	0.334391	0.40659	0.911135	43	43
40	0.182626	0.179756	−0.08743	0.173509	0.182503	0.189794	0.187736	−0.05775	0.184038	0.189441	0.962231	47	47
41	0.52451	0.516267	−0.03044	0.498328	0.524157	1	0.722266	−0.38453	0.52749	0.998919	0.52451	30	10
42	0.53366	0.525273	−0.02992	0.507021	0.533301	1	0.787843	−0.26929	0.642227	0.998771	0.53366	28	8
43	0.41951	0.412916	−0.03806	0.398568	0.419227	0.62923	0.527153	−0.30774	0.434934	0.62508	0.666703	39	29
44	0.854547	0.841116	−0.01869	0.811889	0.853971	1	0.781036	−0.28035	0.663569	0.997884	0.854547	6	9
45	0.574408	0.56538	−0.0278	0.545734	0.574021	0.955102	0.819624	−0.17306	0.667502	0.953702	0.60141	17	6
46	0.566381	0.55748	−0.02819	0.538108	0.566	0.953188	0.811956	−0.18248	0.666522	0.94757	0.594197	18	7
47	0.334781	0.329519	−0.0477	0.318069	0.334555	0.385016	0.325032	−0.47932	0.273834	0.384296	0.869526	45	45
48	0.027124	0.026697	−0.5887	0.02577	0.027105	0.0274	0.0265	−1.24028	0.022284	0.027346	0.989907	48	48

Table 29: 350 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2021

350 TEU. BS Model	ENV Eff 2021	In: Fuel cost 2021, All emissions	Out: TEU-mile										
DMUs	result_crs.score	result_crs.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	result_vrs.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.89867	0.888635	−0.01257	0.866079	0.89849	0.898685	0.884928	−0.0173	0.837534	0.898178	0.999984	21	36
2	0.873627	0.864905	−0.01154	0.845344	0.873005	0.873641	0.857763	−0.02119	0.792338	0.872366	0.999983	28	40
3	0.844969	0.838354	−0.00934	0.829041	0.844155	0.845018	0.831752	−0.01887	0.765026	0.844672	0.999942	35	46
4	1	0.977297	−0.02323	0.900488	0.999071	1	0.927585	−0.07807	0.624833	0.998886	1	4	29
5	1	0.979409	−0.02102	0.94387	0.999542	1	0.962787	−0.03865	0.873566	0.997919	1	3	20
6	0.993502	0.983467	−0.01027	0.950857	0.993163	0.993506	0.968631	−0.02585	0.876064	0.992684	0.999996	1	18
7	1	0.982441	−0.01787	0.943634	0.999321	1	0.972752	−0.02801	0.882349	0.999288	1	2	14
8	1	0.976316	−0.02426	0.902458	0.999676	1	0.937449	−0.06672	0.706382	0.999494	1	5	27
9	0.894273	0.884287	−0.01263	0.861841	0.894093	0.903501	0.895484	−0.00991	0.876918	0.903177	0.989787	22	33
10	0.869072	0.860396	−0.0116	0.840937	0.868453	0.8785	0.870145	−0.01093	0.855973	0.8773	0.989268	29	39
11	0.833527	0.827002	−0.00947	0.817815	0.832724	0.852789	0.846256	−0.00905	0.837412	0.852024	0.977413	39	42
12	0.979937	0.95769	−0.02371	0.882422	0.979027	1	0.97273	−0.02803	0.908913	0.999104	0.979937	9	15
13	0.989953	0.969569	−0.02124	0.934387	0.989499	1	0.984273	−0.01598	0.955979	0.9996	0.989953	7	7
14	0.983964	0.974026	−0.01037	0.941729	0.983629	0.994509	0.984834	−0.00988	0.963527	0.994075	0.989397	6	6
15	0.966763	0.949787	−0.01849	0.91227	0.966107	1	0.972923	−0.02783	0.919344	0.999196	0.966763	12	13
16	0.869894	0.849292	−0.02789	0.785043	0.869613	1	0.94422	−0.05908	0.859724	0.999468	0.869894	32	24
17	0.888776	0.878851	−0.01271	0.856543	0.888598	0.909806	0.901823	−0.00973	0.889651	0.909364	0.976886	24	32
18	0.863379	0.85476	−0.01168	0.835428	0.862764	0.884869	0.877115	−0.00999	0.864741	0.884245	0.975714	31	38
19	0.819224	0.812811	−0.00963	0.803782	0.818436	0.852812	0.847631	−0.00717	0.839026	0.852115	0.960615	40	41
20	0.954859	0.933181	−0.02433	0.859839	0.953972	1	0.977036	−0.0235	0.928957	0.999319	0.954859	15	11
21	0.977395	0.957269	−0.02151	0.922533	0.976947	1	0.98622	−0.01397	0.960164	0.999292	0.977395	10	5
22	0.972042	0.962225	−0.0105	0.930319	0.971711	0.995316	0.987699	−0.00775	0.976925	0.994932	0.976617	8	2
23	0.925217	0.90897	−0.01932	0.873066	0.924588	1	0.974188	−0.0265	0.902451	0.999025	0.925217	18	12
24	0.707262	0.690512	−0.0343	0.638275	0.707033	1	0.958853	−0.04291	0.869734	0.999848	0.707262	45	22
25	0.88328	0.873416	−0.01279	0.851246	0.883102	0.916457	0.909739	−0.00806	0.901064	0.915737	0.963798	25	31
26	0.857685	0.849123	−0.01176	0.829919	0.857075	0.891597	0.883626	−0.01012	0.871305	0.890388	0.961965	33	37
27	0.804922	0.798621	−0.0098	0.789749	0.804147	0.851373	0.844816	−0.00912	0.83721	0.851011	0.945439	41	43
28	0.929781	0.908672	−0.02499	0.837257	0.928917	1	0.977922	−0.02258	0.914315	0.998562	0.929781	19	10
29	0.964836	0.944969	−0.02179	0.91068	0.964394	1	0.987104	−0.01306	0.958724	0.999771	0.964836	13	4
30	0.96012	0.950423	−0.01063	0.918909	0.959793	0.996096	0.98894	−0.00726	0.977756	0.99569	0.963883	11	1
31	0.88367	0.868154	−0.02023	0.833861	0.88307	1	0.968837	−0.03217	0.901048	0.999289	0.88367	26	17
32	0.54463	0.531731	−0.04454	0.491506	0.544454	1	0.97838	−0.0221	0.922932	0.998727	0.54463	46	9
33	0.877783	0.867981	−0.01287	0.845949	0.877606	0.923856	0.914192	−0.01144	0.891357	0.923262	0.950129	27	30
34	0.851992	0.843487	−0.01183	0.82441	0.851385	0.899094	0.88949	−0.01201	0.87686	0.898679	0.947612	34	34
35	0.79062	0.78443	−0.00998	0.775716	0.789858	0.851962	0.844803	−0.00995	0.834872	0.850765	0.927998	42	44
36	0.904703	0.884163	−0.02568	0.814674	0.903862	1	0.971854	−0.02896	0.896373	0.999905	0.904703	23	16
37	0.952278	0.932669	−0.02208	0.898826	0.951841	1	0.983101	−0.01719	0.951675	0.998694	0.952278	16	8
38	0.948199	0.938622	−0.01076	0.907499	0.947876	0.997072	0.987688	−0.00953	0.974311	0.995999	0.950983	14	3
39	0.842124	0.827337	−0.02122	0.794657	0.841552	1	0.960033	−0.04163	0.8876	0.999182	0.842124	38	21
40	0.381998	0.372951	−0.0635	0.344738	0.381875	0.629314	0.617994	−0.02911	0.580308	0.628974	0.607008	47	47
41	0.86679	0.85711	−0.01303	0.835354	0.866615	1	0.88949	−0.012	0.729845	0.999158	0.86679	30	35
42	0.840605	0.832214	−0.012	0.813392	0.840007	1	0.943284	−0.06013	0.859814	0.998772	0.840605	37	25
43	0.762015	0.756049	−0.01035	0.74765	0.761281	0.857343	0.843643	−0.01894	0.787186	0.856648	0.88881	43	45
44	0.854547	0.835146	−0.02718	0.769509	0.853752	1	0.93135	−0.07371	0.782887	0.998972	0.854547	36	28
45	0.927161	0.90807	−0.02268	0.875119	0.926736	1	0.966554	−0.0346	0.882173	0.999291	0.927161	20	19
46	0.924355	0.915019	−0.01104	0.884679	0.92404	1	0.937859	−0.06626	0.810447	0.999455	0.924355	17	26
47	0.759031	0.745703	−0.02355	0.716248	0.758516	1	0.953151	−0.04915	0.866303	0.999545	0.759031	44	23
48	0.056734	0.055391	−0.42758	0.0512	0.056716	0.061279	0.059717	−0.42687	0.055085	0.061253	0.925833	48	48

Source: Author's calculation

350 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2050

350 TEU BS Model	ENV Eff 2050	In: Fuel cost 2050, All emissions	Out: TEU-mile										
DMUs	result_crs.score	result_crs.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	result_vrs.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.543802	0.53268	−0.0384	0.505718	0.543208	0.543855	0.524321	−0.0685	0.444921	0.543611	0.999903	34	45
2	0.554624	0.532675	−0.07429	0.471638	0.554015	0.554677	0.524205	−0.1048	0.437908	0.55443	0.999905	35	46
3	0.666009	0.653924	−0.02775	0.624238	0.665032	0.666223	0.646026	−0.04692	0.584799	0.665162	0.99968	28	35
4	1	0.922819	−0.08364	0.80541	0.996905	1	0.872122	−0.14663	0.691764	0.998897	1	3	15
5	0.789298	0.774311	−0.02452	0.731212	0.788879	0.789488	0.76823	−0.03505	0.687219	0.789316	0.999759	14	29
6	0.781627	0.767531	−0.0235	0.726928	0.781299	0.781823	0.76142	−0.03427	0.682098	0.78142	0.99975	15	30
7	1	0.953726	−0.04852	0.820858	0.999544	1	0.906057	−0.10368	0.711284	0.998697	1	1	10
8	1	0.929204	−0.07619	0.80399	0.997063	1	0.841181	−0.1888	0.685538	0.997944	1	2	18
9	0.541141	0.530073	−0.03858	0.503244	0.54055	0.552785	0.545308	−0.02481	0.526817	0.552598	0.978936	36	44
10	0.551732	0.529898	−0.07468	0.46918	0.551127	0.563592	0.550528	−0.04211	0.521846	0.5631	0.978957	37	43
11	0.656991	0.645069	−0.02813	0.615785	0.656026	0.69308	0.683005	−0.02128	0.66556	0.6924	0.94793	29	34
12	0.979937	0.904305	−0.08535	0.789251	0.976904	1	0.936138	−0.06822	0.819531	0.997692	0.979937	5	5
13	0.781368	0.766532	−0.02477	0.723866	0.780954	0.814572	0.801073	−0.02069	0.779443	0.813282	0.959238	16	27
14	0.774124	0.760163	−0.02372	0.71995	0.773798	0.807658	0.794911	−0.01985	0.774467	0.806982	0.95848	17	28
15	0.966763	0.922027	−0.05019	0.793576	0.966322	1	0.94242	−0.0611	0.845137	0.998065	0.966763	4	3
16	0.869894	0.808309	−0.08759	0.699387	0.86734	1	0.878931	−0.13775	0.731486	0.998082	0.869894	11	13
17	0.537815	0.526815	−0.03882	0.500151	0.537227	0.565078	0.557525	−0.02398	0.540002	0.564511	0.951753	38	42
18	0.548118	0.526426	−0.07518	0.466106	0.547516	0.575865	0.562276	−0.04197	0.513956	0.575194	0.951817	39	41
19	0.645717	0.634	−0.02862	0.605218	0.64477	0.704945	0.693993	−0.02239	0.676623	0.703621	0.915983	30	33
20	0.954859	0.881162	−0.08759	0.769053	0.951904	1	0.944275	−0.05901	0.817263	0.998454	0.954859	7	2
21	0.771455	0.756808	−0.02509	0.714683	0.771047	0.830423	0.8188	−0.01709	0.798289	0.829184	0.928991	18	24
22	0.764744	0.750953	−0.02401	0.711227	0.764423	0.824045	0.812896	−0.01664	0.793252	0.823201	0.928037	19	25
23	0.925217	0.882403	−0.05244	0.759472	0.924794	1	0.936227	−0.06812	0.780178	0.998161	0.925217	6	4
24	0.707262	0.657191	−0.10773	0.568632	0.705185	1	0.885203	−0.12968	0.710046	0.996898	0.707262	27	12
25	0.534489	0.523557	−0.03906	0.497057	0.533905	0.578858	0.56986	−0.02728	0.542059	0.578093	0.92335	40	40
26	0.544504	0.522955	−0.07568	0.463032	0.543906	0.589623	0.573288	−0.04832	0.518908	0.588516	0.923478	41	39
27	0.634444	0.622932	−0.02913	0.594652	0.633513	0.718456	0.707453	−0.02165	0.6827	0.717779	0.883066	31	32
28	0.929781	0.85802	−0.08995	0.748855	0.926903	1	0.944622	−0.05862	0.824975	0.997906	0.929781	8	1
29	0.761543	0.747084	−0.02541	0.7055	0.761139	0.848367	0.836896	−0.01616	0.813415	0.84734	0.897658	20	20
30	0.755365	0.741743	−0.02431	0.702504	0.755047	0.842602	0.831561	−0.01576	0.809233	0.840648	0.896467	21	22
31	0.88367	0.84278	−0.05491	0.725368	0.883267	1	0.928833	−0.07662	0.776119	0.998877	0.88367	9	6
32	0.54463	0.506073	−0.13989	0.437878	0.543031	1	0.928675	−0.0768	0.761615	0.998235	0.54463	46	7
33	0.531163	0.520299	−0.03931	0.493964	0.530582	0.596163	0.580429	−0.04547	0.508986	0.595788	0.890969	42	37
34	0.540889	0.519484	−0.07618	0.459959	0.540295	0.606899	0.576071	−0.08817	0.500875	0.606145	0.891234	43	38
35	0.623171	0.611863	−0.02966	0.584086	0.622256	0.735746	0.719924	−0.02987	0.678915	0.734625	0.846992	32	31
36	0.904703	0.834877	−0.09245	0.728656	0.901903	1	0.926598	−0.07922	0.762116	0.998773	0.904703	10	8
37	0.751631	0.73736	−0.02575	0.696317	0.751232	0.871167	0.854622	−0.02222	0.805868	0.870582	0.862786	22	16
38	0.745986	0.732532	−0.02462	0.693781	0.745672	0.866192	0.850116	−0.02183	0.80236	0.865124	0.861224	23	17
39	0.842124	0.803156	−0.05762	0.691265	0.84174	1	0.896652	−0.11526	0.734191	0.997309	0.842124	12	11
40	0.381998	0.354954	−0.19945	0.307123	0.380876	0.629314	0.582183	−0.12864	0.464999	0.628396	0.607008	47	36
41	0.52451	0.513783	−0.03981	0.487778	0.523937	1	0	Inf	0.515817	0.999354	0.52451	44	48
42	0.53366	0.512541	−0.07721	0.453812	0.533074	1	0.838766	−0.19223	0.685449	0.998586	0.53366	45	19
43	0.600624	0.589726	−0.03077	0.562953	0.599743	0.857343	0.802325	−0.07998	0.65438	0.855997	0.700565	33	26
44	0.854547	0.788592	−0.09787	0.68826	0.851902	1	0.835261	−0.19723	0.684812	0.998318	0.854547	13	21
45	0.731806	0.717911	−0.02645	0.677951	0.731418	1	0.917741	−0.08963	0.71146	0.998883	0.731806	25	9
46	0.727227	0.714112	−0.02525	0.676335	0.726921	1	0.874338	−0.14372	0.70184	0.998699	0.727227	26	14
47	0.759031	0.723908	−0.06392	0.623057	0.758685	1	0.830525	−0.20406	0.611084	0.999004	0.759031	24	23
48	0.056734	0.052718	−1.34293	0.045614	0.056568	0.061279	0.055851	−1.58596	0.04657	0.061108	0.925833	48	47

1100 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2021

1100		BS Model	ECO Eff 2021	In: Fuel cost 2021	Out: TEU-mile										
Day	Fuel	DMUs	result_crs.score	s.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	s.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1 day	VLSFO	1	0.898168	0.893819	−0.00542	0.882645	0.898066	0.898173	0.874657	−0.02993	0.773006	0.897342	0.999995	13	16
	MGO	2	0.819921	0.815951	−0.00593	0.80575	0.819828	0.819925	0.798452	−0.0328	0.705659	0.819129	0.999995	19	22
	Methanol	3	0.426153	0.42409	−0.01142	0.418788	0.426105	0.426363	0.415191	−0.06311	0.366898	0.425657	0.999508	28	33
	Ammonia	4	0.441105	0.43897	−0.01103	0.433482	0.441055	0.441727	0.430266	−0.0603	0.380119	0.440996	0.998592	25	27
	LNG	5	1	0.995158	−0.00487	0.982717	0.999886	1	0.973599	−0.02712	0.860529	0.998346	1	1	5
	LPG	6	0.953292	0.948677	−0.0051	0.936817	0.953184	0.953293	0.928147	−0.02842	0.820373	0.951776	1	7	10
	H2 Liq	7	0.147573	0.146859	−0.03297	0.145023	0.147557	0.148054	0.144255	−0.17789	0.127405	0.147864	0.996752	38	39
	H2 Gas	8	0.158323	0.157556	−0.03073	0.155587	0.158305	0.160966	0.156989	−0.1574	0.138516	0.160833	0.983577	37	37
5 day	VLSFO	9	0.895684	0.891347	−0.00543	0.880204	0.895582	0.900844	0.891673	−0.01142	0.870562	0.900363	0.994272	14	15
	MGO	10	0.817505	0.813547	−0.00595	0.803376	0.817412	0.822212	0.81384	−0.01251	0.794568	0.821777	0.994275	20	21
	Methanol	11	0.422894	0.420847	−0.01151	0.415585	0.422846	0.425307	0.420963	−0.02426	0.410953	0.425114	0.994328	30	30
	Ammonia	12	0.436111	0.434	−0.01116	0.428574	0.436061	0.438596	0.434116	−0.02353	0.423764	0.438406	0.994334	26	25
	LNG	13	0.994324	0.98951	−0.00489	0.977139	0.994211	1	0.989787	−0.01032	0.966288	0.999525	0.994324	2	2
	LPG	14	0.948122	0.943531	−0.00513	0.931735	0.948014	0.953538	0.943803	−0.01082	0.9214	0.953087	0.994319	8	8
	H2 Liq	15	0.144809	0.144108	−0.0336	0.142307	0.144793	0.145632	0.144142	−0.07102	0.140687	0.145574	0.994348	40	40
	H2 Gas	16	0.146835	0.146124	−0.03314	0.144297	0.146818	0.147654	0.146104	−0.07188	0.142481	0.147525	0.994452	39	38
10 day	VLSFO	17	0.892578	0.888257	−0.00545	0.877152	0.892477	0.904271	0.896817	−0.00919	0.883127	0.903667	0.98707	15	13
	MGO	18	0.814485	0.810541	−0.00597	0.800408	0.814392	0.825146	0.818345	−0.01007	0.805849	0.824598	0.98708	21	19
	Methanol	19	0.41882	0.416793	−0.01162	0.411582	0.418773	0.424223	0.420726	−0.01959	0.414291	0.424017	0.987265	31	31
	Ammonia	20	0.429868	0.427787	−0.01132	0.422439	0.429819	0.435384	0.431811	−0.01901	0.425213	0.43517	0.987332	27	26
	LNG	21	0.987229	0.982449	−0.00493	0.970167	0.987116	1	0.991732	−0.00834	0.976559	0.999397	0.987229	3	1
	LPG	22	0.941659	0.937099	−0.00517	0.925384	0.941551	0.953854	0.945971	−0.00874	0.931499	0.953273	0.987215	9	6
	H2 Liq	23	0.141354	0.14067	−0.03442	0.138911	0.141338	0.143147	0.141975	−0.0577	0.139832	0.143048	0.987472	41	41
	H2 Gas	24	0.132475	0.131834	−0.03673	0.130186	0.13246	0.133995	0.132886	−0.06232	0.131083	0.133832	0.988657	44	44
15 day	VLSFO	25	0.889473	0.885166	−0.00547	0.8741	0.889372	0.907799	0.898195	−0.01178	0.875792	0.906835	0.979813	16	12
	MGO	26	0.811464	0.807535	−0.006	0.79744	0.811372	0.828166	0.819416	−0.01289	0.798981	0.827295	0.979832	22	18
	Methanol	27	0.414747	0.412739	−0.01173	0.407579	0.4147	0.423106	0.418792	−0.02435	0.408432	0.422871	0.980243	33	32
	Ammonia	28	0.423625	0.421574	−0.01149	0.416304	0.423577	0.432072	0.427774	−0.02325	0.417416	0.431753	0.980451	29	28
	LNG	29	0.980134	0.975388	−0.00496	0.963194	0.980022	1	0.989627	−0.01048	0.965022	0.999115	0.980134	4	3
	LPG	30	0.935196	0.930668	−0.0052	0.919033	0.935089	0.954178	0.944271	−0.011	0.92078	0.953305	0.980106	10	7
	H2 Liq	31	0.137899	0.137231	−0.03528	0.135516	0.137883	0.140586	0.139254	−0.06802	0.136099	0.140432	0.980888	42	42
	H2 Gas	32	0.118116	0.117544	−0.04119	0.116074	0.118102	0.119915	0.118918	−0.06992	0.117197	0.119825	0.984992	46	46
20 day	VLSFO	33	0.886367	0.882076	−0.00549	0.871048	0.886266	0.911541	0.895766	−0.01932	0.862722	0.909862	0.972384	17	14
	MGO	34	0.808444	0.80453	−0.00602	0.794472	0.808352	0.83137	0.817061	−0.02106	0.786949	0.829845	0.972424	23	20
	Methanol	35	0.410673	0.408685	−0.01185	0.403575	0.410626	0.421956	0.41518	−0.03868	0.400329	0.421492	0.973261	34	34
	Ammonia	36	0.417383	0.415362	−0.01166	0.410169	0.417335	0.428662	0.422047	−0.03656	0.407342	0.428123	0.973688	32	29
	LNG	37	0.973039	0.968328	−0.005	0.956222	0.972928	1	0.983478	−0.0168	0.947961	0.998685	0.973039	5	4
	LPG	38	0.928733	0.924236	−0.00524	0.912681	0.928627	0.954522	0.938704	−0.01765	0.90478	0.953312	0.972981	11	9
	H2 Liq	39	0.134444	0.133793	−0.03619	0.13212	0.134429	0.137948	0.135945	−0.10679	0.131522	0.137734	0.974598	43	43
	H2 Gas	40	0.103756	0.103254	−0.04689	0.101963	0.103744	0.105641	0.104701	−0.08493	0.102843	0.105524	0.98216	47	47
30 day	VLSFO	41	0.880157	0.875895	−0.00553	0.864945	0.880056	1	0.705212	−0.41801	0.519914	0.996278	0.880157	18	24
	MGO	42	0.802403	0.798518	−0.00606	0.788535	0.802312	0.907101	0.73473	−0.25863	0.489769	0.903945	0.88458	24	23
	Methanol	43	0.402526	0.400577	−0.01209	0.395569	0.40248	0.419601	0.38825	−0.19245	0.278347	0.418507	0.959306	36	36
	Ammonia	44	0.404897	0.402936	−0.01202	0.397899	0.404851	0.421681	0.398747	−0.13639	0.320653	0.420993	0.960198	35	35
	LNG	45	0.958849	0.954206	−0.00507	0.942277	0.95874	1	0.903359	−0.10698	0.63814	0.9964	0.958849	6	11
	LPG	46	0.915807	0.911372	−0.00531	0.899979	0.915702	0.96266	0.85826	−0.12636	0.613982	0.956767	0.951329	12	17
	H2 Liq	47	0.127534	0.126916	−0.03815	0.125329	0.127519	0.132548	0.127417	−0.3038	0.118448	0.132173	0.962169	45	45
	H2 Gas	48	0.075037	0.074673	−0.06484	0.07374	0.075028	0.0765	0.075774	−0.12514	0.074054	0.076417	0.980873	48	48

1100 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2050

BS Model	ECO Eff 2050	In: Fuel cost 2050	Out: TEU-mile										
DMUs	result_crs.score	s.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	s.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.542908	0.538049	−0.01664	0.528467	0.542705	0.542925	0.510216	−0.11808	0.393714	0.542758	0.999969	24	31
2	0.553732	0.548775	−0.01631	0.539002	0.553525	0.553748	0.520385	−0.11578	0.401559	0.553579	0.99997	19	30
3	0.464849	0.460689	−0.01943	0.452484	0.464676	0.464856	0.436677	−0.13882	0.336994	0.464675	0.999987	32	38
4	1	0.991049	−0.00903	0.9734	0.999626	1	0.938871	−0.06511	0.724724	0.999425	1	1	5
5	0.618862	0.613323	−0.01459	0.6024	0.618631	0.618874	0.581492	−0.10388	0.448722	0.618627	0.99998	7	19
6	0.608059	0.602617	−0.01485	0.591885	0.607832	0.608072	0.571356	−0.10568	0.440895	0.607828	0.999979	10	20
7	0.441693	0.43774	−0.02045	0.429944	0.441528	0.442509	0.415586	−0.1464	0.320697	0.442255	0.998157	38	42
8	0.483782	0.479452	−0.01867	0.470913	0.483601	0.491167	0.461823	−0.12937	0.355961	0.490885	0.984964	31	34
9	0.541407	0.536561	−0.01668	0.527005	0.541204	0.547779	0.541908	−0.01978	0.530176	0.547571	0.988366	26	27
10	0.5521	0.547158	−0.01636	0.537414	0.551893	0.558595	0.552607	−0.0194	0.540641	0.558384	0.988373	20	23
11	0.461295	0.457166	−0.01958	0.449024	0.461122	0.466641	0.461591	−0.02344	0.451575	0.466419	0.988543	33	35
12	0.988678	0.979829	−0.00913	0.962379	0.988308	1	0.989024	−0.0111	0.967602	0.999413	0.988678	2	2
13	0.615349	0.609842	−0.01468	0.598981	0.615119	0.622526	0.615829	−0.01747	0.602466	0.622295	0.988472	8	13
14	0.604761	0.599349	−0.01493	0.588675	0.604535	0.61182	0.605242	−0.01776	0.59211	0.611609	0.988462	12	17
15	0.43342	0.429541	−0.02084	0.421891	0.433258	0.438372	0.433507	−0.0256	0.424168	0.438124	0.988705	40	39
16	0.448679	0.444663	−0.02013	0.436744	0.448511	0.45371	0.448068	−0.02775	0.438995	0.453459	0.988912	36	37
17	0.539529	0.5347	−0.01674	0.525178	0.539328	0.554175	0.548934	−0.01723	0.539544	0.553778	0.973573	27	26
18	0.55006	0.545137	−0.01642	0.535428	0.549854	0.564979	0.559636	−0.0169	0.550057	0.564579	0.973593	21	22
19	0.456851	0.452762	−0.01977	0.444699	0.45668	0.468993	0.464515	−0.02055	0.456469	0.468564	0.974111	34	33
20	0.974525	0.965803	−0.00927	0.948603	0.974161	1	0.990254	−0.00984	0.973059	0.998757	0.974525	3	1
21	0.610958	0.60549	−0.01478	0.594707	0.61073	0.627337	0.621384	−0.01527	0.610664	0.626875	0.973892	9	12
22	0.600639	0.595263	−0.01504	0.584662	0.600415	0.616758	0.610909	−0.01552	0.600376	0.616318	0.973865	14	15
23	0.423079	0.419292	−0.02135	0.411825	0.422921	0.434015	0.429824	−0.02247	0.422347	0.433454	0.974802	41	40
24	0.4048	0.401177	−0.02231	0.394033	0.404649	0.414265	0.410373	−0.0229	0.403327	0.413788	0.977152	43	44
25	0.537652	0.53284	−0.0168	0.523351	0.537451	0.56097	0.552391	−0.02769	0.504144	0.560411	0.958433	28	24
26	0.54802	0.543115	−0.01648	0.533443	0.547815	0.571764	0.563057	−0.02704	0.514052	0.571204	0.958472	22	21
27	0.452407	0.448358	−0.01996	0.440373	0.452238	0.471492	0.464761	−0.03072	0.428535	0.471097	0.959524	35	32
28	0.960372	0.951777	−0.0094	0.934827	0.960013	1	0.9859	−0.0143	0.917188	0.998833	0.960372	4	3
29	0.606568	0.601139	−0.01489	0.590433	0.606341	0.632449	0.623268	−0.02329	0.572156	0.631948	0.959078	11	11
30	0.596517	0.591177	−0.01514	0.580649	0.596294	0.622005	0.612938	−0.02378	0.562379	0.621504	0.959022	15	14
31	0.412737	0.409043	−0.02188	0.401759	0.412583	0.429381	0.423819	−0.03057	0.40202	0.428849	0.961238	42	41
32	0.360922	0.357692	−0.02502	0.351322	0.360787	0.372312	0.368696	−0.02634	0.361923	0.371674	0.969409	46	45
33	0.535775	0.53098	−0.01686	0.521524	0.535575	0.56864	0.539572	−0.09474	0.444859	0.56793	0.942204	29	28
34	0.54598	0.541094	−0.01654	0.531457	0.545776	0.579422	0.550245	−0.09151	0.453468	0.578818	0.942285	23	25
35	0.447964	0.443954	−0.02016	0.436048	0.447796	0.474312	0.454934	−0.0898	0.375136	0.474064	0.944449	37	36
36	0.94622	0.93775	−0.00954	0.92105	0.945866	1	0.962654	−0.03879	0.798051	0.99858	0.94622	5	4
37	0.602177	0.596787	−0.015	0.586159	0.601952	0.638218	0.610677	−0.07066	0.502483	0.637946	0.943528	13	16
38	0.592394	0.587092	−0.01525	0.576636	0.592173	0.627927	0.600481	−0.07279	0.4941	0.627473	0.943412	17	18
39	0.402396	0.398794	−0.02244	0.391692	0.402246	0.424457	0.410702	−0.0789	0.346083	0.423778	0.948025	44	43
40	0.317044	0.314206	−0.02849	0.30861	0.316925	0.328964	0.325497	−0.03238	0.319205	0.328592	0.963763	47	47
41	0.532021	0.527259	−0.01698	0.517869	0.531822	1	0.729903	−0.37005	0.598337	0.996746	0.532021	30	10
42	0.541901	0.537051	−0.01667	0.527486	0.541698	1	0.794786	−0.2582	0.641063	0.994687	0.541901	25	8
43	0.439077	0.435147	−0.02057	0.427397	0.438913	0.62923	0.530277	−0.29656	0.429564	0.626991	0.6978	39	29
44	0.917914	0.909698	−0.00984	0.893498	0.917571	1	0.782541	−0.27789	0.652311	0.995313	0.917914	6	9
45	0.593395	0.588084	−0.01522	0.577611	0.593173	0.955102	0.817211	−0.17667	0.648062	0.951351	0.62129	16	6
46	0.584149	0.578921	−0.01546	0.568611	0.583931	0.953188	0.81008	−0.18534	0.642981	0.949696	0.612837	18	7
47	0.381713	0.378297	−0.02366	0.37156	0.381571	0.414096	0.339905	−0.5271	0.277552	0.412558	0.921798	45	46
48	0.229287	0.227234	−0.03939	0.223188	0.229201	0.23854	0.235443	−0.05515	0.223248	0.238247	0.961208	48	48

1100 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2021

BS Model	ENV Eff 2021	In: Fuel cost 2021, All emissions	Out: TEU-mile										
DMUs	result_crs.score	s.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	s.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.898168	0.892236	−0.0074	0.873798	0.897859	0.898173	0.884292	−0.01748	0.831223	0.89788	0.999995	26	36
2	0.87312	0.86629	−0.00903	0.853661	0.872745	0.873125	0.858972	−0.01887	0.790013	0.8728	0.999995	32	41
3	0.843288	0.838615	−0.00661	0.830007	0.84302	0.843304	0.830214	−0.0187	0.766008	0.842927	0.999982	39	48
4	1	0.985152	−0.01507	0.954334	0.999129	1	0.953161	−0.04914	0.86667	0.999097	1	4	27
5	1	0.985082	−0.01514	0.954297	0.999429	1	0.966538	−0.03462	0.876101	0.999689	1	5	19
6	0.993353	0.986535	−0.00696	0.973408	0.993159	0.993354	0.969931	−0.02431	0.882947	0.993019	0.999999	2	18
7	1	0.988583	−0.01155	0.968521	0.999403	1	0.97511	−0.02553	0.878599	0.99862	1	1	16
8	1	0.986321	−0.01387	0.952036	0.99929	1	0.955042	−0.04707	0.865091	0.99824	1	3	25
9	0.895684	0.889768	−0.00742	0.871381	0.895375	0.900844	0.893876	−0.00865	0.885984	0.900396	0.994272	27	35
10	0.870547	0.863737	−0.00906	0.851146	0.870173	0.875819	0.868523	−0.00959	0.858386	0.875465	0.99398	33	40
11	0.836839	0.832202	−0.00666	0.823659	0.836574	0.851061	0.845806	−0.0073	0.839257	0.850523	0.98329	40	46
12	0.988678	0.973998	−0.01524	0.943529	0.987817	1	0.979686	−0.02073	0.935994	0.999106	0.988678	9	12
13	0.994324	0.979491	−0.01523	0.948881	0.993757	1	0.986818	−0.01336	0.966665	0.99874	0.994324	7	5
14	0.987965	0.981184	−0.007	0.968128	0.987772	0.994028	0.986119	−0.00807	0.974738	0.993171	0.9939	6	6
15	0.98127	0.970067	−0.01177	0.95038	0.980684	1	0.979227	−0.02121	0.928809	0.998818	0.98127	11	14
16	0.927441	0.914754	−0.01495	0.882957	0.926782	1	0.958311	−0.0435	0.881938	0.998488	0.927441	23	24
17	0.892578	0.886683	−0.00745	0.86836	0.892271	0.904271	0.89731	−0.00858	0.888855	0.903786	0.98707	28	34
18	0.867331	0.860545	−0.00909	0.848001	0.866958	0.879277	0.872927	−0.00827	0.864066	0.878205	0.986413	34	39
19	0.828778	0.824186	−0.00672	0.815725	0.828515	0.852546	0.847772	−0.00661	0.841902	0.851735	0.972122	42	43
20	0.974525	0.960055	−0.01547	0.930023	0.973676	1	0.982741	−0.01756	0.946794	0.998742	0.974525	15	9
21	0.987229	0.972501	−0.01534	0.94211	0.986666	1	0.988176	−0.01197	0.964624	0.999239	0.987229	10	3
22	0.98123	0.974495	−0.00704	0.961529	0.981039	0.994596	0.987692	−0.00703	0.977445	0.994085	0.986562	8	4
23	0.957857	0.946921	−0.01206	0.927704	0.957285	1	0.981221	−0.01914	0.917545	0.999742	0.957857	18	11
24	0.836742	0.825296	−0.01658	0.796609	0.836148	1	0.965907	−0.0353	0.886201	0.999723	0.836742	41	20
25	0.889473	0.883598	−0.00747	0.865339	0.889167	0.907799	0.901091	−0.0082	0.890088	0.907413	0.979812	29	33
26	0.864114	0.857354	−0.00912	0.844856	0.863743	0.882841	0.876516	−0.00817	0.867024	0.882187	0.978788	35	38
27	0.820717	0.816169	−0.00679	0.807791	0.820456	0.851765	0.846406	−0.00743	0.83801	0.850112	0.963549	43	44
28	0.960372	0.946112	−0.01569	0.916516	0.959536	1	0.982833	−0.01747	0.939383	0.999151	0.960372	19	8
29	0.980134	0.965512	−0.01545	0.935339	0.979575	1	0.98836	−0.01178	0.953784	0.999162	0.980134	13	1
30	0.974496	0.967807	−0.00709	0.95493	0.974305	0.995008	0.988229	−0.00689	0.977864	0.994672	0.979385	12	2
31	0.934444	0.923775	−0.01236	0.905028	0.933886	1	0.979242	−0.0212	0.909477	0.999079	0.934444	22	13
32	0.746043	0.735838	−0.01859	0.71026	0.745513	1	0.965349	−0.03589	0.87895	0.999067	0.746043	46	21
33	0.886368	0.880513	−0.0075	0.862318	0.886062	0.911541	0.901377	−0.01237	0.869575	0.911021	0.972384	30	31
34	0.860898	0.854163	−0.00916	0.841712	0.860529	0.886623	0.878442	−0.0105	0.864315	0.886318	0.970986	37	37
35	0.812656	0.808153	−0.00686	0.799857	0.812398	0.852086	0.846136	−0.00825	0.836399	0.85137	0.953725	44	45
36	0.94622	0.93217	−0.01593	0.90301	0.945395	1	0.977829	−0.02267	0.918329	0.998788	0.94622	21	15
37	0.973039	0.958523	−0.01556	0.928569	0.972484	1	0.981625	−0.01872	0.933458	0.999101	0.973039	16	10
38	0.967761	0.961119	−0.00714	0.94833	0.967572	0.995502	0.985055	−0.01065	0.939975	0.994885	0.972133	14	7
39	0.911031	0.90063	−0.01268	0.882353	0.910487	1	0.97462	−0.02604	0.895179	0.999492	0.911031	25	17
40	0.655344	0.64638	−0.02116	0.623912	0.654879	1	0.960132	−0.04152	0.875392	0.998577	0.655344	47	23
41	0.880157	0.874343	−0.00755	0.856275	0.879854	1	0.901377	−0.0515	0.8648	0	0.880157	31	32
42	0.854465	0.847781	−0.00923	0.835423	0.854099	1	0.95102	−0.0535	0.865117	0.999147	0.854465	38	28
43	0.796533	0.79212	−0.007	0.783988	0.79628	0.857343	0.843767	−0.01877	0.783418	0.856309	0.929072	45	47
44	0.917914	0.904285	−0.01642	0.875997	0.917115	1	0.954334	−0.04785	0.864185	0.999371	0.917914	24	26
45	0.958849	0.944545	−0.01579	0.915027	0.958302	1	0.960847	−0.04075	0.86796	0.998786	0.958849	20	22
46	0.954292	0.947742	−0.00724	0.935131	0.954105	1	0.936282	−0.06805	0.863266	0.998319	0.954292	17	30
47	0.864205	0.854338	−0.01336	0.837001	0.863689	1	0.950212	−0.0524	0.864442	0.99862	0.864205	36	29
48	0.473947	0.467463	−0.02926	0.451214	0.47361	0.868336	0.849105	−0.02608	0.786703	0.866948	0.54581	48	42

1100 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2050

BS Model	ENV Eff 2050	In: Fuel cost 2050, All emissions	Out: TEU-mile										
DMUs	**result_crs.score**	**s.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**s.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.542908	0.536689	−0.02135	0.519234	0.542639	0.542925	0.522255	−0.0729	0.451212	0.542662	0.999969	40	47
2	0.553732	0.542498	−0.03739	0.515104	0.553191	0.553748	0.516163	−0.1315	0.450241	0.553437	0.99997	36	48
3	0.662415	0.652404	−0.02316	0.630111	0.661699	0.662481	0.637956	−0.05803	0.559688	0.661357	0.9999	29	38
4	1	0.948771	−0.05399	0.816398	0.99799	1	0.845026	−0.1834	0.689415	0.997318	1	3	20
5	0.786088	0.773746	−0.02029	0.74099	0.785799	0.786148	0.759471	−0.04468	0.65371	0.784717	0.999924	16	32
6	0.778327	0.766521	−0.01979	0.734266	0.777925	0.778388	0.752983	−0.04335	0.648139	0.777379	0.999921	18	33
7	1	0.970107	−0.03081	0.917377	0.999331	1	0.924414	−0.08177	0.721591	0.997972	1	1	8
8	1	0.945917	−0.05718	0.80946	0.999708	1	0.864757	−0.15639	0.693328	0.998713	1	4	17
9	0.541407	0.535204	−0.02141	0.517798	0.541138	0.547779	0.541835	−0.02003	0.530195	0.547336	0.988366	41	46
10	0.5521	0.5409	−0.0375	0.513586	0.551561	0.558595	0.550196	−0.02733	0.533748	0.558145	0.988373	37	44
11	0.657349	0.647415	−0.02334	0.625293	0.656639	0.682421	0.674296	−0.01766	0.659992	0.681241	0.96326	30	37
12	0.988678	0.938029	−0.05461	0.807154	0.986691	1	0.950942	−0.05159	0.848751	0.998194	0.988678	5	5
13	0.781626	0.769355	−0.02041	0.736784	0.781338	0.803813	0.794632	−0.01437	0.778507	0.802992	0.972398	17	30
14	0.774105	0.762363	−0.0199	0.730284	0.773706	0.796564	0.787609	−0.01427	0.77234	0.795834	0.971806	20	31
15	0.98127	0.951936	−0.0314	0.900194	0.980613	1	0.96007	−0.04159	0.870517	0.998584	0.98127	2	2
16	0.927441	0.877282	−0.06165	0.750726	0.927171	1	0.912724	−0.09562	0.783094	0.998949	0.927441	12	12
17	0.539529	0.533349	−0.02148	0.516003	0.539261	0.554175	0.548599	−0.01834	0.537352	0.553919	0.973573	43	45
18	0.55006	0.538901	−0.03764	0.511689	0.549523	0.564979	0.557	−0.02535	0.53971	0.564638	0.973593	38	40
19	0.651017	0.641178	−0.02357	0.619269	0.650314	0.694412	0.688075	−0.01326	0.679421	0.693892	0.937508	31	36
20	0.974525	0.924601	−0.05541	0.7956	0.972567	1	0.963449	−0.03794	0.838225	0.999709	0.974525	7	1
21	0.776049	0.763865	−0.02055	0.731527	0.775763	0.816356	0.808975	−0.01118	0.799002	0.815708	0.950626	19	26
22	0.768828	0.757167	−0.02003	0.725306	0.768432	0.809502	0.802494	−0.01079	0.792968	0.808949	0.949755	22	28
23	0.957857	0.929223	−0.03217	0.878716	0.957215	1	0.955653	−0.04641	0.840662	0.99871	0.957857	6	4
24	0.836742	0.791488	−0.06833	0.677309	0.836498	1	0.920911	−0.08588	0.78588	0.99819	0.836742	15	9
25	0.537652	0.531493	−0.02155	0.514208	0.537385	0.56097	0.553652	−0.02356	0.499108	0.560456	0.958433	44	41
26	0.54802	0.536903	−0.03778	0.509791	0.547485	0.571764	0.559237	−0.03918	0.502375	0.571197	0.958472	39	39
27	0.644685	0.634942	−0.0238	0.613246	0.643988	0.700961	0.693726	−0.01488	0.679624	0.699649	0.919716	32	35
28	0.960372	0.911174	−0.05622	0.784046	0.958442	1	0.956648	−0.04532	0.837309	0.999208	0.960372	8	3
29	0.770472	0.758375	−0.0207	0.72627	0.770188	0.82511	0.8175	−0.01128	0.806946	0.824104	0.933781	21	23
30	0.763551	0.75197	−0.02017	0.720328	0.763158	0.818552	0.811254	−0.01099	0.800493	0.818006	0.932808	24	25
31	0.934444	0.90651	−0.03298	0.857237	0.933818	1	0.942982	−0.06047	0.789613	0.999611	0.934444	9	6
32	0.746043	0.705695	−0.07664	0.603892	0.745826	1	0.905655	−0.10417	0.751143	0.998758	0.746043	28	13
33	0.535775	0.529637	−0.02163	0.512412	0.535509	0.56864	0.551241	−0.05551	0.489185	0.568293	0.942204	46	43
34	0.54598	0.534904	−0.03793	0.507894	0.545447	0.579422	0.551913	−0.08602	0.477283	0.579141	0.942285	42	42
35	0.638352	0.628705	−0.02404	0.607222	0.637663	0.708416	0.694957	−0.02734	0.657237	0.707552	0.901098	33	34
36	0.94622	0.897746	−0.05706	0.772492	0.944318	1	0.933772	−0.07093	0.784409	0.999029	0.94622	10	7
37	0.764894	0.752885	−0.02085	0.721012	0.764613	0.835044	0.821019	−0.02046	0.763732	0.834327	0.915993	23	22
38	0.758275	0.746773	−0.02031	0.71535	0.757884	0.828823	0.815269	−0.02006	0.758498	0.828366	0.914881	25	24
39	0.911031	0.883797	−0.03382	0.835758	0.910421	1	0.918876	−0.08829	0.75912	0.997576	0.911031	11	10
40	0.655344	0.619901	−0.08724	0.530475	0.655153	1	0.900113	−0.11097	0.733906	0.999399	0.655344	34	14
41	0.532021	0.525926	−0.02178	0.508822	0.531757	1	0.866027	−0.1547	0.687887	0.999201	0.532021	47	16
42	0.541901	0.530908	−0.03821	0.504099	0.541372	1	0.856744	−0.16721	0.687663	0.999226	0.541901	45	18
43	0.625688	0.616232	−0.02452	0.595176	0.625013	0.857343	0.805281	−0.07541	0.652982	0.856439	0.729799	35	27
44	0.917914	0.870891	−0.05882	0.749383	0.916069	1	0.847233	−0.18031	0.688178	0.997874	0.917914	13	19
45	0.75374	0.741906	−0.02116	0.710498	0.753462	1	0.918674	−0.08853	0.700319	0.998715	0.75374	26	11
46	0.747721	0.736379	−0.0206	0.705393	0.747335	1	0.875638	−0.14202	0.695711	0.998243	0.747721	27	15
47	0.864205	0.838371	−0.03566	0.792801	0.863626	1	0.838586	−0.19248	0.689201	0.998578	0.864205	14	21
48	0.473947	0.448314	−0.12064	0.383641	0.473808	0.868336	0.800099	−0.09822	0.663003	0.867877	0.54581	48	29

3500 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2021

3500		BS Model	ECO Eff 2021	In: Fuel cost 2021	Out: TEU-mile										
Day	Fuel	DMUs	**result_crs. score**	**result_crs. score_bc**	**result_crs. bias**	**CI_low**	**CI_up**	**result_vrs. score**	**result_vrs. score_bc**	**result_vrs. bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1 day	VLSFO	**1**	0.89802632	0.89392302	−0.0051115	0.88601267	0.897799	0.89802917	0.87709446	−0.0265785	0.82120703	0.8973901	0.999997	13	16
	MGO	**2**	0.81979986	0.816054	−0.0055992	0.80883272	0.8195924	0.8198023	0.80068747	−0.0291205	0.74967005	0.81921912	0.999997	19	22
	Methanol	**3**	0.42619863	0.42425122	−0.0107701	0.42049702	0.4260908	0.42636281	0.41643107	−0.0559375	0.38995291	0.42590242	0.999615	29	34
	Ammonia	**4**	0.44124045	0.43922432	−0.010403	0.43533761	0.4411288	0.44172719	0.43155109	−0.053382	0.40417864	0.44140303	0.998898	25	27
	LNG	**5**	1	0.99543076	−0.0045902	0.98662217	0.9997469	1	0.97653501	−0.0240288	0.91439291	0.99887496	1	1	5
	LPG	**6**	0.95327926	0.94892349	−0.0048152	0.94052644	0.953038	0.95327952	0.93093089	−0.0251833	0.87168216	0.95225414	1	7	10
	H2 Liq	**7**	0.14767784	0.14700306	−0.0310826	0.14570223	0.1476405	0.14805433	0.14468835	−0.1571293	0.13557317	0.14796492	0.997457	39	40
	H2 Gas	**8**	0.158897	0.15817096	−0.028888	0.1567713	0.1588568	0.16096645	0.15745083	−0.1387143	0.14772957	0.16087993	0.987144	37	37
5 day	VLSFO	**9**	0.8960815	0.89198709	−0.0051225	0.88409388	0.8958547	0.90010984	0.89204597	−0.0100429	0.87796848	0.89954306	0.995525	14	15
	MGO	**10**	0.81790832	0.8141711	−0.0056121	0.80696648	0.8177013	0.82158359	0.81422262	−0.0110037	0.80137223	0.82106876	0.995527	20	21
	Methanol	**11**	0.42364742	0.42171167	−0.010835	0.41797993	0.4235402	0.42553732	0.42172179	−0.0212613	0.41505469	0.4252862	0.995559	30	30
	Ammonia	**12**	0.43733076	0.43533249	−0.010496	0.43148022	0.4372201	0.43927992	0.4353423	−0.0205903	0.42845595	0.43901725	0.995563	26	25
	LNG	**13**	0.99555663	0.99100769	−0.0046107	0.98223824	0.9953047	1	0.9910283	−0.0090529	0.97536958	0.9994195	0.995557	2	3
	LPG	**14**	0.94923165	0.94489438	−0.0048357	0.93653299	0.9489914	0.95347093	0.944918	−0.0094932	0.92998917	0.95291336	0.995554	8	8
	H2 Liq	**15**	0.145514	0.14484911	−0.0315449	0.14356734	0.1454772	0.14616135	0.1448501	−0.0619345	0.14255799	0.14608071	0.995571	40	39
	H2 Gas	**16**	0.14990398	0.14921903	−0.0306211	0.14789859	0.149866	0.15056142	0.14918834	−0.0611293	0.146758	0.15048815	0.995633	38	38
10 day	VLSFO	**17**	0.89365048	0.88956718	−0.0051365	0.88169538	0.8934243	0.90276337	0.89604417	−0.0083064	0.88721279	0.90204912	0.989906	15	13
	MGO	**18**	0.8155439	0.81181748	−0.0056284	0.80463369	0.8153375	0.82385531	0.81772266	−0.0091032	0.80966831	0.82320621	0.989912	21	19
	Methanol	**19**	0.4204584	0.41853722	−0.0109172	0.41483357	0.420352	0.42469505	0.42153338	−0.0176607	0.41743417	0.42441619	0.990024	32	31
	Ammonia	**20**	0.43244364	0.4304677	−0.0106146	0.42665848	0.4323342	0.43678295	0.43354325	−0.0171083	0.42931814	0.43654064	0.990065	27	26
	LNG	**21**	0.99000243	0.98547886	−0.0046366	0.97675834	0.9897519	1	0.99253579	−0.0075203	0.98285972	0.99926218	0.990002	3	1
	LPG	**22**	0.94417215	0.939858	−0.0048616	0.93154117	0.9439332	0.95371503	0.94659851	−0.0078829	0.93736101	0.95300693	0.989994	9	7
	H2 Liq	**23**	0.1428092	0.14215667	−0.0321423	0.14089872	0.1427731	0.14422991	0.14316423	−0.0516103	0.14176682	0.1441648	0.99015	41	41
	H2 Gas	**24**	0.13866271	0.13802912	−0.0331035	0.1368077	0.1386276	0.13994506	0.13890508	−0.0534996	0.13752654	0.13982415	0.990837	43	43
15 day	VLSFO	**25**	0.89121946	0.88714726	−0.0051505	0.87929688	0.8909939	0.90547817	0.89839583	−0.0087062	0.88614298	0.90480642	0.984253	16	12
	MGO	**26**	0.81317947	0.80946386	−0.0056448	0.80230089	0.8129737	0.82617949	0.81972501	−0.0095306	0.80855983	0.82557225	0.984265	22	18
	Methanol	**27**	0.41726938	0.41536277	−0.0110006	0.41168722	0.4171638	0.42383262	0.42061185	−0.0180669	0.4149267	0.42365999	0.984515	33	32
	Ammonia	**28**	0.42755652	0.42560291	−0.0107359	0.42183674	0.4274483	0.43422619	0.43098268	−0.0173316	0.42531137	0.4340293	0.98464	28	28
	LNG	**29**	0.98444822	0.97995003	−0.0046627	0.97127843	0.9841991	1	0.99231577	−0.0077437	0.97902386	0.99947261	0.984448	4	2
	LPG	**30**	0.93911265	0.93482162	−0.0048878	0.92654936	0.938875	0.95396478	0.94662543	−0.0081273	0.93396324	0.95344649	0.984431	10	6
	H2 Liq	**31**	0.1401044	0.13946423	−0.0327628	0.13823011	0.1400689	0.14225223	0.14120462	−0.0521542	0.1395957	0.1421645	0.984901	42	42
	H2 Gas	**32**	0.12742143	0.12683921	−0.0360239	0.12571681	0.1273892	0.1290745	0.12812822	−0.0572185	0.12670347	0.12882175	0.987193	46	46
20 day	VLSFO	**33**	0.88878844	0.88472735	−0.0051646	0.87689838	0.8885635	0.90831947	0.89506543	−0.0163025	0.85684092	0.90664295	0.978498	17	14
	MGO	**34**	0.81081505	0.80711024	−0.0056612	0.7999681	0.8106098	0.82861196	0.81657921	−0.0177834	0.78182385	0.82716337	0.978522	23	20
	Methanol	**35**	0.41408036	0.41218832	−0.0110853	0.40854086	0.4139756	0.42295028	0.41715406	−0.0328518	0.40098885	0.42233751	0.979028	34	33
	Ammonia	**36**	0.42266941	0.42073813	−0.0108601	0.41701501	0.4225624	0.4316104	0.42592375	−0.0309338	0.41027937	0.43095589	0.979285	31	29
	LNG	**37**	0.97889401	0.9744212	−0.0046892	0.96579853	0.9786463	1	0.98597445	−0.0142251	0.9467455	0.99828072	0.978894	5	4
	LPG	**38**	0.93405315	0.92978523	−0.0049143	0.92155754	0.9338168	0.95422616	0.94081346	−0.0149404	0.90312143	0.95259518	0.978859	11	9
	H2 Liq	**39**	0.1373996	0.13677179	−0.0334078	0.1355615	0.1373648	0.14022888	0.13850455	−0.0887807	0.13405128	0.14004383	0.979824	44	44
	H2 Gas	**40**	0.11618016	0.11564931	−0.0395095	0.11462592	0.1161508	0.11798459	0.11710819	−0.0634296	0.1156175	0.11793099	0.984706	47	47
30 day	VLSFO	**41**	0.8839264	0.87988752	−0.005193	0.87210138	0.8837027	1	0.71066691	−0.407129	0.52797811	0.99732847	0.883926	18	24
	MGO	**42**	0.8060862	0.80240299	−0.0056945	0.79530251	0.8058822	0.90710092	0.75535131	−0.2214741	0.49004768	0.90434726	0.88864	24	23
	Methanol	**43**	0.40770232	0.40583943	−0.0112588	0.40224815	0.4075991	0.42115381	0.39851238	−0.1349029	0.35424014	0.42082786	0.96806	36	36
	Ammonia	**44**	0.41289517	0.41100855	−0.0111172	0.40737153	0.4127907	0.42628459	0.40749442	−0.1081707	0.36399136	0.42597529	0.96859	35	35
	LNG	**45**	0.96778559	0.96336354	−0.004743	0.95483872	0.9675407	1	0.92139459	−0.0853113	0.70664092	0.99684437	0.967786	6	11
	LPG	**46**	0.92393415	0.91971247	−0.0049681	0.91157391	0.9237003	0.9626602	0.87549476	−0.1034232	0.67067529	0.96086236	0.959772	12	17
	H2 Liq	**47**	0.13199001	0.13138691	−0.034777	0.13022427	0.1319566	0.13610931	0.13141236	−0.2625982	0.12230351	0.13593093	0.969735	45	45
	H2 Gas	**48**	0.09369761	0.09326949	−0.0489897	0.09244414	0.0936739	0.09551708	0.09447384	−0.1156091	0.09204334	0.09536569	0.980951	48	48

3500 TEU results/ CRS and VRS scores with ranks/ Eco efficiency 2050

BS Model	ECO Eff 2050	In: Fuel cost 2050	Out: TEU-mile										
DMUs	result_crs. score	result_crs. score_bc	result_crs. bias	CI_low	CI_up	result_vrs. score	result_vrs. score_bc	result_vrs. bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.5426564	0.5362215	−0.0221145	0.5222268	0.5424629	0.5426666	0.5075397	−0.1275372	0.3922381	0.5423635	0.999981	25	31
2	0.5534801	0.5469168	−0.0216821	0.532643	0.5532827	0.5534903	0.5176606	−0.1250511	0.4000583	0.5531815	0.999982	19	29
3	0.4647568	0.4592456	−0.0258212	0.4472599	0.464591	0.4647605	0.4345578	−0.149544	0.3358587	0.4643745	0.999992	32	38
4	1	0.9881417	−0.0120006	0.9623525	0.9996433	1	0.9346523	−0.0699166	0.7225371	0.9985702	1	1	5
5	0.6186725	0.6113362	−0.0193973	0.595381	0.6184519	0.6186802	0.5785708	−0.1120528	0.4471256	0.6183256	0.999988	7	19
6	0.607865	0.6006568	−0.0197422	0.5849804	0.6076482	0.6078728	0.5684724	−0.1140194	0.4393198	0.6075387	0.999987	11	20
7	0.4418706	0.4366307	−0.0271586	0.4252352	0.4417129	0.4425089	0.4137233	−0.1572332	0.3198374	0.4420386	0.998558	39	43
8	0.4853872	0.4796314	−0.0247237	0.4671136	0.4852141	0.491167	0.4597184	−0.1392773	0.3554305	0.4907569	0.988233	31	35
9	0.5414812	0.5350602	−0.0221625	0.5210958	0.5412881	0.5464265	0.5399047	−0.0221066	0.5198828	0.5462022	0.99095	26	27
10	0.5522031	0.5456549	−0.0217322	0.531414	0.5520061	0.5572441	0.550592	−0.0216809	0.530169	0.5570176	0.990954	20	23
11	0.4619748	0.4564966	−0.0259767	0.4445826	0.46181	0.4661432	0.4605376	−0.0261118	0.4433665	0.4659549	0.991058	33	33
12	0.9911393	0.9793861	−0.0121079	0.9538254	0.9907858	1	0.9878719	−0.012277	0.9509222	0.9993657	0.991139	2	1
13	0.6159236	0.6086198	−0.0194839	0.5927356	0.6157038	0.6215085	0.6140627	−0.0195098	0.591212	0.6212208	0.991014	8	13
14	0.605284	0.5981064	−0.0198264	0.5824966	0.6050681	0.6107759	0.6034618	−0.0198441	0.5810116	0.6104886	0.991008	13	16
15	0.4353961	0.430233	−0.0275625	0.4190045	0.4352408	0.4392813	0.4339098	−0.0281805	0.4175275	0.4389993	0.991156	40	39
16	0.457916	0.4524859	−0.026207	0.4406766	0.4577527	0.4619444	0.4558593	−0.0288966	0.4362484	0.46168	0.991279	35	36
17	0.5400122	0.5336086	−0.0222228	0.5196821	0.5398196	0.5513217	0.5445424	−0.0225812	0.5366286	0.5508981	0.979487	27	25
18	0.5506068	0.5440775	−0.0217952	0.5298778	0.5504103	0.5621312	0.5552231	−0.0221339	0.5471459	0.561703	0.979499	21	22
19	0.4584973	0.4530603	−0.0261737	0.441236	0.4583337	0.4679434	0.4621838	−0.0266307	0.4553782	0.4676721	0.979814	34	32
20	0.9800635	0.9684416	−0.0122447	0.9431665	0.9797139	1	0.9875904	−0.0125656	0.9729944	0.9992931	0.980064	3	2
21	0.6124873	0.6052243	−0.0195932	0.5894287	0.6122688	0.6251907	0.6175222	−0.019863	0.6084542	0.624805	0.979681	9	11
22	0.6020578	0.5949184	−0.0199326	0.5793918	0.601843	0.6145555	0.6070203	−0.020199	0.5981101	0.6141633	0.979664	14	14
23	0.427303	0.4222359	−0.0280845	0.4112161	0.4271506	0.4359208	0.4305401	−0.0286692	0.4241527	0.4356291	0.980231	41	40
24	0.423577	0.4185541	−0.0283315	0.4076303	0.4234259	0.4315193	0.4263263	−0.028228	0.4198549	0.4312065	0.981595	42	41
25	0.5385432	0.532157	−0.0222834	0.5182684	0.5383511	0.5564514	0.5449271	−0.0380058	0.4553577	0.5557076	0.967817	28	24
26	0.5490104	0.5425001	−0.0218586	0.5283415	0.5488146	0.5672526	0.555527	−0.0372095	0.4642869	0.5665046	0.967841	22	21
27	0.4550197	0.449624	−0.0263738	0.4378894	0.4548574	0.4698298	0.4604755	−0.043238	0.3865466	0.4692207	0.968478	36	34
28	0.9689876	0.9574971	−0.0123847	0.9325076	0.968642	1	0.9803099	−0.0200856	0.8262292	0.9982788	0.968988	4	3
29	0.6090511	0.6018288	−0.0197037	0.5861218	0.6088338	0.6290493	0.6163723	−0.0326956	0.5164026	0.6282486	0.968209	10	12
30	0.5988316	0.5917305	−0.02004	0.576287	0.598618	0.6185161	0.6060221	−0.033332	0.507614	0.6177114	0.968175	15	15
31	0.4192099	0.4142388	−0.0286267	0.4034277	0.4190604	0.4323955	0.4241747	−0.0448216	0.3606463	0.4315793	0.969506	43	42
32	0.3892379	0.3846222	−0.030831	0.3745841	0.3890991	0.3996022	0.3934523	−0.0391159	0.3664711	0.3989818	0.974063	46	45
33	0.5370742	0.5307054	−0.0223444	0.5168547	0.5368826	0.5620825	0.531026	−0.1040485	0.4260233	0.5615631	0.955508	29	28
34	0.5474141	0.5409227	−0.0219223	0.5268053	0.5472189	0.5728744	0.5415903	−0.1008307	0.4342949	0.5725451	0.955557	23	26
35	0.4515422	0.4461877	−0.0265769	0.4345427	0.4513811	0.4719006	0.4508042	−0.0991672	0.3597274	0.4715359	0.956859	37	37
36	0.9579117	0.9465526	−0.0125279	0.9218487	0.95757	1	0.9578109	−0.0440474	0.7643385	0.9986424	0.957912	5	4
37	0.6056148	0.5984333	−0.0198155	0.5828149	0.6053988	0.6332851	0.6031512	−0.0788916	0.481663	0.6327166	0.956307	12	17
38	0.5956054	0.5885425	−0.0201486	0.5731823	0.5953929	0.6228639	0.5928766	−0.0812043	0.4735911	0.6223137	0.956237	17	18
39	0.4111168	0.4062417	−0.0291902	0.3956393	0.4109701	0.4287013	0.4124939	−0.0916517	0.3297819	0.4281065	0.958982	44	44
40	0.3548989	0.3506904	−0.0338141	0.3415378	0.3547723	0.3662079	0.3590659	−0.0543146	0.3032848	0.3655538	0.969119	47	46
41	0.5341362	0.5278023	−0.0224673	0.5140273	0.5339457	1	0.7046471	−0.4191501	0.6121427	0.9912968	0.534136	30	10
42	0.5442215	0.5377679	−0.0220509	0.5237329	0.5440274	1	0.7537254	−0.3267431	0.644993	0.996683	0.544222	24	8
43	0.4445871	0.4393151	−0.0269927	0.4278495	0.4444285	0.6292295	0.51332	−0.3588573	0.4307331	0.6281562	0.706558	38	30
44	0.93576	0.9246635	−0.0128244	0.900531	0.9354262	1	0.753314	−0.3274676	0.6511131	0.9971972	0.93576	6	9
45	0.5987424	0.5916423	−0.020043	0.5762012	0.5985288	0.9551019	0.7850124	−0.2268566	0.650618	0.9525606	0.626889	16	6
46	0.5891529	0.5821666	−0.0203692	0.5669727	0.5889427	0.9531882	0.7748474	−0.241466	0.6476866	0.9488546	0.618087	18	7
47	0.3949306	0.3902474	−0.0303866	0.3800624	0.3947897	0.4210255	0.3346548	−0.6130006	0.2856622	0.4202404	0.938021	45	47
48	0.2862208	0.2828267	−0.0419277	0.2754453	0.2861187	0.2977672	0.2880261	−0.1135797	0.2323151	0.2972434	0.961223	48	48

3500 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2021

BS Model	ENV Eff 2021	In: Fuel cost 2021, All emissions	Out: TEU-mile										
DMUs	result_crs. score	result_crs. score_bc	result_crs. bias	CI_low	CI_up	result_vrs. score	result_vrs. score_bc	result_vrs. bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.8980263	0.8920926	−0.0074067	0.8743757	0.8979735	0.8980292	0.8866847	−0.014247	0.8471929	0.8973836	0.999997	26	37
2	0.8729771	0.8669331	−0.0079861	0.8536756	0.8726287	0.8729799	0.8631392	−0.01306	0.8455715	0.8723135	0.999997	33	42
3	0.8428156	0.8386268	−0.0059264	0.8319412	0.8424645	0.8428251	0.8343435	−0.0120613	0.7905588	0.842649	0.999989	40	48
4	1	0.9847602	−0.0154757	0.939111	0.9997449	1	0.9483006	−0.054518	0.8628865	0.9987428	1	5	31
5	1	0.9874126	−0.0127479	0.955844	0.9996072	1	0.9766364	−0.0239225	0.9121224	0.9985438	1	3	19
6	0.9933104	0.9874323	−0.0059931	0.9748409	0.9931274	0.9933113	0.9808228	−0.0128184	0.9077588	0.9929116	0.999999	2	14
7	1	0.9903424	−0.0097517	0.9688806	0.9998534	1	0.9782397	−0.0222443	0.8809409	0.999311	1	1	17
8	1	0.986275	−0.013916	0.9559699	0.9994525	1	0.9599495	−0.0417215	0.862322	0.9989451	1	4	25
9	0.8960815	0.8901607	−0.0074228	0.8724821	0.8960288	0.9001098	0.8933803	−0.0083686	0.8850833	0.8997663	0.995525	27	36
10	0.8709628	0.8649328	−0.0080045	0.8517059	0.8706153	0.8750782	0.8684626	−0.008705	0.860759	0.8744809	0.995297	34	41
11	0.8377705	0.8336068	−0.0059621	0.8269612	0.8374215	0.8488361	0.8440148	−0.0067296	0.8388528	0.8476135	0.986964	41	47
12	0.9911393	0.9760345	−0.015614	0.9307899	0.9908865	1	0.9823873	−0.0179284	0.9539935	0.9993418	0.991139	10	12
13	0.9955566	0.9830252	−0.0128048	0.9515968	0.9951655	1	0.9886953	−0.011434	0.9702973	0.9994918	0.995557	7	2
14	0.9890929	0.9832397	−0.0060186	0.9707017	0.9889106	0.9938362	0.986509	−0.0074734	0.9742561	0.9934473	0.995227	6	7
15	0.9853476	0.9758315	−0.0098968	0.9546841	0.9852032	1	0.9806988	−0.0196811	0.949352	0.9981994	0.985348	11	15
16	0.9434035	0.9304552	−0.0147509	0.9018653	0.9428869	1	0.9693832	−0.0315838	0.8794419	0.9986282	0.943404	23	21
17	0.8936505	0.8877457	−0.007443	0.8701151	0.8935979	0.9027634	0.8957027	−0.0087319	0.8884801	0.9018464	0.989906	28	35
18	0.868445	0.8624324	−0.0080277	0.8492437	0.8680985	0.8777555	0.8715338	−0.008133	0.8654522	0.8769233	0.989393	35	40
19	0.8314642	0.8273318	−0.0060073	0.8207362	0.8311178	0.8500775	0.8452044	−0.0067825	0.8388055	0.8497079	0.978104	42	46
20	0.9800635	0.9651275	−0.0157905	0.9203884	0.9798135	1	0.9841181	−0.0161382	0.9427946	0.9986868	0.980064	16	9
21	0.9900024	0.9775409	−0.0128766	0.9462878	0.9896135	1	0.9889085	−0.0112159	0.975771	0.9988718	0.990002	9	1
22	0.9838209	0.9779989	−0.0060509	0.9655278	0.9836396	0.9942807	0.9877472	−0.0066526	0.9798427	0.9936014	0.98948	8	5
23	0.967032	0.9576929	−0.0100842	0.9369386	0.9668903	1	0.9833317	−0.0169509	0.9543993	0.9987437	0.967032	17	11
24	0.8726578	0.8606805	−0.0159467	0.8342346	0.87218	1	0.9633884	−0.038003	0.8771565	0.9996088	0.872658	36	23
25	0.8912195	0.8853308	−0.0074633	0.8677481	0.891167	0.9054782	0.8989049	−0.0080759	0.8904032	0.9045477	0.984253	29	34
26	0.8659272	0.8599321	−0.0080511	0.8467816	0.8655817	0.8804963	0.8744095	−0.0079058	0.8673219	0.8793459	0.983454	37	39
27	0.8251578	0.8210568	−0.0060532	0.8145112	0.8248141	0.8518688	0.8472953	−0.0063363	0.8401898	0.8512955	0.968644	43	43
28	0.9689876	0.9542204	−0.0159709	0.9099869	0.9687404	1	0.9835704	−0.0167041	0.9243488	0.9991134	0.968988	20	10
29	0.9844482	0.9720566	−0.0129493	0.9409789	0.9840615	1	0.9884055	−0.0117305	0.9671151	0.9989524	0.984448	13	3
30	0.9785489	0.9727581	−0.0060835	0.9603539	0.9783686	0.9947165	0.9882817	−0.0065457	0.9803125	0.9938453	0.983747	12	4
31	0.9487165	0.9395542	−0.0102789	0.919193	0.9485775	1	0.9810863	−0.0192784	0.9144394	0.9993817	0.948717	22	13
32	0.8019121	0.7909059	−0.0173536	0.7666039	0.8014731	1	0.968573	−0.0324467	0.8808477	0.9993463	0.801912	46	22
33	0.8887884	0.8829158	−0.0074837	0.8653811	0.8887362	0.9083195	0.8997334	−0.0105061	0.8748152	0.9077741	0.978498	31	32
34	0.8634094	0.8574317	−0.0080746	0.8443195	0.8630649	0.8833666	0.8756666	−0.0099543	0.8621357	0.8826196	0.977408	38	38
35	0.8188515	0.8147818	−0.0060998	0.8082863	0.8185104	0.8521175	0.8465898	−0.0076625	0.8368981	0.8517901	0.960961	44	44
36	0.9579117	0.9433134	−0.0161556	0.8995855	0.9576674	1	0.9802342	−0.0201643	0.9098676	0.9989444	0.957912	21	16
37	0.978894	0.9665723	−0.0130227	0.9356699	0.9785095	1	0.9853073	−0.0149118	0.9493141	0.9997118	0.978894	15	8
38	0.973277	0.9675174	−0.0061164	0.9551799	0.9730976	0.995092	0.9875359	−0.0076892	0.9761537	0.9948695	0.978077	14	6
39	0.930401	0.9214156	−0.0104812	0.9014474	0.9302646	1	0.9767518	−0.0238016	0.8968569	0.9995959	0.930401	25	18
40	0.7311665	0.7211312	−0.0190327	0.6989732	0.7307661	1	0.9623845	−0.0390857	0.8820176	0.9997786	0.731167	47	24
41	0.8839264	0.8780859	−0.0075249	0.8606471	0.8838744	1	0.8997332	−0.0448526	0.8601546	0.9993651	0.883926	32	33
42	0.8583738	0.852431	−0.0081219	0.8393952	0.8580313	1	0.9579897	−0.0438526	0.8688379	0.9993651	0.858374	39	26
43	0.8062388	0.8022318	−0.0061952	0.7958363	0.805903	0.8573426	0.8458715	−0.0158178	0.8219547	0.8569206	0.940393	45	45
44	0.93576	0.9214992	−0.0165381	0.8787826	0.9355213	1	0.9563583	−0.0456332	0.8655968	0.9981962	0.93576	24	27
45	0.9677856	0.9556037	−0.0131722	0.925052	0.9674054	1	0.970653	−0.0302343	0.8831193	0.9993605	0.967786	19	20
46	0.962733	0.9570358	−0.0061834	0.944832	0.9625556	1	0.9559346	−0.0460967	0.8635909	0.9993065	0.962733	18	28
47	0.8937699	0.8851383	−0.0109108	0.8659563	0.8936389	1	0.9535069	−0.0487601	0.8667947	0.9996744	0.89377	30	29
48	0.5896752	0.5815818	−0.0235995	0.5637117	0.5893523	1	0.9524935	−0.049876	0.862655	0.9990499	0.589675	48	30

3500 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2050

BS Model	ENV Eff 2050	In: Fuel cost 2050, All emissions	Out: TEU-mile											
DMUs	**result_crs. score**	**result_crs. score_bc**	**result_crs. bias**	**CI_low**	**CI_up**	**result_vrs. score**	**result_vrs. score_bc**	**result_vrs. bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.5426564	0.5376669	−0.0171012	0.5276756	0.5422359	0.5426666	0.5226173	−0.0706938	0.4484991	0.5421215	0.999981	42	46
2	0.5534801	0.5443717	−0.0302305	0.5165383	0.5528889	0.5534903	0.5221961	−0.108273	0.4465646	0.5526301	0.999982	37	47
3	0.6614083	0.6521489	−0.0214668	0.6277532	0.6603249	0.6614488	0.6391378	−0.0527751	0.5657402	0.6608803	0.999939	30	37
4	1	0.9564625	−0.0455193	0.81676	0.9985433	1	0.8502649	−0.1761041	0.6868788	0.9982219	1	3	19
5	0.7851875	0.7756934	−0.015588	0.748268	0.7843018	0.7852238	0.7596247	−0.0429172	0.6589305	0.7844788	0.999954	16	31
6	0.7774006	0.7682017	−0.0154033	0.7411835	0.7767654	0.7774379	0.7529153	−0.0418942	0.6534732	0.7769069	0.999952	18	32
7	1	0.9719368	−0.0288734	0.856577	0.9990254	1	0.9136161	−0.0945516	0.7451176	0.9985669	1	1	13
8	1	0.9507115	−0.0518438	0.8120775	0.9985648	1	0.8335676	−0.1996628	0.6866135	0.9985026	1	4	21
9	0.5414812	0.5365025	−0.0171383	0.5265328	0.5410616	0.5464265	0.5414266	−0.0169004	0.5334645	0.5462651	0.99095	43	45
10	0.5522031	0.5431157	−0.0303004	0.5153465	0.5516132	0.5572441	0.5498427	−0.0241561	0.5306111	0.5570817	0.990954	38	42
11	0.6574491	0.6482451	−0.021596	0.6239955	0.6563722	0.6767607	0.6690736	−0.0169766	0.6543541	0.6759772	0.971465	31	36
12	0.9911393	0.9479875	−0.0459263	0.8095229	0.9896955	1	0.9589593	−0.0427971	0.876174	0.9976194	0.991139	5	5
13	0.7816986	0.7722467	−0.0156576	0.7449432	0.7808169	0.7988323	0.790446	−0.0132814	0.7751904	0.7982955	0.978552	17	29
14	0.7740998	0.7649399	−0.015469	0.7380364	0.7734673	0.7914366	0.7832822	−0.013154	0.7684397	0.791166	0.978095	20	30
15	0.9853476	0.9576956	−0.0293028	0.844026	0.9843873	1	0.9647661	−0.0365207	0.8862241	0.9987143	0.985348	2	3
16	0.9434035	0.8969045	−0.054954	0.7661168	0.9420495	1	0.9263665	−0.0794863	0.7849176	0.9994355	0.943404	12	9
17	0.5400122	0.535047	−0.0171849	0.5251044	0.5395938	0.5513217	0.5463911	−0.0163679	0.5402574	0.5501354	0.979487	45	44
18	0.5506068	0.5415456	−0.0303883	0.5138567	0.5500186	0.5621312	0.5556597	−0.0207187	0.5479793	0.5606936	0.979499	39	39
19	0.6525002	0.6433655	−0.0217598	0.6192984	0.6514313	0.6893639	0.6834434	−0.0125663	0.677883	0.6883324	0.946525	32	35
20	0.9800635	0.9373939	−0.0464453	0.8004766	0.9786358	1	0.971364	−0.0294802	0.8758307	0.9975413	0.980064	7	2
21	0.7773375	0.7679384	−0.0157454	0.7407871	0.7764607	0.8093695	0.8016082	−0.0119626	0.7922939	0.8089124	0.960424	19	27
22	0.7699737	0.7608627	−0.0155519	0.7341026	0.7693446	0.8024689	0.7949606	−0.0117699	0.7858909	0.8020667	0.959506	23	28
23	0.967032	0.9398941	−0.0298578	0.8283374	0.9660896	1	0.9598976	−0.0417778	0.8594832	0.9981164	0.967032	6	4
24	0.8726578	0.8296458	−0.0594091	0.7086658	0.8714053	1	0.9246837	−0.0814508	0.8001562	0.9986421	0.872658	15	10
25	0.5385432	0.5335915	−0.0172318	0.5236759	0.5381259	0.5564514	0.5520728	−0.0142533	0.5468986	0.5560147	0.967817	46	41
26	0.5490104	0.5399756	−0.0304766	0.512367	0.548424	0.5672526	0.5605772	−0.0209923	0.5542089	0.5667625	0.967841	40	38
27	0.6475512	0.6384858	−0.0219261	0.6146012	0.6464905	0.6966002	0.6904012	−0.0128893	0.6812697	0.6957432	0.929588	33	33
28	0.9689876	0.9268003	−0.0469762	0.7914303	0.9675761	1	0.971824	−0.0289929	0.8472112	0.9986583	0.968988	8	1
29	0.7729765	0.76363	−0.0158343	0.7366311	0.7721045	0.8192839	0.8128482	−0.0096639	0.803543	0.8187973	0.943478	21	22
30	0.7658477	0.7567855	−0.0156357	0.7301688	0.765222	0.8125287	0.8062624	−0.0095652	0.7969076	0.8120124	0.942548	25	25
31	0.9487165	0.9220925	−0.0304342	0.8126487	0.9477919	1	0.9512364	−0.0512633	0.8323664	0.9989628	0.948717	9	6
32	0.8019121	0.7623871	−0.0646502	0.6512148	0.8007612	1	0.9210251	−0.0857467	0.7603448	0.9966052	0.801912	22	12
33	0.5370742	0.532136	−0.0172789	0.5222474	0.536658	0.5620825	0.5470827	−0.0487788	0.4706478	0.5617112	0.955508	47	43
34	0.5474141	0.5384055	−0.0305655	0.5108772	0.5468294	0.5728744	0.5540513	−0.0593035	0.4783399	0.5721212	0.955557	41	40
35	0.6426022	0.6336061	−0.022095	0.6099041	0.6415496	0.7020374	0.6903127	−0.0241933	0.6610544	0.7005233	0.915339	34	34
36	0.9579117	0.9162066	−0.0475194	0.782384	0.9565163	1	0.9488548	−0.053902	0.7726621	0.9985145	0.957912	10	7
37	0.7686154	0.7593216	−0.0159241	0.7324751	0.7677484	0.8265467	0.8119015	−0.0218235	0.7535325	0.8258322	0.929912	24	23
38	0.7617217	0.7527083	−0.0157204	0.726235	0.7610993	0.820037	0.8058902	−0.0214066	0.7505345	0.8190918	0.928887	26	26
39	0.930401	0.904291	−0.0310333	0.79696	0.9294942	1	0.9345346	−0.0700514	0.7862836	0.9978491	0.930401	11	8
40	0.7311665	0.6951284	−0.0709056	0.5937639	0.7301171	1	0.8959616	−0.1161193	0.7171221	0.9980536	0.731167	29	14
41	0.5341362	0.529225	−0.017374	0.5193905	0.5337223	1	0	Inf	0.6869517	0	0.534136	48	48
42	0.5442215	0.5352654	−0.0307448	0.5078976	0.5436402	1	0.842939	−0.1863255	0.6882946	0.9983063	0.544222	44	20
43	0.6327043	0.6238467	−0.0224406	0.6005098	0.6316679	0.8573426	0.8083346	−0.0707166	0.6527377	0.8565146	0.737983	35	24
44	0.93576	0.8950193	−0.0486443	0.7642913	0.9343969	1	0.8684062	−0.1515348	0.6862174	0.9984816	0.93576	13	16
45	0.7598932	0.7507049	−0.0161069	0.724163	0.759036	1	0.9218321	−0.0847962	0.6998376	0.9987667	0.759893	27	11
46	0.7534696	0.7445539	−0.0158926	0.7183674	0.752854	1	0.8757281	−0.1419069	0.6937493	0.9992884	0.75347	28	15
47	0.8937699	0.8686879	−0.0323052	0.7655827	0.8928989	1	0.8565089	−0.1675302	0.6880679	0.9988734	0.89377	14	18
48	0.5896752	0.560611	−0.0879193	0.478862	0.5888288	1	0.8658963	−0.1548727	0.7006962	0.999051	0.589675	36	17

6500 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2021

6500		BS Model	ECO Eff 2021	In: Fuel cost 2021	Out: TEU-mile										
Day	Fuel	DMUs	result_crs. score	result_crs. score_bc	result_crs. bias	CI_low	CI_up	result_vrs. score	result_vrs. score_bc	result_vrs. bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1 day	VLSFO	1	0.89798887	0.89421834	−0.0046956	0.8830245	0.89783332	0.8979913	0.87183018	−0.0334159	0.79313541	0.896714	1	13	16
	MGO	2	0.8197678	0.81632571	−0.0051436	0.80610693	0.8196258	0.8197699	0.79588398	−0.03661	0.72404476	0.8186029	1	19	22
	Methanol	3	0.42621067	0.42442107	−0.0098931	0.41910816	0.42613684	0.4263628	0.41395236	−0.0703166	0.37658845	0.4257482	0.99964	29	34
	Ammonia	4	0.44127614	0.43942328	−0.0095554	0.43392258	0.4411997	0.4417272	0.42896307	−0.0673623	0.39023854	0.4410904	0.99898	25	28
	LNG	5	1	0.99580114	−0.0042166	0.98333569	0.99982678	1	0.970749	−0.0301324	0.88316175	0.9985585	1	1	5
	LPG	6	0.95327581	0.94927314	−0.0044232	0.93739012	0.95311069	0.953276	0.9254065	−0.0315921	0.8419148	0.9519222	1	7	10
	H2 Liq	7	0.14770544	0.14708525	−0.0285471	0.14524403	0.14767986	0.1480543	0.14382112	−0.1988045	0.13085042	0.1479261	0.99764	39	40
	H2 Gas	8	0.15904874	0.15838091	−0.0265111	0.1563983	0.15902119	0.1609664	0.15647539	−0.1783065	0.14226214	0.1608591	0.98809	37	37
5 day	VLSFO	9	0.89618665	0.89242369	−0.004705	0.88125231	0.89603142	0.8999168	0.89225826	−0.0095379	0.88186222	0.8993935	0.99586	14	15
	MGO	10	0.81801495	0.81458022	−0.0051546	0.80438329	0.81787326	0.8214184	0.81442709	−0.0104505	0.80493729	0.8209404	0.99586	20	21
	Methanol	11	0.42384651	0.42206684	−0.0099483	0.4167834	0.4237731	0.4255982	0.42196644	−0.0202225	0.41704758	0.425352	0.99588	31	30
	Ammonia	12	0.43765311	0.43581547	−0.0096345	0.43035993	0.43757731	0.4394603	0.43570685	−0.0196027	0.43062961	0.4392341	0.99589	26	25
	LNG	13	0.99588243	0.99170086	−0.004234	0.97928673	0.99570993	1	0.99146889	−0.0086045	0.97991122	0.999393	0.99588	2	2
	LPG	14	0.94952499	0.94553807	−0.0044407	0.93370181	0.94936051	0.9534532	0.94532096	−0.0090226	0.93430164	0.9528766	0.99588	8	8
	H2 Liq	15	0.14570026	0.14508849	−0.02894	0.14327227	0.14567503	0.1463009	0.14504721	−0.0590772	0.14335996	0.1462223	0.99589	40	39
	H2 Gas	16	0.15071511	0.15008228	−0.0279771	0.14820354	0.150689	0.1513283	0.14999277	−0.0588381	0.14816735	0.1512292	0.99595	38	38
10 day	VLSFO	17	0.89393388	0.89018037	−0.0047169	0.87903708	0.89377903	0.9023688	0.89493963	−0.0091995	0.88470816	0.9018999	0.99065	15	13
	MGO	18	0.81582389	0.81239836	−0.0051685	0.80222875	0.81568258	0.8235176	0.81673719	−0.0100809	0.80740757	0.8230896	0.99066	21	19
	Methanol	19	0.42089132	0.41912406	−0.0100182	0.41387746	0.42081842	0.4248191	0.42132427	−0.0195258	0.41662496	0.4245841	0.99075	32	31
	Ammonia	20	0.43312433	0.4313057	−0.0097352	0.42590661	0.43304931	0.4371508	0.43356407	−0.0189239	0.42883099	0.4369288	0.99079	27	26
	LNG	21	0.99073547	0.98657551	−0.004256	0.97422554	0.99056386	1	0.99175726	−0.0083113	0.98057508	0.9994725	0.99074	3	1
	LPG	22	0.94483646	0.94086923	−0.0044627	0.92909141	0.9446728	0.9536787	0.94581934	−0.0087132	0.93514143	0.9531834	0.99073	9	6
	H2 Liq	23	0.14319379	0.14259254	−0.0294466	0.14080756	0.14316898	0.1445144	0.14333276	−0.0570477	0.14184011	0.144446	0.99086	41	41
	H2 Gas	24	0.14029807	0.13970898	−0.0300543	0.1379601	0.14027377	0.1415089	0.14036243	−0.0577219	0.13892594	0.1413499	0.99144	43	43
15 day	VLSFO	25	0.8916811	0.88793706	−0.0047288	0.87682185	0.89152665	0.9048732	0.89677367	−0.0099813	0.87347173	0.9042655	0.98542	16	12
	MGO	26	0.81363283	0.8102165	−0.0051824	0.8000742	0.8134919	0.8256615	0.81827835	−0.010928	0.79703982	0.8251131	0.98543	22	18
	Methanol	27	0.41793613	0.41618127	−0.010089	0.41097151	0.41786374	0.4240228	0.42029567	−0.0209139	0.40976458	0.4238591	0.98565	33	32
	Ammonia	28	0.42859555	0.42679594	−0.0098381	0.4214533	0.42852131	0.4347901	0.43100061	−0.020222	0.42055768	0.4346096	0.98575	28	27
	LNG	29	0.98558851	0.98145016	−0.0042782	0.96916435	0.98541779	1	0.99114494	−0.0089342	0.96590373	0.9996456	0.98559	4	3
	LPG	30	0.94014793	0.93620039	−0.004485	0.92448101	0.93998508	0.9539091	0.94545764	−0.009371	0.92133383	0.9535696	0.98557	10	7
	H2 Liq	31	0.14068731	0.14009658	−0.0299712	0.13834285	0.14066294	0.1426884	0.1414601	−0.0608542	0.13828361	0.1425999	0.98598	42	42
	H2 Gas	32	0.12988103	0.12933568	−0.0324648	0.12771666	0.12985854	0.1314721	0.13038965	−0.0631459	0.12847282	0.1312953	0.9879	46	46
20 day	VLSFO	33	0.88942833	0.88569375	−0.0047408	0.87460662	0.88927427	0.9074852	0.89276014	−0.0181754	0.85482381	0.9057264	0.9801	17	14
	MGO	34	0.81144177	0.80803464	−0.0051964	0.79791965	0.81130122	0.8278978	0.81450975	−0.0198538	0.77990211	0.8263027	0.98012	23	20
	Methanol	35	0.41498094	0.41323849	−0.0101609	0.40806556	0.41490905	0.4232096	0.41684426	−0.036082	0.39936011	0.4228065	0.98056	35	33
	Ammonia	36	0.42406677	0.42228617	−0.0099432	0.41699999	0.42399331	0.4323791	0.42617139	−0.0336885	0.40863019	0.4319166	0.98078	30	29
	LNG	37	0.98044155	0.97632481	−0.0043007	0.96410316	0.98027172	1	0.98454069	−0.0157021	0.94290028	0.9986174	0.98044	5	4
	LPG	38	0.93545941	0.93153154	−0.0045075	0.91987062	0.93529737	0.9541494	0.9393533	−0.0165083	0.89958987	0.9527806	0.98041	11	9
	H2 Liq	39	0.13818083	0.13760063	−0.0305148	0.13587815	0.1381569	0.1408235	0.13893678	−0.096429	0.13351592	0.1406617	0.98123	44	44
	H2 Gas	40	0.119464	0.11896238	−0.0352957	0.11747321	0.1194433	0.1212212	0.1201435	−0.0739972	0.11705096	0.1211587	0.9855	47	47
30 day	VLSFO	41	0.88492279	0.88120712	−0.0047649	0.87017615	0.8847695	1	0.774018	−0.1892	0.5323333	0.9965954	0.88492	18	24
	MGO	42	0.80705965	0.80367092	−0.0052246	0.79361056	0.80691986	0.9071009	0.77401939	−0.1895441	0.48987028	0.9041525	0.88971	24	23
	Methanol	43	0.40907055	0.40735292	−0.0103077	0.40225367	0.40899969	0.421556	0.39024372	−0.1903373	0.28624313	0.4209531	0.97038	36	36
	Ammonia	44	0.41500921	0.41326664	−0.0101602	0.40809336	0.41493732	0.427477	0.40409436	−0.1353625	0.35690169	0.4267954	0.97083	34	35
	LNG	45	0.97014763	0.96607411	−0.0043463	0.95398078	0.96997958	1	0.9001692	−0.1109023	0.64957851	0.9980269	0.97015	6	11
	LPG	46	0.92608235	0.92219386	−0.0045531	0.91064983	0.92592194	0.9626602	0.8604728	−0.1233636	0.62400674	0.9602405	0.962	12	17
	H2 Liq	47	0.13316788	0.13260873	−0.0316635	0.13094873	0.13314482	0.1370317	0.13157684	−0.3025389	0.11905362	0.1368754	0.9718	45	45
	H2 Gas	48	0.09862992	0.09821579	−0.0427514	0.09698632	0.09861284	0.10049	0.09918706	−0.1307246	0.09544737	0.1003701	0.98149	48	48

6500 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2050

BS Model	ECO Eff 2050	In: Fuel cost 2050	Out: TEU-mile										
DMUs	result_crs. score	result_crs. score_bc	result_crs. bias	CI_low	CI_up	result_vrs. score	result_vrs. score_bc	result_vrs. bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.5425899	0.5390476	−0.0121112	0.531232	0.5424228	0.5425986	0.5080822	−0.1252025	0.3909289	0.5420841	0.99998	25	31
2	0.5534137	0.5498008	−0.0118743	0.5418292	0.5532432	0.5534224	0.5182144	−0.1227651	0.3987244	0.5528976	0.99998	19	30
3	0.4647323	0.4616983	−0.0141402	0.4550042	0.4645892	0.4647355	0.4350435	−0.1468592	0.3347206	0.464192	0.99999	32	38
4	1	0.9934715	−0.0065714	0.9790672	0.9996919	1	0.9357643	−0.0686452	0.720026	0.9981619	1	1	5
5	0.6186225	0.6145838	−0.0106226	0.605673	0.6184319	0.6186291	0.5792007	−0.1100397	0.4456315	0.61803	0.99999	7	19
6	0.6078137	0.6038455	−0.0108116	0.5950904	0.6076264	0.6078204	0.5690894	−0.1119703	0.437852	0.607245	0.99999	11	20
7	0.4419174	0.4390324	−0.0148702	0.4326668	0.4417813	0.4425089	0.4142111	−0.1543863	0.3186179	0.4418077	0.99866	39	44
8	0.4858115	0.4826398	−0.0135267	0.475642	0.4856618	0.491167	0.4604868	−0.1356476	0.3537432	0.4905751	0.9891	31	35
9	0.541501	0.5379658	−0.0121355	0.5301658	0.5413342	0.5460732	0.5401873	−0.0199531	0.527138	0.5458841	0.99163	26	27
10	0.5522304	0.5486252	−0.0118998	0.5406707	0.5520603	0.5568912	0.5508886	−0.0195664	0.5375738	0.5567006	0.99163	20	23
11	0.4621545	0.4591373	−0.0142191	0.4524803	0.4620121	0.4660133	0.4609635	−0.0235076	0.449693	0.4658379	0.99172	33	34
12	0.9917897	0.9853148	−0.0066258	0.9710287	0.9914841	1	0.9890748	−0.0110459	0.9647175	0.9995519	0.99179	2	1
13	0.6160753	0.6120532	−0.0106666	0.6031791	0.6158855	0.6212426	0.6145351	−0.0175693	0.599573	0.6210327	0.99168	8	13
14	0.6054221	0.6014696	−0.0108543	0.5927489	0.6052356	0.6105031	0.6039137	−0.0178723	0.5892189	0.6102965	0.99168	13	17
15	0.4359181	0.4330723	−0.0150749	0.4267931	0.4357839	0.4395206	0.4346753	−0.0253616	0.4238313	0.4393051	0.9918	40	39
16	0.4603565	0.4573511	−0.0142746	0.45072	0.4602147	0.4641115	0.4585442	−0.0261603	0.4461056	0.4638157	0.99191	34	36
17	0.5401398	0.5366135	−0.0121661	0.5288331	0.5399734	0.5505828	0.5445053	−0.0202723	0.5390193	0.5503148	0.98103	27	26
18	0.5507512	0.5471557	−0.0119317	0.5392225	0.5505816	0.5613935	0.5551961	−0.0198836	0.5496	0.5611269	0.98104	21	22
19	0.4589322	0.4559361	−0.0143189	0.4493255	0.4587908	0.4676716	0.462473	−0.0240361	0.4577822	0.4673598	0.98131	35	33
20	0.9815267	0.9751188	−0.0066951	0.9609806	0.9812244	1	0.9887803	−0.011347	0.9787442	0.9991153	0.98153	3	2
21	0.6128913	0.60889	−0.010722	0.6000617	0.6127025	0.6246349	0.6177182	−0.0179257	0.6114627	0.6242907	0.9812	9	12
22	0.6024327	0.5984997	−0.0109081	0.5898221	0.6022471	0.613985	0.6071886	−0.0182302	0.601042	0.6136538	0.98118	14	16
23	0.4284191	0.4256221	−0.0153387	0.419451	0.4282871	0.4364186	0.4315402	−0.0259033	0.4271672	0.4359687	0.98167	42	40
24	0.4285379	0.4257402	−0.0153345	0.4195674	0.4284059	0.4360268	0.4312102	−0.0256176	0.4264867	0.4351593	0.98282	41	41
25	0.5387786	0.5352612	−0.0121969	0.5275004	0.5386126	0.5552914	0.5489017	−0.0209637	0.5438052	0.5546372	0.97026	28	25
26	0.5492721	0.5456862	−0.0119638	0.5377743	0.5491029	0.5660945	0.5595885	−0.020538	0.5544059	0.5654405	0.97028	22	21
27	0.4557099	0.4527348	−0.0144202	0.4461706	0.4555696	0.4694032	0.4640044	−0.0247876	0.4598383	0.4686932	0.97083	36	32
28	0.9712638	0.9649229	−0.0067658	0.9509325	0.9709646	1	0.9883542	−0.0117831	0.9794804	0.9984688	0.97126	4	3
29	0.6097072	0.6057268	−0.010778	0.5969443	0.6095194	0.6281768	0.6209897	−0.018424	0.615374	0.6273201	0.9706	10	11
30	0.5994433	0.5955298	−0.0109625	0.5868952	0.5992586	0.6176205	0.6105576	−0.01873	0.6050325	0.6167899	0.97057	16	15
31	0.42092	0.418172	−0.015612	0.4121089	0.4207903	0.4331762	0.4281579	−0.027058	0.4242607	0.4325141	0.97171	43	42
32	0.3967192	0.3941293	−0.0165644	0.3884148	0.396597	0.4066711	0.4021098	−0.0278931	0.3980828	0.4058982	0.97553	46	45
33	0.5374174	0.5339089	−0.0122278	0.5261677	0.5372519	0.5604233	0.5393134	−0.0698437	0.4500178	0.5598521	0.95895	29	28
34	0.5477929	0.5442167	−0.0119962	0.5363261	0.5476242	0.5712179	0.5500015	−0.0675314	0.4588114	0.5706438	0.95899	23	24
35	0.4524876	0.4495336	−0.0145228	0.4430158	0.4523483	0.4712904	0.4579409	−0.061854	0.3813443	0.4710109	0.9601	37	37
36	0.9610009	0.954727	−0.0068381	0.9408844	0.9607049	1	0.9742115	−0.0264712	0.8141066	0.9988362	0.961	5	4
37	0.6065232	0.6025635	−0.0108346	0.593827	0.6063364	0.632037	0.6127388	−0.049831	0.5098059	0.6315994	0.95963	12	14
38	0.5964538	0.5925599	−0.0110175	0.5839684	0.5962701	0.6215828	0.6022917	−0.0515289	0.5011748	0.6211208	0.95957	17	18
39	0.4134209	0.4107219	−0.0158952	0.4047668	0.4132935	0.4297908	0.4204828	−0.0515048	0.3548405	0.4292111	0.96191	44	43
40	0.3649006	0.3625183	−0.0180088	0.3572622	0.3647882	0.3760198	0.3717119	−0.0308207	0.368355	0.3755489	0.97043	47	46
41	0.534695	0.5312043	−0.01229	0.5235024	0.5345303	1	0.7164059	−0.3958567	0.6033153	0.9973649	0.5347	30	10
42	0.5448346	0.5412777	−0.0120613	0.5334297	0.5446668	1	0.7853247	−0.2733586	0.6439127	0.994776	0.54483	24	9
43	0.4460431	0.4431311	−0.0147327	0.4367061	0.4459057	0.6292295	0.5325818	−0.2884008	0.4370234	0.6281949	0.70887	38	29
44	0.9404751	0.9343352	−0.0069873	0.9207883	0.9401853	1	0.791317	−0.2637161	0.6524349	0.9984557	0.94048	6	8
45	0.6001552	0.596237	−0.0109495	0.5875922	0.5999703	0.9551019	0.8150883	−0.1798523	0.6623666	0.9511114	0.62837	15	6
46	0.590475	0.58662	−0.011129	0.5781146	0.5902931	0.9531882	0.8094585	−0.1862831	0.6596511	0.9482806	0.61947	18	7
47	0.3984227	0.3958216	−0.0164936	0.3900826	0.3983	0.4227786	0.3495252	−0.49572	0.2821639	0.4224944	0.94239	45	47
48	0.3012633	0.2992965	−0.0218128	0.294957	0.3011705	0.3130272	0.3066441	−0.0664987	0.26056	0.3125983	0.96242	48	48

6500 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2021

BS Model	ENV Eff 2021	In: Fuel cost 2021, All emissions	Out: TEU-mile											
DMUs	result_crs. score	result_crs. score_bc	result_crs. bias	CI_low	CI_up	result_vrs. score	result_vrs. score_bc	result_vrs. bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.8979889	0.892953	-0.0062803	0.8823003	0.8978106	0.8979913	0.8862111	-0.0148028	0.8466807	0.8973653	1	27	37
2	0.8729393	0.8676502	-0.0069832	0.8581298	0.8724632	0.8729418	0.8610341	-0.0158424	0.8162532	0.872046	1	34	42
3	0.8426908	0.8387273	-0.0056078	0.8301937	0.8424448	0.8426989	0.8311118	-0.0165442	0.7866942	0.8414653	0.99999	40	48
4	1	0.9895457	-0.0105648	0.9542833	0.9998356	1	0.9428574	-0.0606057	0.8562558	0.9994686	1	2	31
5	1	0.9876395	-0.0125152	0.9583113	0.9994777	1	0.9684679	-0.0325587	0.8763113	0.9979868	1	4	21
6	0.9932993	0.9874198	-0.0059946	0.9741243	0.9930229	0.9933	0.974777	-0.0191306	0.8836201	0.9924203	1	5	18
7	1	0.9921361	-0.0079262	0.9808628	0.9997279	1	0.9782153	-0.0222699	0.8964971	0.9995453	1	1	17
8	1	0.989159	-0.0109598	0.9561061	0.999817	1	0.9489767	-0.0537666	0.8647446	0.9987889	1	3	30
9	0.8961867	0.8911609	-0.0062929	0.8805296	0.8960087	0.8999168	0.8939076	-0.0074701	0.8854151	0.8990889	0.99586	28	36
10	0.8710728	0.865795	-0.0069981	0.8562949	0.8705977	0.8748835	0.8687112	-0.0081212	0.8595864	0.8742199	0.99564	35	41
11	0.8380164	0.8340749	-0.0056391	0.8255887	0.8377718	0.8482544	0.8427102	-0.0077559	0.8354372	0.8477702	0.98793	41	47
12	0.9917897	0.9814212	-0.0106522	0.9464483	0.9916266	1	0.9837289	-0.0165402	0.94942	0.9993824	0.99179	8	13
13	0.9958824	0.9835728	-0.012567	0.9543654	0.9953623	1	0.9889461	-0.0111775	0.9724523	0.998462	0.99588	6	1
14	0.989391	0.9835347	-0.0060182	0.9702915	0.9891157	0.9937858	0.9869313	-0.0069887	0.9770348	0.9933507	0.99558	7	7
15	0.9864245	0.9786674	-0.0080353	0.967547	0.986156	1	0.9823553	-0.0179616	0.9517527	0.9992834	0.98642	10	15
16	0.9476033	0.9373303	-0.0115658	0.9060093	0.9474299	1	0.9648756	-0.036403	0.8901661	0.9987333	0.9476	23	22
17	0.8939339	0.8889207	-0.0063088	0.8783161	0.8937564	0.9023688	0.8964173	-0.0073576	0.8895395	0.9019898	0.99065	29	35
18	0.8687396	0.8634759	-0.0070169	0.8540013	0.8682658	0.8773574	0.8713966	-0.0077967	0.8627307	0.8767677	0.99018	36	40
19	0.8321735	0.8282595	-0.0056787	0.8198324	0.8319306	0.8493948	0.8437083	-0.0079349	0.8372854	0.8488207	0.97973	42	46
20	0.9815267	0.9712655	-0.0107636	0.9366546	0.9813654	1	0.9862653	-0.0139259	0.9682211	0.9993775	0.98153	14	8
21	0.9907355	0.9784894	-0.0126323	0.949433	0.990218	1	0.9889211	-0.0112031	0.9709611	0.999586	0.99074	11	2
22	0.9845056	0.9786782	-0.0060481	0.9655004	0.9842317	0.9941963	0.987269	-0.0070576	0.9772862	0.9936623	0.99025	9	5
23	0.969455	0.9618314	-0.0081759	0.9509024	0.9691912	1	0.9851558	-0.0150678	0.9555992	0.9998516	0.96946	17	10
24	0.8821074	0.8725445	-0.0124246	0.8433883	0.881946	1	0.9692588	-0.0317162	0.8966932	0.9990221	0.88211	33	20
25	0.8916811	0.8866806	-0.0063247	0.8761027	0.8915041	0.9048732	0.8980764	-0.0083638	0.890009	0.9045267	0.98542	30	34
26	0.8664064	0.8611569	-0.0070358	0.8517077	0.8659339	0.8798854	0.8738969	-0.007788	0.8662063	0.879213	0.98468	37	39
27	0.8263306	0.822444	-0.0057188	0.8140761	0.8260894	0.8516779	0.8470053	-0.0064773	0.8403345	0.8512996	0.97024	43	43
28	0.9712638	0.9611099	-0.0108774	0.9268609	0.9711042	1	0.9873081	-0.0128551	0.9657806	0.9988804	0.97126	18	4
29	0.9855885	0.9734061	-0.0126982	0.9445006	0.9850738	1	0.9873755	-0.0127859	0.9545654	0.9998996	0.98559	13	3
30	0.9796203	0.9738217	-0.0060783	0.9607093	0.9793476	0.9946132	0.9870628	-0.0076908	0.9775184	0.994349	0.98493	12	6
31	0.9524856	0.9449954	-0.0083216	0.9342577	0.9522264	1	0.9858292	-0.0143745	0.9614637	0.9990978	0.95249	22	9
32	0.8166115	0.8077586	-0.0134211	0.7807673	0.8164621	1	0.9705327	-0.0303619	0.8854761	0.9996554	0.81661	45	19
33	0.8894283	0.8844404	-0.0063407	0.8738893	0.8892517	0.9074852	0.8983465	-0.0112099	0.8731077	0.907184	0.9801	31	32
34	0.8640732	0.8588379	-0.0070548	0.8494141	0.863602	0.8825237	0.8740308	-0.0110104	0.8626043	0.8818269	0.97909	38	38
35	0.8204877	0.8166286	-0.0057595	0.8083199	0.8202482	0.8521257	0.8455942	-0.0090646	0.8399427	0.8509833	0.96287	44	45
36	0.9610009	0.9509543	-0.0109935	0.9170671	0.9608429	1	0.9839183	-0.0163445	0.9174154	0.9996395	0.961	21	12
37	0.9804415	0.9683228	-0.0127649	0.9395682	0.9799295	1	0.9826312	-0.0176758	0.9322829	0.9991963	0.98044	16	14
38	0.9747349	0.9689653	-0.0061087	0.9559183	0.9744636	0.9949857	0.9847174	-0.0104803	0.9459773	0.9943827	0.97965	15	11
39	0.9355162	0.9281594	-0.0084725	0.917613	0.9352616	1	0.9788595	-0.0215971	0.9130963	0.9988989	0.93552	25	16
40	0.7511157	0.7429728	-0.0145914	0.7181463	0.7509782	1	0.961459	-0.040086	0.877109	0.9994513	0.75112	47	24
41	0.8849228	0.8799602	-0.006373	0.8694625	0.8847471	1	0.8983463	-0.0454323	0.8652875	0.9993513	0.88492	32	33
42	0.8594069	0.8541998	-0.0070931	0.8448269	0.8589382	1	0.9566426	-0.0453225	0.8692431	0.9990843	0.85941	39	26
43	0.8088019	0.8049977	-0.0058427	0.7968073	0.8085658	0.8573426	0.8459664	-0.0156852	0.8224127	0.8565523	0.94338	46	44
44	0.9404751	0.930643	-0.0112335	0.8974797	0.9403205	1	0.9523881	-0.0499921	0.862964	0.9987	0.94048	24	28
45	0.9701476	0.9581561	-0.0129004	0.9297035	0.9696409	1	0.9630771	-0.0383385	0.8777784	0.9973516	0.97015	20	23
46	0.9649641	0.9592524	-0.0061706	0.9463361	0.9646956	1	0.9587865	-0.0429851	0.8661923	0.9992524	0.96496	19	25
47	0.9015773	0.8944875	-0.0087915	0.8843237	0.901332	1	0.9510375	-0.0514832	0.8647807	0.9988096	0.90158	26	29
48	0.6201239	0.6134011	-0.0176736	0.5929043	0.6200104	1	0.9536158	-0.0486404	0.8640996	0.9985836	0.62012	48	27

6500 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2050

BS Model	ENV Eff 2050	In: Fuel cost 2050, All emissions	Out: TEU-mile										
DMUs	result_crs. score	result_crs. score_bc	result_crs. bias	CI_low	CI_up	result_vrs. score	result_vrs. score_bc	result_vrs. bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.5425899	0.5367826	−0.0199393	0.5209424	0.5425346	0.5425986	0.5230669	−0.0688185	0.4505481	0.5423519	0.99998	42	46
2	0.5534137	0.5431527	−0.0341366	0.5045151	0.5533573	0.5534224	0.5225291	−0.106831	0.4530144	0.5530544	0.99998	37	47
3	0.6611429	0.6539437	−0.0166512	0.6390619	0.6610278	0.6611776	0.6427065	−0.0434671	0.5630613	0.6608796	0.99995	30	37
4	1	0.9508311	−0.0517115	0.814386	0.9991202	1	0.8492949	−0.1774473	0.686937	0.9987194	1	5	20
5	0.7849499	0.7771195	−0.0128367	0.7534148	0.7845692	0.784981	0.7638498	−0.0352417	0.6652924	0.7842175	0.99996	17	31
6	0.7771562	0.7697198	−0.0124314	0.7464113	0.7767813	0.7771882	0.7573438	−0.0337146	0.6588948	0.776406	0.99996	20	32
7	1	0.9828282	−0.0174718	0.9409452	0.9995307	1	0.937457	−0.0667156	0.7441888	0.9992418	1	1	9
8	1	0.9525355	−0.0498296	0.8117598	0.9995198	1	0.8705309	−0.1487243	0.6880573	0.9992466	1	4	17
9	0.541501	0.5357053	−0.0199794	0.5198969	0.5414457	0.5460732	0.5405901	−0.0185739	0.5273966	0.5459137	0.99163	43	45
10	0.5522304	0.5419913	−0.0342097	0.5034364	0.5521741	0.5568912	0.5487898	−0.0265085	0.5313259	0.556545	0.99163	38	41
11	0.6574756	0.6503164	−0.0167441	0.6355171	0.6573611	0.6752954	0.6665039	−0.0195328	0.65475	0.6749535	0.97361	31	36
12	0.9917897	0.9430244	−0.0521396	0.8076996	0.9909171	1	0.9578305	−0.044026	0.8453791	0.9986478	0.99179	6	6
13	0.7817178	0.7739196	−0.0128898	0.7503126	0.7813387	0.7975386	0.7890734	−0.0134514	0.7736351	0.7971767	0.98016	18	29
14	0.7740984	0.7666912	−0.0124806	0.7434745	0.773725	0.7901052	0.7817906	−0.0134608	0.766628	0.7894619	0.97974	21	30
15	0.9864245	0.9694858	−0.0177123	0.9281713	0.9859615	1	0.970336	−0.0305709	0.8809952	0.9973599	0.98642	2	1
16	0.9476033	0.9026258	−0.0525849	0.7692263	0.9471483	1	0.9205478	−0.0863097	0.7853962	0.9995017	0.9476	12	13
17	0.5401398	0.5343586	−0.0200298	0.51859	0.5400847	0.5505828	0.5455431	−0.0167785	0.5382548	0.5502941	0.98103	45	43
18	0.5507512	0.5405396	−0.0343016	0.5020879	0.5506951	0.5613935	0.5540368	−0.0236526	0.5409135	0.5608011	0.98104	39	39
19	0.6528914	0.6457822	−0.0168616	0.6310861	0.6527778	0.6879057	0.6822593	−0.0120308	0.6743801	0.6875258	0.9491	32	35
20	0.9815267	0.9332661	−0.0526848	0.7993416	0.9806632	1	0.9671319	−0.0339851	0.843451	0.9974589	0.98153	8	3
21	0.7776777	0.7699198	−0.0129568	0.7464348	0.7773006	0.8073807	0.7999838	−0.0114523	0.7898164	0.806565	0.96321	19	27
22	0.7702761	0.7629055	−0.0125425	0.7398034	0.7699045	0.8004694	0.7934388	−0.0110696	0.783684	0.7998688	0.96228	23	28
23	0.969455	0.9528078	−0.0180223	0.912204	0.9690001	1	0.9688479	−0.0321537	0.8770656	0.9985117	0.96946	3	2
24	0.8821074	0.8402387	−0.0564893	0.7160594	0.8816838	1	0.9378182	−0.0663047	0.7816406	0.9984926	0.88211	15	8
25	0.5387786	0.533012	−0.0200804	0.5172832	0.5387236	0.5552914	0.5504858	−0.0157211	0.5443752	0.5551505	0.97026	46	40
26	0.5492721	0.5390878	−0.034394	0.5007395	0.5492161	0.5660945	0.5575473	−0.02708	0.5286872	0.5654159	0.97028	40	38
27	0.6483073	0.6412479	−0.0169808	0.626655	0.6481945	0.6954847	0.6896923	−0.0120756	0.6751342	0.6948174	0.93217	33	33
28	0.9712638	0.9235078	−0.0532415	0.7909836	0.9704093	1	0.9589303	−0.0428286	0.8193398	0.9986612	0.97126	9	5
29	0.7736376	0.76592	−0.0130244	0.742557	0.7732624	0.8177916	0.8109013	−0.0103903	0.7967718	0.8172044	0.94601	22	23
30	0.7664538	0.7591198	−0.012605	0.7361323	0.766084	0.8109861	0.8043417	−0.0101859	0.7894544	0.8104192	0.94509	25	25
31	0.9524856	0.9361297	−0.0183434	0.8962368	0.9520386	1	0.9625648	−0.0388911	0.8441101	0.9995538	0.95249	7	4
32	0.8166115	0.7778515	−0.06102	0.6628925	0.8162194	1	0.9211709	−0.085575	0.7669895	0.9992629	0.81661	16	12
33	0.5374174	0.5316654	−0.0201312	0.5159763	0.5373626	0.5604233	0.5449236	−0.050754	0.4652638	0.5602066	0.95895	47	44
34	0.5477929	0.5376361	−0.0344868	0.499391	0.547737	0.5712179	0.5479184	−0.074444	0.4604455	0.5706155	0.95899	41	42
35	0.6437232	0.6367137	−0.0171018	0.622224	0.6436111	0.7004314	0.6860411	−0.029947	0.6309931	0.6996004	0.91904	34	34
36	0.9610009	0.9137495	−0.0538101	0.7826257	0.9601554	1	0.9352492	−0.0692338	0.7550964	0.9996072	0.961	11	10
37	0.7695975	0.7619202	−0.0130928	0.7386792	0.7692243	0.8244035	0.8064621	−0.0269857	0.7412738	0.8234663	0.93352	24	24
38	0.7626314	0.755334	−0.0126682	0.7324612	0.7622636	0.8178212	0.8003104	−0.026754	0.7371267	0.817231	0.93252	26	26
39	0.9355162	0.9194517	−0.0186761	0.8802695	0.9350771	1	0.9407324	−0.0630016	0.7691997	0.9993281	0.93552	10	7
40	0.7511157	0.7154644	−0.0663408	0.6097255	0.750755	1	0.9088392	−0.1003046	0.7462646	0.9994935	0.75112	29	14
41	0.534695	0.5289722	−0.0202337	0.5133625	0.5346405	1	0	Inf	0.6883508	0	0.5347	48	48
42	0.5448346	0.5347327	−0.0346741	0.4966941	0.544779	1	0.8543889	−0.1704272	0.6873923	0.9991904	0.54483	44	18
43	0.6345549	0.6276453	−0.0173489	0.613362	0.6344445	0.8573426	0.8113154	−0.0661715	0.6794708	0.8558829	0.74014	35	22
44	0.9404751	0.8942329	−0.0549845	0.7659097	0.9396476	1	0.8383937	−0.1927571	0.686116	0.9978672	0.94048	13	21
45	0.7615172	0.7539206	−0.0132317	0.7309236	0.761148	1	0.9252135	−0.0808316	0.7018295	0.9990686	0.76152	27	11
46	0.7549868	0.7477626	−0.0127965	0.725119	0.7546226	1	0.8763311	−0.1411212	0.6907678	0.9988401	0.75499	28	15
47	0.9015773	0.8860956	−0.0193792	0.8483349	0.9011542	1	0.8510397	−0.1750333	0.6884734	0.9977858	0.90158	14	19
48	0.6201239	0.5906901	−0.0803543	0.5033917	0.6198261	1	0.8728126	−0.1457213	0.6936065	0.9987854	0.62012	36	16

10500 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2021

10500		BS Model	ECO Eff 2021	In: Fuel cost 2021	Out: TEU-mile										
Day	Fuel	DMUs	result_crs.score	result_crs.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	result_vrs.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1 day	VLSFO	1	0.8979347	0.894155	−0.004708	0.8849549	0.8979007	0.8979366	0.8780392	−0.025237	0.8203496	0.8968934	1	13	16
	MGO	2	0.8197214	0.8162709	−0.005157	0.8078722	0.8196904	0.8197231	0.8015556	−0.02765	0.7488922	0.8187594	1	19	22
	Methanol	3	0.4262281	0.4244339	−0.009918	0.4200669	0.426212	0.4263628	0.4169251	−0.053092	0.3894834	0.4256748	0.99968	29	34
	Ammonia	4	0.4413278	0.4394701	−0.009578	0.4349483	0.4413111	0.4417272	0.4320374	−0.050774	0.4036026	0.4411045	0.9991	25	28
	LNG	5	1	0.9957907	−0.004227	0.9855448	0.9999622	1	0.9777265	−0.022781	0.9134005	0.9983864	1	1	5
	LPG	6	0.9532708	0.9492582	−0.004434	0.9394912	0.9532348	0.953271	0.932052	−0.023882	0.870735	0.9517714	1	7	10
	H2 Liq	7	0.1477454	0.1471235	−0.028611	0.1456097	0.1477398	0.1480543	0.1448598	−0.148949	0.1353326	0.1479383	0.99791	39	40
	H2 Gas	8	0.1592682	0.1585978	−0.026541	0.156966	0.1592622	0.1609664	0.1576959	−0.128846	0.1475809	0.1609292	0.98945	37	37
5 day	VLSFO	9	0.8963387	0.8925658	−0.004716	0.883382	0.8963048	0.8996385	0.8917336	−0.009854	0.8803408	0.899309	0.99633	14	15
	MGO	10	0.8181692	0.8147252	−0.005167	0.8063424	0.8181382	0.82118	0.8139641	−0.010796	0.803564	0.8208798	0.99633	20	21
	Methanol	11	0.4241345	0.4223492	−0.009966	0.4180036	0.4241185	0.4256861	0.4219417	−0.020847	0.416541	0.4255303	0.99636	31	30
	Ammonia	12	0.4381194	0.4362752	−0.009648	0.4317863	0.4381028	0.4397209	0.4358527	−0.020183	0.4302694	0.4395558	0.99636	26	25
	LNG	13	0.9963537	0.9921597	−0.004243	0.9819512	0.996316	1	0.9912026	−0.008875	0.9785227	0.9996393	0.99635	2	3
	LPG	14	0.9499493	0.9459506	−0.00445	0.9362176	0.9499133	0.9534276	0.9450411	−0.009308	0.9329527	0.9530859	0.99635	8	8
	H2 Liq	15	0.1459697	0.1453553	−0.028959	0.1438597	0.1459642	0.1465025	0.1452127	−0.060624	0.1433502	0.1464379	0.99636	40	39
	H2 Gas	16	0.1518884	0.151249	−0.02783	0.1496928	0.1518826	0.1524364	0.151078	−0.058987	0.1491309	0.1523344	0.99641	38	38
10 day	VLSFO	17	0.8943438	0.8905792	−0.004727	0.8814159	0.89431	0.901801	0.8949463	−0.008493	0.8870638	0.9014318	0.99173	15	13
	MGO	18	0.8162289	0.8127931	−0.005179	0.8044302	0.816198	0.8230314	0.8167751	−0.009307	0.809579	0.8227003	0.99173	21	19
	Methanol	19	0.4215175	0.4197432	−0.010028	0.4154244	0.4215016	0.4249981	0.4217652	−0.018036	0.4180268	0.4248485	0.99181	32	31
	Ammonia	20	0.4341089	0.4322816	−0.009737	0.4278338	0.4340925	0.4376813	0.4343577	−0.017482	0.4304922	0.4375213	0.99184	27	26
	LNG	21	0.9917958	0.987621	−0.004262	0.9774592	0.9917583	1	0.9923831	−0.007675	0.9836086	0.9996645	0.9918	3	1
	LPG	22	0.9457974	0.9418162	−0.004469	0.9321257	0.9457616	0.9536265	0.9463647	−0.008046	0.9380002	0.953305	0.99179	9	7
	H2 Liq	23	0.1437501	0.143145	−0.029406	0.1416721	0.1437446	0.1449248	0.1438267	−0.052683	0.1425351	0.1448744	0.99189	41	41
	H2 Gas	24	0.1426636	0.142063	−0.02963	0.1406013	0.1426582	0.1437646	0.1426715	−0.053292	0.1413215	0.1436574	0.99234	42	42
15 day	VLSFO	25	0.8923488	0.8885927	−0.004737	0.8794498	0.8923151	0.9040041	0.8970807	−0.008537	0.8833205	0.9035159	0.98711	16	12
	MGO	26	0.8142886	0.810861	−0.005191	0.8025179	0.8142578	0.8249176	0.8186028	−0.009351	0.8060518	0.824475	0.98712	22	18
	Methanol	27	0.4189006	0.4171373	−0.010091	0.4128453	0.4188847	0.4242966	0.4210681	−0.018071	0.4147251	0.4241099	0.98728	33	32
	Ammonia	28	0.4300985	0.428288	−0.009828	0.4238813	0.4300822	0.4356018	0.4322988	−0.01754	0.4258825	0.4354171	0.98737	28	27
	LNG	29	0.9872379	0.9830823	−0.004282	0.9729672	0.9872005	1	0.9923688	−0.00769	0.9772853	0.9995523	0.98724	4	2
	LPG	30	0.9416454	0.9376817	−0.004489	0.9280338	0.9416098	0.9538292	0.9465507	−0.008062	0.9321495	0.9533928	0.98723	10	6
	H2 Liq	31	0.1415305	0.1409347	−0.029867	0.1394846	0.1415251	0.1433163	0.1422372	−0.052936	0.1401916	0.143253	0.98754	43	43
	H2 Gas	32	0.1334387	0.132877	−0.031678	0.1315099	0.1334337	0.1349232	0.1339184	−0.055614	0.1324242	0.1347393	0.989	46	45
20 day	VLSFO	33	0.8903539	0.8866061	−0.004748	0.8774837	0.8903202	0.9062908	0.8938916	−0.015305	0.8633649	0.9057461	0.98242	17	14
	MGO	34	0.8123483	0.8089289	−0.005204	0.8006057	0.8123176	0.8268752	0.8156132	−0.016699	0.7878767	0.8263909	0.98243	23	20
	Methanol	35	0.4162836	0.4145313	−0.010154	0.4102661	0.4162678	0.423582	0.4182604	−0.030037	0.4057421	0.4233523	0.98277	35	33
	Ammonia	36	0.426088	0.4242944	−0.009921	0.4199288	0.4260719	0.4334832	0.4283105	−0.02786	0.415915	0.4331784	0.98294	30	29
	LNG	37	0.98268	0.9785436	−0.004302	0.9684752	0.9826428	1	0.9870486	−0.013121	0.9557082	0.9994616	0.98268	5	4
	LPG	38	0.9374935	0.9335473	−0.004509	0.9239419	0.937458	0.9540395	0.941639	−0.013804	0.9115317	0.9535289	0.98266	11	9
	H2 Liq	39	0.1393108	0.1387244	−0.030343	0.1372971	0.1393056	0.1416775	0.1401621	−0.076312	0.1361772	0.1415437	0.9833	44	44
	H2 Gas	40	0.1242139	0.1236911	−0.034031	0.1224184	0.1242092	0.1259155	0.1248987	−0.064655	0.122936	0.1257647	0.98649	47	47
30 day	VLSFO	41	0.886364	0.882633	−0.004769	0.8735515	0.8863305	1	0.720352	−0.38821	0.5335524	0.9964577	0.88636	18	24
	MGO	42	0.8084677	0.8050646	−0.005229	0.7967812	0.8084371	0.9071009	0.7279214	−0.271361	0.490737	0.9032841	0.89127	24	23
	Methanol	43	0.4110496	0.4093194	−0.010284	0.4051079	0.4110341	0.4221319	0.3930938	−0.174994	0.2949113	0.4212425	0.97375	36	36
	Ammonia	44	0.4180671	0.4163073	−0.010111	0.4120238	0.4180512	0.4291842	0.4076836	−0.122881	0.3668763	0.4284284	0.9741	34	35
	LNG	45	0.9735642	0.9694662	−0.004342	0.9594912	0.9735274	1	0.9063362	−0.103343	0.647079	0.9973327	0.97356	6	11
	LPG	46	0.9291896	0.9252784	−0.004549	0.9157581	0.9291545	0.9626602	0.8638644	−0.118801	0.6197302	0.9595432	0.96523	12	17
	H2 Liq	47	0.1348716	0.1343039	−0.031342	0.132922	0.1348665	0.1383522	0.1328492	−0.299404	0.1219883	0.1381462	0.97484	45	46
	H2 Gas	48	0.1057643	0.1053191	−0.039967	0.1042355	0.1057603	0.1076375	0.1062226	−0.123749	0.1027685	0.1075833	0.9826	48	48

10500 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2050

BS Model	ECO Eff 2050	In: Fuel cost 2050	Out: TEU-mile										
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.5424937	0.5379026	−0.015733	0.5283632	0.5424558	0.5425006	0.5063711	−0.13152	0.3911036	0.5421786	0.99999	25	31
2	0.5533177	0.548635	−0.015425	0.5389052	0.553279	0.5533245	0.5164715	−0.128958	0.3989044	0.5529877	0.99999	19	30
3	0.464697	0.4607643	−0.018367	0.4525928	0.4646645	0.4646995	0.4336321	−0.154174	0.3349582	0.4641805	0.99999	32	40
4	1	0.991537	−0.008535	0.9739526	0.99993	1	0.9328255	−0.072012	0.7206641	0.998697	1	1	5
5	0.6185501	0.6133154	−0.013799	0.6024385	0.6185069	0.6185553	0.5772855	−0.115575	0.4458887	0.6179991	0.99999	7	19
6	0.6077394	0.6025961	−0.014044	0.5919093	0.6076969	0.6077446	0.5672043	−0.117605	0.4380996	0.6072229	0.99999	12	20
7	0.4419852	0.4382447	−0.019311	0.4304726	0.4419543	0.4425089	0.4128943	−0.162086	0.3189205	0.4420933	0.99882	39	44
8	0.4864249	0.4823084	−0.017547	0.4737548	0.4863909	0.491167	0.4587039	−0.144089	0.3540746	0.490711	0.99035	31	36
9	0.5415295	0.5369466	−0.015761	0.5274241	0.5414916	0.545565	0.53978	−0.019644	0.531535	0.5452386	0.9926	26	28
10	0.5522699	0.5475961	−0.015455	0.5378847	0.5522313	0.5563839	0.5504837	−0.019264	0.5420747	0.5560518	0.99261	20	23
11	0.4624144	0.458501	−0.018458	0.4503697	0.4623821	0.4658264	0.4608618	−0.023126	0.4538237	0.4655218	0.99268	34	35
12	0.9927302	0.9843287	−0.008598	0.9668721	0.9926607	1	0.9892726	−0.010844	0.9741958	0.999343	0.99273	2	2
13	0.6162947	0.611079	−0.013849	0.6002418	0.6162516	0.6208604	0.6142623	−0.017301	0.6048756	0.6204554	0.99265	8	13
14	0.6056218	0.6004964	−0.014093	0.5898469	0.6055794	0.6101107	0.6036286	−0.017601	0.5944042	0.6097129	0.99264	13	17
15	0.4366731	0.4329776	−0.019546	0.4252989	0.4366426	0.4398661	0.4351118	−0.024841	0.428523	0.4394118	0.99274	40	39
16	0.463886	0.4599601	−0.018399	0.4518029	0.4638535	0.4672392	0.4618456	−0.024994	0.4552484	0.4668873	0.99282	33	33
17	0.5403243	0.5357515	−0.015796	0.5262502	0.5402865	0.5495248	0.5444384	−0.017001	0.5356665	0.5492765	0.98326	27	26
18	0.5509602	0.5462974	−0.015491	0.5366091	0.5509217	0.5603373	0.5551537	−0.016664	0.5462039	0.5600889	0.98327	21	21
19	0.4595613	0.455672	−0.018572	0.4475909	0.4595291	0.4672826	0.4630069	−0.019762	0.4566033	0.4669809	0.98348	35	32
20	0.9836429	0.9753184	−0.008677	0.9580216	0.9835741	1	0.9908191	−0.009266	0.9787556	0.9992314	0.98364	3	1
21	0.6134754	0.6082836	−0.013913	0.597496	0.6134325	0.6238391	0.6181089	−0.01486	0.6092533	0.6234894	0.98339	9	11
22	0.6029748	0.5978719	−0.014155	0.5872689	0.6029326	0.6131681	0.6075327	−0.015128	0.5986975	0.6128311	0.98338	14	15
23	0.4300331	0.4263937	−0.019848	0.4188318	0.430003	0.4371345	0.4331817	−0.020875	0.4278524	0.4367657	0.98375	42	41
24	0.4357122	0.4320248	−0.019589	0.4243631	0.4356818	0.4425082	0.4385145	−0.020581	0.4330324	0.4420867	0.98464	41	38
25	0.539119	0.5345565	−0.015832	0.5250764	0.5390813	0.5536381	0.5443643	−0.030771	0.4889144	0.5528878	0.97378	28	27
26	0.5496505	0.5449988	−0.015528	0.5353335	0.549612	0.5644438	0.5550037	−0.030134	0.498489	0.5636833	0.97379	22	22
27	0.4567081	0.452843	−0.018689	0.444812	0.4566762	0.4687952	0.4611293	−0.035461	0.4147084	0.4683858	0.97422	36	34
28	0.9745556	0.966308	−0.008758	0.949171	0.9744875	1	0.9836247	−0.016648	0.8857902	0.998871	0.97456	4	3
29	0.6106561	0.6054882	−0.013977	0.5947501	0.6106134	0.6269331	0.616665	−0.02656	0.5542175	0.6263971	0.97404	10	12
30	0.6003278	0.5952473	−0.014218	0.5846908	0.6002858	0.6163439	0.6062377	−0.027047	0.5448087	0.6158184	0.97401	16	16
31	0.4233931	0.4198099	−0.020159	0.4123648	0.4233634	0.4342941	0.4272924	−0.03773	0.3858595	0.4339625	0.9749	43	42
32	0.4075385	0.4040895	−0.020943	0.3969232	0.40751	0.4167918	0.4109354	−0.034193	0.3807494	0.4160586	0.9778	45	45
33	0.5379137	0.5333614	−0.015867	0.5239025	0.5378761	0.5580751	0.5360246	−0.073713	0.4197751	0.5575518	0.96387	29	29
34	0.5483408	0.5437002	−0.015565	0.5340579	0.5483024	0.5688735	0.5466049	−0.071615	0.4279318	0.5683263	0.96391	23	25
35	0.4538549	0.450014	−0.018806	0.4420332	0.4538232	0.4704269	0.4541136	−0.076363	0.3546285	0.4696976	0.96477	37	37
36	0.9654684	0.9572976	−0.00884	0.9403204	0.9654008	1	0.9663778	−0.034792	0.7551441	0.9986393	0.96547	5	4
37	0.6078369	0.6026928	−0.014042	0.5920043	0.6077943	0.6302707	0.6079318	−0.058301	0.4746976	0.6294683	0.96441	11	14
38	0.5976808	0.5926227	−0.014281	0.5821128	0.597639	0.6197698	0.5977063	−0.05956	0.4667354	0.6190051	0.96436	17	18
39	0.416753	0.413226	−0.02048	0.4058977	0.4167239	0.4313436	0.4178365	−0.074943	0.3274171	0.4306542	0.96617	44	43
40	0.3793648	0.3761542	−0.022499	0.3694833	0.3793382	0.390079	0.382621	−0.049969	0.3333182	0.3894354	0.97253	47	46
41	0.5355032	0.5309713	−0.015939	0.5215548	0.5354658	1	0.737967	−0.355074	0.6005024	0.9975899	0.5355	30	10
42	0.5457214	0.5411029	−0.01564	0.5315067	0.5456832	1	0.8070043	−0.239151	0.6407156	0.9935743	0.54572	24	8
43	0.4481486	0.4443559	−0.019045	0.4364755	0.4481173	0.6292295	0.549321	−0.231184	0.4377971	0.6265827	0.71222	38	24
44	0.9472938	0.9392769	−0.00901	0.9226193	0.9472275	1	0.7855647	−0.27297	0.6521315	0.9982267	0.94729	6	9
45	0.6021983	0.5971019	−0.014173	0.5865126	0.6021562	0.9551019	0.8529101	−0.125448	0.667165	0.9523592	0.63051	15	6
46	0.5923869	0.5873735	−0.014408	0.5769567	0.5923454	0.9531882	0.8479905	−0.130148	0.6643651	0.9518198	0.62148	18	7
47	0.4034729	0.4000584	−0.021154	0.3929635	0.4034447	0.4252598	0.3481358	−0.520938	0.2884066	0.4244761	0.94877	46	47
48	0.3230173	0.3202836	−0.026423	0.3146035	0.3229947	0.3349971	0.3228317	−0.112489	0.2522047	0.3346178	0.96424	48	48

10500 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2021

BS Model	ENV Eff 2021	In: Fuel cost 2021, All emissions	Out: TEU-mile										
DMUs	result_crs.score	result_crs.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	result_vrs.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.8979347	0.8924064	−0.006899	0.8826131	0.8977254	0.8979366	0.882375	−0.019641	0.8277807	0.8977452	1	27	37
2	0.8728847	0.8685896	−0.005665	0.8586426	0.8726708	0.8728866	0.8597514	−0.017503	0.7969351	0.8723729	1	34	42
3	0.8425103	0.8381107	−0.006231	0.8308357	0.8419267	0.8425167	0.8330351	−0.01351	0.8007354	0.8420804	0.99999	40	48
4	1	0.9909857	−0.009096	0.9696934	0.9995341	1	0.9534894	−0.048779	0.8619065	0.9987876	1	2	27
5	1	0.9885005	−0.011633	0.9616454	0.9995576	1	0.9663495	−0.034822	0.8739988	0.9989526	1	3	22
6	0.9932832	0.9873747	−0.006025	0.9721994	0.9929723	0.9932838	0.9738051	−0.020138	0.8849045	0.9928373	1	5	17
7	1	0.9912388	−0.008839	0.9784694	0.9993598	1	0.9724311	−0.028351	0.879809	0.9992405	1	1	18
8	1	0.9883433	−0.011794	0.9550828	0.9993982	1	0.9525815	−0.049779	0.8663779	0.9990709	1	4	29
9	0.8963387	0.8908203	−0.006911	0.8810444	0.8961298	0.8996385	0.8933373	−0.00784	0.8845777	0.8992857	0.99633	28	36
10	0.8712318	0.8669448	−0.005676	0.8570167	0.8710183	0.8746027	0.868082	−0.008589	0.8588334	0.8738847	0.99615	35	41
11	0.838372	0.833994	−0.006262	0.8267548	0.8377913	0.8474175	0.8420719	−0.007491	0.835236	0.8459996	0.98933	41	47
12	0.9927302	0.9837814	−0.009163	0.9626439	0.9922676	1	0.9830767	−0.017215	0.9451408	0.9992868	0.99273	8	13
13	0.9963537	0.9848961	−0.011676	0.958139	0.9959129	1	0.9890006	−0.011122	0.9690884	0.9993339	0.99635	6	2
14	0.9898223	0.9839343	−0.006046	0.9688119	0.9895124	0.9937131	0.9867507	−0.007101	0.9701701	0.9933962	0.99608	7	9
15	0.9879814	0.9793255	−0.008946	0.9667096	0.9873489	1	0.9813637	−0.01899	0.9487987	0.9993074	0.98798	11	14
16	0.953664	0.9425475	−0.012367	0.910828	0.9530901	1	0.9652716	−0.035978	0.8911654	0.9991316	0.95366	23	23
17	0.8943438	0.8888376	−0.006927	0.8790835	0.8941353	0.901801	0.8958351	−0.007385	0.8868787	0.9013511	0.99173	29	35
18	0.8691656	0.8648888	−0.005689	0.8549842	0.8689526	0.8767843	0.8708587	−0.00776	0.8648009	0.8761085	0.99131	36	40
19	0.8331992	0.8288481	−0.0063	0.8216536	0.832622	0.8484147	0.8426521	−0.00806	0.8368488	0.8473855	0.98207	42	46
20	0.9836429	0.974776	−0.009248	0.9538321	0.9831846	1	0.9880393	−0.012106	0.9589517	0.9995066	0.98364	14	4
21	0.9917958	0.9803906	−0.011729	0.9537559	0.991357	1	0.9893921	−0.010722	0.9777532	0.9994164	0.9918	9	1
22	0.9854961	0.9796338	−0.006072	0.9645775	0.9851876	0.9940749	0.9874204	−0.006779	0.9782395	0.9933715	0.99137	10	6
23	0.9729582	0.9644339	−0.009084	0.9520098	0.9723353	1	0.9831485	−0.01714	0.9600929	0.9987093	0.97296	18	12
24	0.895744	0.8853026	−0.013167	0.8555097	0.895205	1	0.971189	−0.029666	0.9068333	0.9991459	0.89574	31	20
25	0.8923488	0.8868549	−0.006942	0.8771226	0.8921408	0.9040041	0.8976362	−0.007847	0.8847273	0.9033646	0.98711	30	34
26	0.8670995	0.8628329	−0.005703	0.8529518	0.866887	0.879008	0.8731921	−0.007577	0.8631474	0.8782101	0.98645	37	39
27	0.8280263	0.8237022	−0.00634	0.8165524	0.8274527	0.8512131	0.8467043	−0.006256	0.8418845	0.8508732	0.97276	44	44
28	0.9745556	0.9657707	−0.009334	0.9450202	0.9741015	1	0.9873449	−0.012817	0.9629018	0.9998203	0.97456	17	7
29	0.9872379	0.9758852	−0.011784	0.9493728	0.9868012	1	0.9888103	−0.011316	0.9636274	0.9991487	0.98724	12	3
30	0.9811699	0.9753334	−0.006099	0.9603431	0.9808627	0.9944413	0.9880366	−0.006518	0.9782676	0.9937598	0.98665	13	5
31	0.957935	0.9495423	−0.009227	0.93731	0.9573217	1	0.9842306	−0.016022	0.9390924	0.9989298	0.95794	22	11
32	0.837824	0.8280578	−0.014077	0.8001913	0.8373198	1	0.9712215	−0.029631	0.8941785	0.9994982	0.83782	43	19
33	0.8903539	0.8848723	−0.006958	0.8751617	0.8901463	0.9062908	0.8984146	−0.009673	0.8816999	0.9056645	0.98242	32	33
34	0.8650334	0.8607769	−0.005716	0.8509194	0.8648214	0.8813171	0.8740469	−0.009438	0.8583396	0.8809662	0.98152	38	38
35	0.8228534	0.8185564	−0.00638	0.8114512	0.8222834	0.8521375	0.846757	−0.007457	0.8403854	0.8516594	0.96563	45	43
36	0.9654684	0.9567653	−0.009422	0.9362083	0.9650185	1	0.9797168	−0.020703	0.911795	0.9995609	0.96547	21	15
37	0.98268	0.9713797	−0.011838	0.9449897	0.9822453	1	0.985198	−0.015024	0.9480579	0.9989902	0.98268	15	10
38	0.9768437	0.9710329	−0.006126	0.9561087	0.9765379	0.9948336	0.9868047	−0.008179	0.9741871	0.9945766	0.98192	16	8
39	0.9429117	0.9346507	−0.009374	0.9226103	0.9423081	1	0.9780335	−0.02246	0.9173328	0.9980492	0.94291	25	16
40	0.779904	0.7708129	−0.015123	0.7448729	0.7794347	1	0.9595234	−0.042184	0.876	0.9995682	0.7799	47	24
41	0.886364	0.880907	−0.006989	0.8712399	0.8861574	1	0.898416	−0.049389	0.8647149	0.9985682	0.88636	33	32
42	0.8609011	0.856665	−0.005744	0.8468546	0.8606901	1	0.9529352	−0.049389	0.8669482	0.9997342	0.8609	39	28
43	0.8125076	0.8082646	−0.006461	0.8012488	0.8119448	0.8573426	0.8458721	−0.015817	0.8321485	0.8567874	0.9477	46	45
44	0.9472938	0.9387546	−0.009602	0.9185846	0.9468524	1	0.9593766	−0.042344	0.8670788	0.9992659	0.94729	24	25
45	0.9735642	0.9623687	−0.011949	0.9362236	0.9731335	1	0.9685614	−0.032459	0.8822594	0.9991991	0.97356	20	21
46	0.9681913	0.962432	−0.006181	0.94764	0.9678882	1	0.9554923	−0.046581	0.86307	0.9987356	0.96819	19	26
47	0.9128653	0.9048675	−0.009682	0.8932107	0.9122809	1	0.9480374	−0.054811	0.8619995	0.999622	0.91287	26	30
48	0.664064	0.6563232	−0.017761	0.6342361	0.6636644	1	0.9436851	−0.059676	0.8613141	0.9994003	0.66406	48	31

10500 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2050

BS Model	ENV Eff 2050	In: Fuel cost 2050, All emissions	Out: TEU-mile										
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.5424937	0.5368503	−0.019378	0.5247232	0.5422105	0.5425006	0.5208447	−0.076642	0.4452386	0.5423309	0.99999	43	47
2	0.5533177	0.5447413	−0.028454	0.5273589	0.552734	0.5533245	0.5117463	−0.146835	0.4505002	0.5530002	0.99999	37	48
3	0.6607594	0.6539126	−0.015846	0.6390366	0.6603021	0.6607865	0.6382197	−0.053511	0.5490158	0.6598234	0.99996	30	38
4	1	0.967326	−0.033778	0.825698	0.9983846	1	0.8420092	−0.187636	0.6882652	0.9994503	1	3	19
5	0.7846063	0.7772189	−0.012114	0.7614419	0.7841496	0.7846307	0.7610658	−0.039462	0.6394036	0.7843624	0.99997	17	32
6	0.776803	0.7697076	−0.011867	0.7543154	0.7762728	0.7768281	0.7547268	−0.037697	0.6331993	0.7764712	0.99997	20	33
7	1	0.9814563	−0.018894	0.9480286	0.9989711	1	0.9117107	−0.096839	0.6928026	0.9985001	1	1	12
8	1	0.9613501	−0.040204	0.8191135	0.9988387	1	0.8452773	−0.183044	0.6881797	0.9991288	1	4	18
9	0.5415295	0.5358961	−0.019412	0.5237906	0.5412468	0.545565	0.5394263	−0.020859	0.5282396	0.5451398	0.9926	44	46
10	0.5522699	0.5437098	−0.028508	0.5263603	0.5516873	0.5563839	0.5475135	−0.029119	0.5267119	0.5558777	0.99261	38	42
11	0.6575138	0.6507007	−0.015924	0.6358977	0.6570588	0.6731981	0.6651276	−0.018024	0.6505485	0.6728741	0.9767	31	37
12	0.9927302	0.9602937	−0.034025	0.8196954	0.9911265	1	0.9542676	−0.047924	0.8458517	0.9986542	0.99273	5	4
13	0.7817454	0.774385	−0.012159	0.7586654	0.7812904	0.7956837	0.7867345	−0.014296	0.7692996	0.7947188	0.98248	18	30
14	0.7740964	0.7670257	−0.011909	0.7516871	0.773568	0.7881966	0.7795164	−0.014128	0.7625667	0.7872713	0.98211	22	31
15	0.9879814	0.9696606	−0.019124	0.9366346	0.9869649	1	0.9659477	−0.035253	0.852996	0.9991527	0.98798	2	1
16	0.953664	0.9168049	−0.042157	0.781159	0.9525565	1	0.9176859	−0.089697	0.7668901	0.998452	0.95366	12	10
17	0.5403243	0.5347034	−0.019455	0.5226248	0.5400422	0.5495248	0.5436262	−0.019745	0.5357338	0.5492884	0.98326	45	44
18	0.5509602	0.5424204	−0.028575	0.5251121	0.550379	0.5603373	0.5526868	−0.024704	0.5169993	0.5600174	0.98327	39	40
19	0.6534568	0.6466858	−0.016023	0.6319742	0.6530047	0.6854689	0.6801925	−0.011317	0.6696119	0.6852335	0.9533	32	36
20	0.9836429	0.9515034	−0.034339	0.812192	0.9820539	1	0.9627827	−0.038656	0.8378582	0.9975335	0.98364	7	2
21	0.7781693	0.7708425	−0.012214	0.7551949	0.7777163	0.8044527	0.7965941	−0.012263	0.783162	0.8033444	0.96733	19	28
22	0.770713	0.7636732	−0.011961	0.7484017	0.770187	0.7975048	0.7900457	−0.011839	0.7773397	0.7968344	0.96641	24	29
23	0.9729582	0.954916	−0.019419	0.9223922	0.9719571	1	0.9617755	−0.039744	0.8480193	0.9983924	0.97296	6	3
24	0.895744	0.8611235	−0.044883	0.733716	0.8947038	1	0.9153077	−0.092529	0.7483097	0.9993935	0.89574	15	11
25	0.539119	0.5335106	−0.019499	0.521459	0.5388375	0.5536381	0.5470475	−0.021761	0.5229613	0.5533489	0.97378	46	43
26	0.5496505	0.541131	−0.028644	0.5238638	0.5490707	0.5644438	0.554716	−0.031069	0.5003416	0.5641402	0.97379	40	39
27	0.6493999	0.6426709	−0.016123	0.6280506	0.6489505	0.6938974	0.6883781	−0.011555	0.6809247	0.6928933	0.93587	33	34
28	0.9745556	0.942713	−0.03466	0.8046887	0.9729813	1	0.9537632	−0.048478	0.7705343	0.9988661	0.97456	8	5
29	0.7745931	0.7673	−0.012271	0.7517243	0.7741422	0.8156668	0.8083245	−0.011136	0.7966271	0.8152252	0.94964	21	24
30	0.7673297	0.7603208	−0.012014	0.7451163	0.766806	0.8087898	0.801884	−0.010648	0.7924445	0.8086676	0.94874	25	26
31	0.957935	0.9401713	−0.019724	0.9081497	0.9569493	1	0.9505205	−0.052055	0.8382047	0.9993831	0.95794	9	6
32	0.837824	0.8054422	−0.047986	0.6862729	0.8368511	1	0.9115944	−0.096979	0.7281363	0.9984266	0.83782	16	13
33	0.5379137	0.5323179	−0.019543	0.5202932	0.5376329	0.5580751	0.5420382	−0.053015	0.4682068	0.5573454	0.96387	47	45
34	0.5483408	0.5398415	−0.028712	0.5226155	0.5477623	0.5688735	0.5476567	−0.068101	0.4741996	0.5683807	0.96391	41	41
35	0.6453429	0.6386559	−0.016225	0.624127	0.6448964	0.6981642	0.6848872	−0.027767	0.6424021	0.6975495	0.92434	34	35
36	0.9654684	0.9339227	−0.034986	0.7971853	0.9639087	1	0.9364719	−0.067838	0.7507189	0.9976116	0.96547	10	7
37	0.771017	0.7637575	−0.012328	0.7482537	0.7705681	0.8213749	0.8038221	−0.026586	0.7399559	0.8206226	0.93869	23	25
38	0.7639464	0.7569684	−0.012067	0.7418309	0.7634249	0.8146902	0.7976953	−0.026151	0.7348978	0.8139648	0.93771	26	27
39	0.9429117	0.9254267	−0.020038	0.8939073	0.9419416	1	0.9189307	−0.088221	0.7539288	0.9996267	0.94291	11	9
40	0.779904	0.7497608	−0.05155	0.6388299	0.7789983	1	0.8918647	−0.121246	0.7101416	0.9988276	0.7799	29	15
41	0.5355032	0.5299325	−0.019631	0.5179617	0.5352236	1	0.8580631	−0.165415	0.6870398	0.9993972	0.5355	48	16
42	0.5457214	0.5372627	−0.02885	0.520119	0.5451457	1	0.838335	−0.192841	0.6869459	0.9978519	0.54572	42	20
43	0.637229	0.6306261	−0.016431	0.6162798	0.6367881	0.8573426	0.8171213	−0.057414	0.6586512	0.8568939	0.74326	36	23
44	0.9472938	0.916342	−0.035657	0.7821786	0.9457635	1	0.8500404	−0.176415	0.6865222	0.9992225	0.94729	13	17
45	0.7638647	0.7566726	−0.012443	0.7413126	0.76342	1	0.9359989	−0.068377	0.7618207	0.9975454	0.76386	27	8
46	0.7571797	0.7502635	−0.012175	0.7352602	0.7566629	1	0.8943407	−0.118142	0.7033539	0.9985623	0.75718	28	14
47	0.9128653	0.8959374	−0.020698	0.8654224	0.911926	1	0.8302718	−0.204425	0.6856507	0.9984222	0.91287	14	22
48	0.664064	0.638398	−0.060542	0.5439438	0.6632929	1	0.8319355	−0.202016	0.6865578	0.9975826	0.66406	35	21

14500 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2021

14500		BS Model	ECO Eff 2021	In: Fuel cost 2021	Out: TEU-mile										
Day	Fuel	DMUs	result_crs .score	result_crs .score_bc	result_crs .bias	CI_low	CI_up	result_vrs .score	result_vrs .score_bc	result_vrs .bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1 day	VLSFO	1	0.8979226	0.8945018	−0.004259	0.8885998	0.8977899	0.8979244	0.8779649	−0.025318	0.8194388	0.8971937	1	13	17
	MGO	2	0.8197111	0.8165882	−0.004665	0.8112003	0.81959	0.8197126	0.8014869	−0.027741	0.7480613	0.8190335	1	19	22
	Methanol	3	0.426232	0.4246081	−0.008972	0.4218065	0.426169	0.4263628	0.41688	−0.053352	0.3891665	0.4259524	0.99969	30	34
	Ammonia	4	0.4413393	0.4396579	−0.008665	0.436757	0.441274	0.4417272	0.4319789	−0.051087	0.4033115	0.4413684	0.99912	25	28
	LNG	5	1	0.9961902	−0.003824	0.9896173	0.9998522	1	0.9776321	−0.02288	0.9125532	0.9990373	1	1	5
	LPG	6	0.9532697	0.949638	−0.004012	0.9433722	0.9531288	0.9532699	0.931962	−0.023984	0.8699127	0.9523686	1	7	10
	H2 Liq	7	0.1477543	0.1471914	−0.025883	0.1462202	0.1477324	0.1480543	0.1448224	−0.15073	0.1352357	0.1479341	0.99797	39	40
	H2 Gas	8	0.1593171	0.1587101	−0.024005	0.157663	0.1592936	0.1609664	0.1575712	−0.133861	0.1470299	0.1608357	0.98975	37	37
5 day	VLSFO	9	0.8963726	0.8929576	−0.004266	0.8870658	0.8962402	0.8995766	0.8910197	−0.010676	0.8806628	0.8990561	0.99644	14	15
	MGO	10	0.8182035	0.8150864	−0.004674	0.8097084	0.8180826	0.8211271	0.8133159	−0.011696	0.803859	0.8206527	0.99644	20	21
	Methanol	11	0.4241986	0.4225825	−0.009015	0.4197943	0.424136	0.4257056	0.4216517	−0.022585	0.4167001	0.4254733	0.99646	31	31
	Ammonia	12	0.4382232	0.4365537	−0.008727	0.4336733	0.4381585	0.4397789	0.4355911	−0.021861	0.430438	0.4395343	0.99646	26	25
	LNG	13	0.9964586	0.9926624	−0.003838	0.9861127	0.9963114	1	0.990476	−0.009616	0.9788914	0.9994597	0.99646	2	3
	LPG	14	0.9500438	0.9464243	−0.004025	0.9401798	0.9499034	0.9534219	0.9443425	−0.010084	0.9333035	0.9529033	0.99646	8	8
	H2 Liq	15	0.1460297	0.1454734	−0.026189	0.1445135	0.1460081	0.1465473	0.1451511	−0.065639	0.1434093	0.1464627	0.99647	40	39
	H2 Gas	16	0.1521497	0.15157	−0.025135	0.15057	0.1521272	0.1526831	0.1512147	−0.063599	0.149283	0.152597	0.99651	38	38
10 day	VLSFO	17	0.8944351	0.8910275	−0.004276	0.8851484	0.8943029	0.9016749	0.8945281	−0.008861	0.8878843	0.9007525	0.99197	15	13
	MGO	18	0.8163191	0.8132091	−0.004685	0.8078435	0.8161985	0.8229235	0.8164001	−0.00971	0.8103362	0.8220843	0.99197	21	19
	Methanol	19	0.421657	0.4200506	−0.00907	0.4172791	0.4215947	0.4250379	0.4216655	−0.018817	0.4185327	0.4246431	0.99205	32	30
	Ammonia	20	0.4343282	0.4326735	−0.008805	0.4298187	0.434264	0.4377992	0.4343303	−0.018243	0.4310894	0.4374165	0.99207	27	26
	LNG	21	0.9920319	0.9882525	−0.003855	0.981732	0.9918854	1	0.9920563	−0.008007	0.9846836	0.9990215	0.99203	3	2
	LPG	22	0.9460114	0.9424073	−0.004043	0.9361892	0.9458716	0.9536149	0.9460414	−0.008395	0.9390107	0.9526849	0.99203	9	7
	H2 Liq	23	0.143874	0.1433258	−0.026581	0.1423802	0.1438527	0.145016	0.1438683	−0.055012	0.1427871	0.1448825	0.99213	41	41
	H2 Gas	24	0.1431904	0.1426449	−0.026708	0.1417037	0.1431692	0.144266	0.1431117	−0.055906	0.1419985	0.1440735	0.99254	42	42
15 day	VLSFO	25	0.8924976	0.8890974	−0.004285	0.883231	0.8923657	0.9038116	0.8966317	−0.00886	0.8835875	0.9024669	0.98748	16	12
	MGO	26	0.8144347	0.8113318	−0.004696	0.8059786	0.8143143	0.8247527	0.8182026	−0.009706	0.8062993	0.8235266	0.98749	22	18
	Methanol	27	0.4191154	0.4175186	−0.009125	0.4147638	0.4190534	0.4243574	0.4210077	−0.018749	0.4149023	0.4237581	0.98765	33	32
	Ammonia	28	0.4304332	0.4287933	−0.008885	0.4259641	0.4303696	0.435782	0.4323642	−0.018139	0.4261238	0.4351981	0.98773	28	27
	LNG	29	0.9876053	0.9838427	−0.003872	0.9773512	0.9874593	1	0.9920654	−0.007998	0.9776562	0.9984472	0.98761	4	1
	LPG	30	0.941979	0.9383902	−0.00406	0.9321987	0.9418398	0.9538115	0.9462429	−0.008386	0.932497	0.9523329	0.98759	10	6
	H2 Liq	31	0.1417183	0.1411783	−0.026986	0.1402468	0.1416973	0.1434556	0.142344	−0.05444	0.1403113	0.1432619	0.98789	43	43
	H2 Gas	32	0.1342311	0.1337197	−0.028491	0.1328374	0.1342113	0.1356892	0.1346661	−0.055987	0.1333194	0.1356151	0.98925	46	45
20 day	VLSFO	33	0.8905601	0.8871672	−0.004294	0.8813136	0.8904285	0.9060268	0.8944342	−0.014305	0.8651879	0.905714	0.98293	17	14
	MGO	34	0.8125502	0.8094546	−0.004707	0.8041137	0.8124301	0.8266492	0.8161108	−0.015621	0.7894226	0.8263708	0.98294	23	20
	Methanol	35	0.4165737	0.4149867	−0.00918	0.4122486	0.4165122	0.4236645	0.4186736	−0.028137	0.4050852	0.42344	0.98326	35	33
	Ammonia	36	0.4265382	0.4249132	−0.008966	0.4221095	0.4264751	0.4337279	0.4289164	−0.025863	0.4151563	0.4334727	0.98342	29	29
	LNG	37	0.9831786	0.9794329	−0.00389	0.9729705	0.9830333	1	0.9878166	−0.012334	0.9556022	0.9994914	0.98318	5	4
	LPG	38	0.9379465	0.9343732	−0.004077	0.9282081	0.9378079	0.9540152	0.9423493	−0.012976	0.9116025	0.9535458	0.98316	11	9
	H2 Liq	39	0.1395625	0.1390308	−0.027402	0.1381135	0.1395419	0.1418668	0.1404764	−0.069767	0.1364652	0.14178	0.98376	44	44
	H2 Gas	40	0.1252719	0.1247946	−0.030528	0.1239712	0.1252533	0.1269558	0.1259155	−0.065074	0.1240899	0.1267438	0.98674	47	47
30 day	VLSFO	41	0.886685	0.883307	−0.004313	0.8774788	0.886554	1	0.7466066	−0.339393	0.5358408	0.996866	0.88669	18	24
	MGO	42	0.8087813	0.8057001	−0.004729	0.800384	0.8086618	0.9071009	0.7700357	−0.196228	0.4909731	0.9047382	0.89161	24	23
	Methanol	43	0.4114904	0.4099227	−0.009294	0.407218	0.4114296	0.4222592	0.3997557	−0.133314	0.3631528	0.4218851	0.9745	36	36
	Ammonia	44	0.4187481	0.4171528	−0.009133	0.4144004	0.4186862	0.4295616	0.4114518	−0.102463	0.3840772	0.429114	0.97483	34	35
	LNG	45	0.9743252	0.9706132	−0.003925	0.964209	0.9741812	1	0.9251821	−0.080868	0.6684399	0.9985556	0.97433	6	11
	LPG	46	0.9298817	0.9263391	−0.004113	0.920227	0.9297443	0.9626602	0.8811539	−0.096087	0.6391446	0.9600265	0.96595	12	16
	H2 Liq	47	0.1352511	0.1347358	−0.028276	0.1338468	0.1352311	0.1386441	0.1339305	−0.25385	0.1254139	0.1384556	0.97553	45	46
	H2 Gas	48	0.1073533	0.1069443	−0.035624	0.1062387	0.1073374	0.1092422	0.1077673	−0.125283	0.1041778	0.109171	0.98271	48	48

14500 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2050

BS Model	ECO Eff 2050	In: Fuel cost 2050	Out: TEU-mile										
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.542472	0.539214	−0.01114	0.530403	0.54226	0.542479	0.504014	−0.14068	0.391665	0.542091	1	25	31
2	0.553296	0.549973	−0.01092	0.540986	0.55308	0.553303	0.514068	−0.13794	0.399477	0.5529	1	19	30
3	0.464689	0.461898	−0.013	0.45435	0.464508	0.464692	0.431622	−0.16488	0.33545	0.464097	1	32	41
4	1	0.993994	−0.00604	0.977751	0.999609	1	0.928563	−0.07693	0.721793	0.998147	1	1	5
5	0.618534	0.614819	−0.00977	0.604772	0.618292	0.618539	0.574602	−0.12362	0.446538	0.617939	1	7	19
6	0.607723	0.604073	−0.00994	0.594201	0.607485	0.607728	0.564569	−0.12579	0.438736	0.607162	1	12	20
7	0.442	0.439345	−0.01367	0.432166	0.441828	0.442509	0.411036	−0.17304	0.319441	0.442124	0.9989	39	45
8	0.486562	0.483639	−0.01242	0.475736	0.486372	0.491167	0.456738	−0.15347	0.354885	0.490865	0.9906	31	36
9	0.541536	0.538283	−0.01116	0.529487	0.541324	0.545452	0.538674	−0.02307	0.511471	0.545262	0.9928	26	26
10	0.552279	0.548962	−0.01094	0.539991	0.552063	0.556271	0.549359	−0.02262	0.521609	0.556078	0.9928	20	23
11	0.462472	0.459695	−0.01307	0.452183	0.462292	0.465785	0.45998	−0.02709	0.436617	0.465633	0.9929	34	35
12	0.99294	0.986976	−0.00609	0.970847	0.992552	1	0.987466	−0.01269	0.937136	0.999467	0.9929	2	2
13	0.616344	0.612642	−0.0098	0.60263	0.616103	0.620776	0.613057	−0.02028	0.581983	0.620576	0.9929	8	13
14	0.605666	0.602028	−0.00998	0.592191	0.60543	0.610024	0.60244	−0.02064	0.571913	0.609826	0.9929	13	16
15	0.436841	0.434217	−0.01383	0.427122	0.436671	0.439943	0.434392	−0.02905	0.412023	0.439718	0.9929	41	39
16	0.464672	0.461881	−0.013	0.454333	0.46449	0.467935	0.461675	−0.02897	0.436155	0.46781	0.993	33	32
17	0.540365	0.53712	−0.01118	0.528343	0.540154	0.549291	0.542716	−0.02206	0.536254	0.548813	0.9838	27	25
18	0.551007	0.547697	−0.01097	0.538747	0.550792	0.560104	0.5534	−0.02163	0.546809	0.559616	0.9838	21	22
19	0.459701	0.45694	−0.01314	0.449473	0.459522	0.467197	0.461612	−0.0259	0.456093	0.466744	0.984	35	33
20	0.984114	0.978203	−0.00614	0.962218	0.98373	1	0.98803	−0.01212	0.976167	0.998897	0.9841	3	1
21	0.613606	0.60992	−0.00985	0.599953	0.613366	0.623663	0.616209	−0.0194	0.608849	0.623103	0.9839	9	11
22	0.603096	0.599473	−0.01002	0.589677	0.60286	0.612988	0.60566	−0.01974	0.598428	0.612438	0.9839	14	14
23	0.430393	0.427807	−0.01404	0.420817	0.430224	0.437293	0.43207	−0.02765	0.42687	0.436787	0.9842	42	40
24	0.43731	0.434683	−0.01382	0.42758	0.437139	0.443946	0.438626	−0.02732	0.433343	0.443269	0.9851	40	38
25	0.539195	0.535956	−0.01121	0.527198	0.538984	0.553274	0.543241	−0.03338	0.456086	0.552888	0.9746	28	24
26	0.549735	0.546433	−0.01099	0.537504	0.54952	0.56408	0.553882	−0.03264	0.465066	0.563682	0.9746	22	21
27	0.45693	0.454186	−0.01322	0.446764	0.456752	0.468661	0.460569	−0.03749	0.387997	0.468242	0.975	36	34
28	0.975289	0.969431	−0.0062	0.953589	0.974908	1	0.982976	−0.01732	0.830658	0.998905	0.9753	4	3
29	0.610868	0.607198	−0.00989	0.597276	0.610629	0.626659	0.615737	−0.02831	0.517893	0.626175	0.9748	10	12
30	0.600525	0.596918	−0.01006	0.587164	0.60029	0.616063	0.605303	−0.02885	0.509022	0.615603	0.9748	16	15
31	0.423944	0.421397	−0.01425	0.414511	0.423778	0.434541	0.427281	−0.0391	0.363598	0.433965	0.9756	43	42
32	0.409948	0.407486	−0.01474	0.400827	0.409788	0.419029	0.412951	−0.03513	0.376524	0.418249	0.9783	45	43
33	0.538024	0.534793	−0.01123	0.526054	0.537814	0.55756	0.526623	−0.10536	0.415188	0.556987	0.965	29	29
34	0.548463	0.545169	−0.01102	0.53626	0.548249	0.56836	0.53695	−0.10292	0.423304	0.56777	0.965	23	27
35	0.454159	0.451432	−0.01331	0.444055	0.453982	0.470238	0.44608	−0.11517	0.351875	0.469819	0.9658	37	37
36	0.966463	0.960658	−0.00625	0.94496	0.966086	1	0.95036	−0.05223	0.751198	0.998808	0.9665	5	4
37	0.608129	0.604477	−0.00994	0.594599	0.607892	0.629883	0.596771	−0.08809	0.470392	0.629317	0.9655	11	17
38	0.597954	0.594363	−0.01011	0.58465	0.597721	0.619372	0.586699	−0.08991	0.462426	0.618712	0.9654	17	18
39	0.417495	0.414987	−0.01447	0.408206	0.417332	0.431686	0.41122	−0.11529	0.327143	0.430979	0.9671	44	44
40	0.382586	0.380288	−0.01579	0.374074	0.382436	0.393177	0.383431	−0.06465	0.31936	0.392463	0.9731	47	46
41	0.535683	0.532466	−0.01128	0.523765	0.535474	1	0.718394	−0.39199	0.612079	0.99421	0.5357	30	10
42	0.545919	0.54264	−0.01107	0.533773	0.545706	1	0.782868	−0.27735	0.641892	0.997935	0.5459	24	9
43	0.448618	0.445923	−0.01347	0.438636	0.448442	0.62923	0.532239	−0.28961	0.439806	0.626976	0.713	38	28
44	0.948812	0.943113	−0.00637	0.927702	0.948442	1	0.784466	−0.27475	0.66206	0.995643	0.9488	6	8
45	0.602653	0.599034	−0.01003	0.589245	0.602418	0.955102	0.815786	−0.1788	0.675511	0.953329	0.631	15	6
46	0.592813	0.589252	−0.01019	0.579623	0.592581	0.953188	0.810198	−0.18516	0.671457	0.951885	0.6219	18	7
47	0.404598	0.402167	−0.01494	0.395596	0.40444	0.425804	0.3537	−0.47876	0.28867	0.424772	0.9502	46	47
48	0.327862	0.325893	−0.01843	0.320567	0.327734	0.339922	0.319634	−0.18674	0.25245	0.339616	0.9645	48	48

14500 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2021

BS Model	ENV Eff 2021	In: Fuel cost 2021, All emissions	Out: TEU-mile										
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.897923	0.893102	−0.00601	0.882628	0.897719	0.897924	0.883855	−0.01773	0.841086	0.89747	1	27	37
2	0.872873	0.868092	−0.00631	0.857292	0.872682	0.872874	0.862582	−0.01367	0.84078	0.872556	1	34	42
3	0.84247	0.838775	−0.00523	0.831424	0.842119	0.842476	0.832888	−0.01366	0.790673	0.841747	1	40	48
4	1	0.986771	−0.01341	0.941334	0.999183	1	0.952953	−0.04937	0.866286	0.999058	1	5	30
5	1	0.988348	−0.01179	0.952456	0.999731	1	0.969524	−0.03143	0.877655	0.998705	1	3	22
6	0.99328	0.987393	−0.006	0.97449	0.993028	0.99328	0.975119	−0.01875	0.876912	0.99245	1	4	17
7	1	0.991353	−0.00872	0.980487	0.999016	1	0.97047	−0.03043	0.87583	0.999143	1	1	21
8	1	0.99041	−0.00968	0.965787	0.999912	1	0.954642	−0.04751	0.861531	0.999619	1	2	29
9	0.896373	0.89156	−0.00602	0.881104	0.89617	0.899577	0.893384	−0.00771	0.885337	0.898988	0.9964	28	36
10	0.871267	0.866495	−0.00632	0.855715	0.871077	0.87454	0.868896	−0.00743	0.861713	0.874059	0.9963	35	41
11	0.838451	0.834774	−0.00525	0.827457	0.838102	0.847232	0.842254	−0.00698	0.835618	0.846983	0.9896	41	47
12	0.99294	0.979804	−0.0135	0.934688	0.992128	1	0.98451	−0.01573	0.960439	0.998689	0.9929	10	11
13	0.996459	0.984848	−0.01183	0.949083	0.996191	1	0.988561	−0.01157	0.969283	0.998633	0.9965	6	3
14	0.989918	0.984051	−0.00602	0.971192	0.989667	0.993697	0.987141	−0.00668	0.978992	0.993439	0.9962	7	7
15	0.988328	0.979782	−0.00883	0.969043	0.987356	1	0.983001	−0.01729	0.953521	0.998996	0.9883	11	14
16	0.955012	0.945853	−0.01014	0.922338	0.954928	1	0.972187	−0.02861	0.904177	0.998991	0.955	23	19
17	0.894435	0.889633	−0.00604	0.8792	0.894233	0.901675	0.896118	−0.00688	0.887128	0.901566	0.992	30	35
18	0.869261	0.864499	−0.00634	0.853744	0.869071	0.876657	0.871953	−0.00615	0.866153	0.876289	0.9916	36	40
19	0.833428	0.829772	−0.00529	0.822499	0.83308	0.848198	0.84273	−0.00765	0.837002	0.847391	0.9826	43	46
20	0.984114	0.971095	−0.01362	0.92638	0.98331	1	0.986129	−0.01407	0.968312	0.999801	0.9841	16	9
21	0.992032	0.980473	−0.01188	0.944866	0.991765	1	0.990674	−0.00941	0.976316	0.999865	0.992	8	1
22	0.985717	0.979875	−0.00605	0.96707	0.985467	0.994048	0.988379	−0.00577	0.981381	0.993801	0.9916	9	5
23	0.973738	0.965318	−0.00896	0.954738	0.97278	1	0.983428	−0.01685	0.934191	0.998972	0.9737	17	13
24	0.898776	0.890157	−0.01077	0.868026	0.898697	1	0.972283	−0.02851	0.879812	0.998908	0.8988	29	18
25	0.892498	0.887706	−0.00605	0.877295	0.892296	0.903812	0.897966	−0.0072	0.888234	0.90333	0.9875	31	32
26	0.867254	0.862504	−0.00635	0.851774	0.867065	0.878814	0.873886	−0.00642	0.867652	0.87817	0.9868	37	38
27	0.828404	0.824771	−0.00532	0.817542	0.828059	0.85111	0.846416	−0.00652	0.84118	0.850098	0.9733	44	45
28	0.975289	0.962386	−0.01375	0.918072	0.974492	1	0.986715	−0.01346	0.972017	0.999691	0.9753	20	8
29	0.987605	0.976098	−0.01194	0.94065	0.98734	1	0.98987	−0.01023	0.970106	0.999525	0.9876	12	2
30	0.981515	0.975698	−0.00607	0.962948	0.981266	0.994403	0.98854	−0.00596	0.982206	0.993837	0.987	13	4
31	0.959148	0.950855	−0.00909	0.940433	0.958205	1	0.982728	−0.01758	0.912794	0.99947	0.9591	22	15
32	0.842541	0.834461	−0.01149	0.813715	0.842466	1	0.968762	−0.03225	0.87847	0.998917	0.8425	42	23
33	0.89056	0.885779	−0.00606	0.875391	0.890358	0.906027	0.897668	−0.01028	0.87504	0.905784	0.9829	32	34
34	0.865247	0.860508	−0.00637	0.849803	0.865059	0.88105	0.873672	−0.00959	0.861932	0.880332	0.9821	38	39
35	0.82338	0.819769	−0.00535	0.812584	0.823037	0.85214	0.846499	−0.00782	0.838295	0.851171	0.9662	45	44
36	0.966463	0.953678	−0.01387	0.909764	0.965674	1	0.983571	−0.0167	0.923502	0.999141	0.9665	21	12
37	0.983179	0.971723	−0.01199	0.936434	0.982914	1	0.985539	−0.01467	0.949191	0.999656	0.9832	14	10
38	0.977313	0.971521	−0.0061	0.958826	0.977065	0.9948	0.987327	−0.00761	0.977254	0.994384	0.9824	15	6
39	0.944558	0.936391	−0.00923	0.926128	0.943629	1	0.975391	−0.02523	0.900183	0.999639	0.9446	24	16
40	0.786305	0.778765	−0.01231	0.759403	0.786236	1	0.963697	−0.03767	0.890306	0.998311	0.7863	47	24
41	0.886685	0.881924	−0.00609	0.871582	0.886484	1	0.897668	−0.03767	0.865667	0.997311	0.8867	33	33
42	0.861234	0.856517	−0.00639	0.845861	0.861046	1	0.951333	−0.05116	0.864429	0.998855	0.8612	39	31
43	0.813333	0.809766	−0.00542	0.802668	0.812994	0.857343	0.847113	−0.01409	0.827578	0.856742	0.9487	46	43
44	0.948812	0.93626	−0.01413	0.893149	0.948037	1	0.962136	−0.03935	0.864191	0.998126	0.9488	25	25
45	0.974325	0.962973	−0.0121	0.928001	0.974063	1	0.972011	−0.02879	0.891013	0.999231	0.9743	19	20
46	0.96891	0.963167	−0.00615	0.950581	0.968664	1	0.956573	−0.0454	0.862945	0.999722	0.9689	18	27
47	0.915379	0.907463	−0.00953	0.897517	0.914478	1	0.958957	−0.0428	0.869943	0.997938	0.9154	26	26
48	0.673834	0.667372	−0.01437	0.65078	0.673775	1	0.956558	−0.04541	0.869194	0.999517	0.6738	48	28

14500 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2050

BS Model	ENV Eff 2050	In: Fuel cost 2050, All emissions	Out: TEU-mile											
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.542472	0.537573	−0.0168	0.524232	0.542382	0.542479	0.527241	−0.05327	0.44736	0.542349	1	43	46
2	0.553296	0.544946	−0.02769	0.512633	0.553197	0.553303	0.526	−0.09381	0.45247	0.55317	1	37	47
3	0.660674	0.653698	−0.01615	0.638356	0.659753	0.6607	0.638075	−0.05367	0.552976	0.659928	1	30	37
4	1	0.95079	−0.05176	0.816945	0.999636	1	0.86149	−0.16078	0.689545	0.999677	1	5	17
5	0.78453	0.777374	−0.01173	0.758825	0.784133	0.784553	0.760585	−0.04017	0.65473	0.784026	1	17	31
6	0.776724	0.770059	−0.01114	0.75136	0.776312	0.776748	0.753617	−0.03952	0.648305	0.775931	1	20	32
7	1	0.981706	−0.01863	0.943778	0.998717	1	0.913298	−0.09493	0.694412	0.998747	1	1	14
8	1	0.954933	−0.04719	0.81536	0.998926	1	0.830737	−0.20375	0.688083	0.998671	1	4	21
9	0.541536	0.536645	−0.01683	0.523327	0.541446	0.545452	0.540584	−0.01651	0.5336	0.545414	0.9928	44	45
10	0.552279	0.543944	−0.02774	0.51169	0.55218	0.556271	0.549609	−0.02179	0.535811	0.556129	0.9928	38	40
11	0.657522	0.650579	−0.01623	0.635311	0.656605	0.672735	0.664607	−0.01818	0.64939	0.671973	0.9774	31	36
12	0.99294	0.944077	−0.05212	0.811178	0.992579	1	0.962115	−0.03938	0.8521	0.999019	0.9929	6	4
13	0.781752	0.774621	−0.01177	0.756138	0.781356	0.795273	0.787873	−0.01181	0.772939	0.794348	0.983	18	29
14	0.774096	0.767453	−0.01118	0.748817	0.773685	0.787774	0.780563	−0.01173	0.765995	0.786837	0.9826	22	30
15	0.988328	0.970248	−0.01885	0.932762	0.98706	1	0.965368	−0.03587	0.888002	0.998827	0.9883	2	3
16	0.955012	0.911972	−0.04942	0.778678	0.953986	1	0.923959	−0.0823	0.791247	0.997893	0.955	12	11
17	0.540365	0.535485	−0.01687	0.522196	0.540276	0.549291	0.544972	−0.01443	0.540906	0.548943	0.9838	45	43
18	0.551007	0.542691	−0.02781	0.510512	0.550908	0.560104	0.553826	−0.02024	0.545171	0.559569	0.9838	39	38
19	0.653583	0.646681	−0.01633	0.631504	0.652671	0.684904	0.679023	−0.01265	0.669315	0.684165	0.9543	32	35
20	0.984114	0.935686	−0.05259	0.803968	0.983756	1	0.973429	−0.0273	0.848952	0.998701	0.9841	8	1
21	0.778279	0.77118	−0.01183	0.752779	0.777885	0.803793	0.795997	−0.01218	0.786951	0.802944	0.9683	19	27
22	0.77081	0.764195	−0.01123	0.745639	0.770401	0.796834	0.78949	−0.01167	0.780645	0.796344	0.9673	24	28
23	0.973738	0.955925	−0.01914	0.918993	0.972489	1	0.967793	−0.03328	0.88069	0.999057	0.9737	3	2
24	0.898776	0.858271	−0.05251	0.732826	0.89781	1	0.935999	−0.06838	0.809853	0.998608	0.8988	15	8
25	0.539195	0.534325	−0.0169	0.521065	0.539105	0.553274	0.546285	−0.02312	0.495891	0.553061	0.9746	46	41
26	0.549735	0.541438	−0.02787	0.509333	0.549636	0.56408	0.553303	−0.03453	0.490965	0.563875	0.9746	40	39
27	0.649643	0.642783	−0.01643	0.627698	0.648737	0.693526	0.687154	−0.01337	0.662644	0.692847	0.9367	34	33
28	0.975289	0.927295	−0.05307	0.796758	0.974934	1	0.960676	−0.04093	0.808984	0.998342	0.9753	9	5
29	0.774806	0.767739	−0.01188	0.749419	0.774414	0.815167	0.806419	−0.01331	0.754096	0.81425	0.9505	21	23
30	0.767525	0.760938	−0.01128	0.742461	0.767117	0.808275	0.79992	−0.01292	0.74945	0.807718	0.9496	25	25
31	0.959148	0.941602	−0.01943	0.905223	0.957918	1	0.958868	−0.0429	0.845933	0.998472	0.9591	7	6
32	0.842541	0.80457	−0.05601	0.686974	0.841635	1	0.933492	−0.07125	0.808789	0.998637	0.8425	16	10
33	0.538024	0.533165	−0.01694	0.519934	0.537935	0.55756	0.541815	−0.05212	0.456487	0.557218	0.965	47	44
34	0.548463	0.540186	−0.02794	0.508155	0.548365	0.56836	0.545145	−0.07492	0.463089	0.567922	0.965	41	42
35	0.645703	0.638885	−0.01653	0.623891	0.644803	0.697668	0.683804	−0.02906	0.636191	0.69671	0.9255	35	34
36	0.966463	0.918904	−0.05355	0.789548	0.966112	1	0.937151	−0.06706	0.754494	0.998687	0.9665	11	7
37	0.771333	0.764298	−0.01193	0.74606	0.770943	0.820712	0.80376	−0.0257	0.726906	0.820078	0.9398	23	24
38	0.764239	0.75768	−0.01133	0.739282	0.763833	0.814005	0.797513	−0.0254	0.722465	0.813707	0.9389	26	26
39	0.944558	0.927279	−0.01973	0.891453	0.943347	1	0.933877	−0.0708	0.775463	0.998863	0.9446	10	9
40	0.786305	0.750869	−0.06002	0.641121	0.78546	1	0.91787	−0.08948	0.746748	0.998651	0.7863	29	13
41	0.535683	0.530845	−0.01701	0.517671	0.535594	1	0	Inf	0.687067	0.999699	0.5357	48	48
42	0.545919	0.53768	−0.02807	0.505798	0.545821	1	0.853663	−0.17142	0.688092	0.99951	0.5459	42	19
43	0.637824	0.631089	−0.01673	0.616278	0.636935	0.857343	0.818001	−0.0561	0.695736	0.856413	0.744	36	22
44	0.948812	0.902121	−0.05455	0.775128	0.948467	1	0.846746	−0.18099	0.688671	0.99861	0.9488	13	20
45	0.764387	0.757415	−0.01204	0.739342	0.764001	1	0.922162	−0.08441	0.702535	0.99796	0.7644	27	12
46	0.757668	0.751166	−0.01142	0.732926	0.757265	1	0.864625	−0.15657	0.691543	0.999015	0.7577	28	16
47	0.915379	0.898633	−0.02036	0.863914	0.914204	1	0.855451	−0.16897	0.690766	0.998678	0.9154	14	18
48	0.673834	0.643467	−0.07004	0.549417	0.67311	1	0.881731	−0.13413	0.693327	0.998157	0.6738	33	15

18750 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2021

18750		BS Model	ECO Eff 2021	In: Fuel cost 2021	Out: TEU-mile										
Day	Fuel	DMUs	result_crs.score	result_crs.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	result_vrs.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1 day	VLSFO	1	0.897844	0.894582	−0.00406	0.885513	0.897804	0.897845	0.877241	−0.02616	0.829391	0.897321	1	13	16
	MGO	2	0.819644	0.816666	−0.00445	0.808387	0.819607	0.819645	0.800833	−0.02866	0.757145	0.819166	1	19	22
	Methanol	3	0.426257	0.424709	−0.00855	0.420403	0.426238	0.426363	0.416592	−0.05501	0.393831	0.426133	0.9998	30	34
	Ammonia	4	0.441414	0.439811	−0.00826	0.435352	0.441394	0.441727	0.431677	−0.05271	0.408099	0.441489	0.9993	25	28
	LNG	5	1	0.996367	−0.00365	0.986266	0.999955	1	0.976962	−0.02358	0.923606	0.999385	1	1	5
	LPG	6	0.953263	0.949799	−0.00383	0.940171	0.95322	0.953263	0.931311	−0.02473	0.880452	0.952706	1	7	10
	H2 Liq	7	0.147812	0.147275	−0.02467	0.145782	0.147806	0.148054	0.144715	−0.15586	0.136783	0.147974	0.9984	39	41
	H2 Gas	8	0.159635	0.159055	−0.02284	0.157443	0.159628	0.160966	0.157451	−0.1387	0.148712	0.16088	0.9917	37	37
5 day	VLSFO	9	0.896593	0.893336	−0.00407	0.88428	0.896553	0.899175	0.8926	−0.00819	0.88176	0.898785	0.9971	14	14
	MGO	10	0.818427	0.815454	−0.00446	0.807187	0.818391	0.820783	0.814782	−0.00897	0.804886	0.820427	0.9971	20	20
	Methanol	11	0.424616	0.423074	−0.00859	0.418785	0.424597	0.425833	0.422718	−0.0173	0.417572	0.425657	0.9971	31	30
	Ammonia	12	0.438899	0.437305	−0.00831	0.432872	0.43888	0.440156	0.436937	−0.01674	0.431609	0.439981	0.9971	26	25
	LNG	13	0.997142	0.993519	−0.00366	0.983448	0.997097	1	0.992684	−0.00737	0.980609	0.999573	0.9971	2	1
	LPG	14	0.950659	0.947205	−0.00384	0.937603	0.950617	0.953385	0.946411	−0.00773	0.9349	0.952977	0.9971	8	6
	H2 Liq	15	0.14642	0.145888	−0.0249	0.14441	0.146414	0.146839	0.145765	−0.05018	0.143982	0.146784	0.9971	41	40
	H2 Gas	16	0.153851	0.153292	−0.0237	0.151738	0.153844	0.154287	0.153132	−0.04891	0.151241	0.154186	0.9972	38	38
10 day	VLSFO	17	0.89503	0.891778	−0.00407	0.882738	0.894989	0.900858	0.893825	−0.00873	0.879388	0.89989	0.9935	15	13
	MGO	18	0.816906	0.813939	−0.00446	0.805687	0.81687	0.822224	0.815806	−0.00957	0.80263	0.821344	0.9935	21	19
	Methanol	19	0.422565	0.42103	−0.00863	0.416762	0.422546	0.425296	0.42198	−0.01848	0.415196	0.424861	0.9936	33	31
	Ammonia	20	0.435756	0.434173	−0.00837	0.429771	0.435736	0.438565	0.435151	−0.01789	0.428186	0.438109	0.9936	27	26
	LNG	21	0.99357	0.98996	−0.00367	0.979924	0.993525	1	0.992192	−0.00787	0.976207	0.998986	0.9936	3	2
	LPG	22	0.947405	0.943963	−0.00385	0.934393	0.947362	0.95354	0.946096	−0.00825	0.930849	0.952574	0.9936	9	7
	H2 Liq	23	0.144681	0.144155	−0.0252	0.142694	0.144674	0.145608	0.144478	−0.05374	0.142187	0.145452	0.9936	42	42
	H2 Gas	24	0.146621	0.146088	−0.02487	0.144607	0.146614	0.147521	0.146392	−0.0523	0.14425	0.147453	0.9939	40	39
15 day	VLSFO	25	0.893466	0.89022	−0.00408	0.881195	0.893426	0.902566	0.89445	−0.01005	0.875337	0.901802	0.9899	16	12
	MGO	26	0.815386	0.812423	−0.00447	0.804187	0.815349	0.823687	0.816283	−0.01101	0.798841	0.822996	0.9899	22	18
	Methanol	27	0.420514	0.418986	−0.00867	0.414739	0.420495	0.424751	0.420976	−0.02112	0.411995	0.424551	0.99	34	32
	Ammonia	28	0.432613	0.431041	−0.00843	0.426671	0.432593	0.436949	0.433091	−0.02039	0.423884	0.436724	0.9901	28	27
	LNG	29	0.989997	0.9864	−0.00368	0.976401	0.989953	1	0.991066	−0.00901	0.969897	0.999404	0.99	4	3
	LPG	30	0.94415	0.94072	−0.00386	0.931184	0.944108	0.953697	0.945174	−0.00946	0.924983	0.953099	0.99	10	8
	H2 Liq	31	0.142941	0.142422	−0.02551	0.140978	0.142935	0.144359	0.143101	−0.06089	0.140081	0.144271	0.9902	43	43
	H2 Gas	32	0.13939	0.138884	−0.02616	0.137476	0.139384	0.140652	0.139479	−0.0598	0.13689	0.14048	0.991	45	45
20 day	VLSFO	33	0.891902	0.888662	−0.00409	0.879653	0.891862	0.904325	0.891944	−0.01535	0.859328	0.903489	0.9863	17	15
	MGO	34	0.813865	0.810908	−0.00448	0.802687	0.813828	0.825192	0.813912	−0.0168	0.784153	0.824433	0.9863	23	21
	Methanol	35	0.418463	0.416942	−0.00871	0.412716	0.418444	0.424198	0.418549	−0.03182	0.403397	0.42383	0.9865	35	33
	Ammonia	36	0.429469	0.427909	−0.00849	0.423571	0.42945	0.43531	0.429586	−0.03061	0.414229	0.434995	0.9866	29	29
	LNG	37	0.986424	0.982841	−0.0037	0.972877	0.98638	1	0.986537	−0.01365	0.950641	0.99914	0.9864	5	4
	LPG	38	0.940896	0.937478	−0.00388	0.927974	0.940854	0.953859	0.941004	−0.01432	0.906744	0.953041	0.9864	11	9
	H2 Liq	39	0.141201	0.140688	−0.02582	0.139262	0.141195	0.14309	0.141253	−0.09089	0.136331	0.142971	0.9868	44	44
	H2 Gas	40	0.13216	0.131679	−0.02759	0.130344	0.132154	0.133682	0.1323	−0.07816	0.129403	0.133541	0.9886	47	47
30 day	VLSFO	41	0.888775	0.885546	−0.0041	0.876569	0.888735	1	0.710877	−0.40671	0.537671	0.997259	0.8888	18	24
	MGO	42	0.810823	0.807877	−0.0045	0.799688	0.810787	0.907101	0.73923	−0.25035	0.489685	0.904384	0.8939	24	23
	Methanol	43	0.41436	0.412855	−0.0088	0.40867	0.414342	0.42308	0.398586	−0.14525	0.359692	0.422419	0.9794	36	36
	Ammonia	44	0.423182	0.421645	−0.00862	0.41737	0.423163	0.431994	0.41543	−0.0923	0.382469	0.431619	0.9796	32	35
	LNG	45	0.979279	0.975722	−0.00372	0.96583	0.979236	1	0.910121	−0.09876	0.651595	0.99696	0.9793	6	11
	LPG	46	0.934387	0.930993	−0.0039	0.921555	0.934346	0.96266	0.871441	−0.10874	0.621643	0.960037	0.9706	12	17
	H2 Liq	47	0.137722	0.137221	−0.02648	0.13583	0.137715	0.140526	0.136266	−0.22247	0.126238	0.140387	0.98	46	46
	H2 Gas	48	0.117699	0.117271	−0.03098	0.116082	0.117693	0.119585	0.117386	−0.15663	0.112306	0.119397	0.9842	48	48

18750 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2050

BS Model	ECO Eff 2050	In: Fuel cost 2050	Out: TEU-mile										
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.542333	0.539664	−0.00912	0.533901	0.54227	0.542337	0.505762	−0.13334	0.391261	0.542016	1	25	31
2	0.553157	0.550435	−0.00894	0.544557	0.553093	0.553161	0.515855	−0.13074	0.399068	0.552834	1	19	30
3	0.464638	0.462351	−0.01064	0.457414	0.464584	0.464639	0.43323	−0.15604	0.335153	0.46425	1	33	41
4	1	0.995079	−0.00495	0.984453	0.999884	1	0.93217	−0.07277	0.721208	0.998779	1	1	5
5	0.618429	0.615386	−0.008	0.608814	0.618357	0.618432	0.576685	−0.11706	0.446123	0.618057	1	7	19
6	0.607615	0.604625	−0.00814	0.598168	0.607545	0.607618	0.566607	−0.11912	0.438326	0.60726	1	12	20
7	0.442099	0.439923	−0.01119	0.435225	0.442047	0.442509	0.41256	−0.16405	0.319141	0.441969	0.9991	40	45
8	0.487451	0.485052	−0.01015	0.479872	0.487394	0.491167	0.458116	−0.14688	0.354233	0.490663	0.9924	31	36
9	0.541577	0.538912	−0.00913	0.533157	0.541514	0.544723	0.539522	−0.0177	0.527765	0.544414	0.9942	26	27
10	0.552336	0.549618	−0.00895	0.543749	0.552272	0.555543	0.550238	−0.01735	0.538246	0.555227	0.9942	20	23
11	0.462849	0.460571	−0.01068	0.455653	0.462795	0.465517	0.461048	−0.02082	0.450931	0.465233	0.9943	34	35
12	0.994303	0.98941	−0.00497	0.978844	0.994188	1	0.99034	−0.00975	0.968424	0.999358	0.9943	2	3
13	0.616662	0.613627	−0.00802	0.607074	0.61659	0.620227	0.614291	−0.01558	0.600875	0.619864	0.9943	8	13
14	0.605956	0.602974	−0.00816	0.596535	0.605885	0.609461	0.603629	−0.01585	0.590448	0.609106	0.9942	13	16
15	0.437936	0.435781	−0.01129	0.431127	0.437885	0.440442	0.436155	−0.02231	0.426342	0.440158	0.9943	41	39
16	0.469788	0.467476	−0.01053	0.462484	0.469734	0.472453	0.467551	−0.02219	0.455803	0.472359	0.9944	32	32
17	0.540633	0.537972	−0.00915	0.532227	0.54057	0.547783	0.543928	−0.01294	0.538014	0.547658	0.9869	27	25
18	0.55131	0.548597	−0.00897	0.542738	0.551246	0.558599	0.554666	−0.01269	0.548635	0.55847	0.987	21	22
19	0.460613	0.458347	−0.01074	0.453452	0.46056	0.466642	0.463337	−0.01529	0.458287	0.4665	0.9871	35	33
20	0.987182	0.982324	−0.00501	0.971834	0.987067	1	0.99286	−0.00719	0.98204	0.999596	0.9872	3	1
21	0.614452	0.611429	−0.00805	0.604899	0.614381	0.622529	0.618135	−0.01142	0.611401	0.622372	0.987	9	12
22	0.603881	0.60091	−0.00819	0.594493	0.603811	0.611824	0.607506	−0.01161	0.600889	0.611673	0.987	15	15
23	0.432732	0.430603	−0.01143	0.426004	0.432682	0.438321	0.435197	−0.01638	0.430488	0.438117	0.9872	42	40
24	0.44771	0.445506	−0.01105	0.440749	0.447658	0.453249	0.450007	−0.0159	0.445423	0.452862	0.9878	39	38
25	0.539688	0.537033	−0.00916	0.531298	0.539626	0.550935	0.545404	−0.01841	0.535091	0.550554	0.9796	28	24
26	0.550283	0.547575	−0.00899	0.541728	0.550219	0.561746	0.556118	−0.01801	0.545679	0.561364	0.9796	22	21
27	0.458377	0.456122	−0.01079	0.451251	0.458324	0.467801	0.463312	−0.02071	0.454832	0.467597	0.9799	36	34
28	0.98006	0.975238	−0.00505	0.964823	0.979947	1	0.990536	−0.00955	0.972513	0.99938	0.9801	4	2
29	0.612243	0.60923	−0.00808	0.602724	0.612172	0.6249	0.618804	−0.01577	0.607496	0.624598	0.9797	10	11
30	0.601807	0.598846	−0.00822	0.592451	0.601737	0.614257	0.608251	−0.01608	0.597134	0.613952	0.9797	16	14
31	0.427529	0.425425	−0.01157	0.420882	0.427479	0.436134	0.432214	−0.0208	0.424448	0.435839	0.9803	43	42
32	0.425631	0.423537	−0.01162	0.419014	0.425582	0.433452	0.430458	−0.01604	0.424824	0.432654	0.982	44	43
33	0.538744	0.536093	−0.00918	0.530368	0.538681	0.554278	0.531045	−0.07893	0.435586	0.553857	0.972	29	29
34	0.549257	0.546554	−0.009	0.540717	0.549193	0.565083	0.541525	−0.07699	0.444148	0.564658	0.972	23	26
35	0.456141	0.453897	−0.01084	0.44905	0.456089	0.469031	0.451529	−0.08264	0.370212	0.468667	0.9725	37	37
36	0.972939	0.968151	−0.00508	0.957813	0.972826	1	0.964738	−0.03655	0.792023	0.998951	0.9729	5	4
37	0.610034	0.607032	−0.00811	0.600549	0.609963	0.627415	0.603101	−0.06425	0.494339	0.627039	0.9723	11	17
38	0.599733	0.596782	−0.00825	0.590409	0.599663	0.616838	0.59279	−0.06577	0.485896	0.616467	0.9723	17	18
39	0.422325	0.420247	−0.01171	0.415759	0.422276	0.433882	0.419597	−0.07846	0.346249	0.433447	0.9734	45	44
40	0.403553	0.401567	−0.01225	0.397278	0.403506	0.413062	0.40529	−0.04642	0.364931	0.412117	0.977	47	46
41	0.536855	0.534213	−0.00921	0.528508	0.536792	1	0.733773	−0.36282	0.6312	0.998265	0.5369	30	10
42	0.547204	0.544511	−0.00904	0.538697	0.547141	1	0.802345	−0.24635	0.647131	0.996247	0.5472	24	8
43	0.45167	0.449447	−0.01095	0.444647	0.451617	0.62923	0.538027	−0.2694	0.435336	0.628457	0.7178	38	28
44	0.958697	0.953979	−0.00516	0.943791	0.958585	1	0.773118	−0.29346	0.649052	0.997605	0.9587	6	9
45	0.605615	0.602635	−0.00817	0.596199	0.605545	0.955102	0.833261	−0.1531	0.661423	0.953808	0.6341	14	6
46	0.595584	0.592653	−0.0083	0.586324	0.595515	0.953188	0.828414	−0.15801	0.660138	0.951159	0.6248	18	7
47	0.411918	0.409891	−0.01201	0.405514	0.41187	0.429272	0.3492	−0.53416	0.291136	0.428964	0.9596	46	47
48	0.359396	0.357627	−0.01376	0.353808	0.359354	0.371318	0.335558	−0.28701	0.281281	0.37056	0.9679	48	48

18750 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2021

BS Model	ENV Eff 2021	In: Fuel cost 2021, All emissions	Out: TEU-mile										
DMUs	result_crs.score	result_crs.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	result_vrs.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.897844	0.893737	−0.00512	0.882896	0.89768	0.897845	0.884687	−0.01657	0.835804	0.897089	1	28	37
2	0.872793	0.868818	−0.00524	0.861283	0.872671	0.872795	0.859238	−0.01808	0.790398	0.871922	1	34	42
3	0.842209	0.839152	−0.00433	0.833808	0.84198	0.842213	0.833378	−0.01259	0.81451	0.841349	1	41	48
4	1	0.992224	−0.00784	0.973391	0.999773	1	0.952948	−0.04938	0.864805	0.998651	1	2	28
5	1	0.991016	−0.00907	0.962979	0.99953	1	0.969899	−0.03103	0.874638	0.999159	1	3	22
6	0.993256	0.988452	−0.00489	0.979126	0.993054	0.993257	0.972975	−0.02099	0.880391	0.992658	1	5	19
7	1	0.993262	−0.00678	0.98282	0.999585	1	0.980426	−0.01996	0.898824	0.99863	1	1	15
8	1	0.989519	−0.01059	0.966412	0.999816	1	0.953647	−0.04861	0.857615	0.99951	1	4	27
9	0.896593	0.892492	−0.00513	0.881666	0.896429	0.899175	0.893071	−0.0076	0.884012	0.898769	0.9971	29	36
10	0.871498	0.867528	−0.00525	0.860004	0.871376	0.874135	0.868093	−0.00796	0.86004	0.873899	0.997	35	41
11	0.838967	0.835921	−0.00434	0.830598	0.838739	0.846029	0.841355	−0.00657	0.835503	0.845223	0.9917	42	47
12	0.994303	0.986571	−0.00788	0.967846	0.994077	1	0.986282	−0.01391	0.960712	0.999067	0.9943	7	10
13	0.997142	0.988183	−0.00909	0.960227	0.996673	1	0.988754	−0.01137	0.974478	0.99923	0.9971	6	3
14	0.990544	0.985753	−0.00491	0.976452	0.990342	0.993592	0.986836	−0.00689	0.974657	0.993094	0.9969	8	9
15	0.990584	0.983909	−0.00685	0.973566	0.990173	1	0.985276	−0.01494	0.961194	0.998821	0.9906	10	14
16	0.963765	0.953664	−0.01099	0.931394	0.963588	1	0.969487	−0.03147	0.897603	0.99974	0.9638	23	23
17	0.89503	0.890935	−0.00513	0.880128	0.894866	0.900858	0.8956	−0.00652	0.889041	0.900599	0.9935	30	35
18	0.869878	0.865916	−0.00526	0.858406	0.869757	0.875833	0.870866	−0.00651	0.863415	0.875086	0.9932	36	40
19	0.834914	0.831883	−0.00436	0.826586	0.834687	0.846795	0.841719	−0.00712	0.835584	0.846476	0.986	43	46
20	0.987182	0.979505	−0.00794	0.960914	0.986957	1	0.985629	−0.01458	0.964654	0.999446	0.9872	13	12
21	0.99357	0.984643	−0.00912	0.956787	0.993102	1	0.990669	−0.00942	0.974946	0.999642	0.9936	9	1
22	0.987153	0.982378	−0.00492	0.973109	0.986952	0.993873	0.988258	−0.00572	0.979962	0.993718	0.9932	11	6
23	0.978814	0.972218	−0.00693	0.961998	0.978408	1	0.988476	−0.01166	0.967745	0.999415	0.9788	18	4
24	0.918471	0.908845	−0.01153	0.887622	0.918303	1	0.972817	−0.02794	0.890088	0.999775	0.9185	27	21
25	0.893466	0.889379	−0.00514	0.878591	0.893302	0.902566	0.896682	−0.00727	0.887228	0.902079	0.9899	31	34
26	0.868259	0.864304	−0.00527	0.856808	0.868138	0.877557	0.872373	−0.00677	0.86621	0.87669	0.9894	37	39
27	0.830861	0.827845	−0.00438	0.822573	0.830636	0.850241	0.845735	−0.00627	0.841016	0.849491	0.9772	44	44
28	0.98006	0.972439	−0.008	0.953982	0.979838	1	0.985503	−0.01471	0.947544	0.999705	0.9801	17	13
29	0.989997	0.981103	−0.00916	0.953347	0.989531	1	0.989543	−0.01057	0.964818	0.999053	0.99	12	2
30	0.983762	0.979004	−0.00494	0.969767	0.983562	0.994157	0.988307	−0.00595	0.98137	0.993779	0.9895	14	5
31	0.967044	0.960528	−0.00702	0.95043	0.966643	1	0.986158	−0.01404	0.945401	0.99925	0.967	22	11
32	0.873177	0.864025	−0.01213	0.843849	0.873017	1	0.973439	−0.02729	0.885441	0.998701	0.8732	38	18
33	0.891902	0.887822	−0.00515	0.877053	0.891739	0.904325	0.897021	−0.009	0.88112	0.90369	0.9863	32	33
34	0.866639	0.862692	−0.00528	0.85521	0.866518	0.879332	0.872806	−0.0085	0.863513	0.878936	0.9856	39	38
35	0.826808	0.823807	−0.00441	0.818561	0.826584	0.852157	0.847428	−0.00655	0.841661	0.851508	0.9703	45	43
36	0.972939	0.965373	−0.00806	0.947051	0.972718	1	0.980367	−0.02003	0.916668	0.999749	0.9729	21	16
37	0.986424	0.977562	−0.00919	0.949906	0.98596	1	0.987654	−0.0125	0.955985	0.999294	0.9864	15	7
38	0.980371	0.975629	−0.00496	0.966424	0.980172	0.994583	0.987592	−0.00712	0.97489	0.99408	0.9857	16	8
39	0.955274	0.948837	−0.0071	0.938862	0.954877	1	0.975054	−0.02558	0.914651	0.999137	0.9553	25	17
40	0.827884	0.819206	−0.01279	0.800077	0.827732	1	0.972924	−0.02783	0.888703	0.999706	0.8279	46	20
41	0.888775	0.884709	−0.00517	0.873978	0.888612	1	0.897021	−0.04706	0.860439	0.999735	0.8888	33	32
42	0.863401	0.859468	−0.0053	0.852014	0.86328	1	0.955056	−0.04706	0.865846	0.999328	0.8634	40	26
43	0.818702	0.815731	−0.00445	0.810536	0.81848	0.857343	0.842923	−0.01995	0.782148	0.856798	0.9549	47	45
44	0.958697	0.951241	−0.00817	0.933187	0.958479	1	0.950603	−0.05196	0.866793	0.998588	0.9587	24	30
45	0.979279	0.970481	−0.00926	0.943026	0.978819	1	0.968877	−0.03212	0.889354	0.999108	0.9793	19	24
46	0.973589	0.96888	−0.00499	0.959739	0.973391	1	0.960579	−0.04104	0.869688	0.999066	0.9736	20	25
47	0.931734	0.925456	−0.00728	0.915727	0.931347	1	0.949913	−0.05273	0.867279	0.999638	0.9317	26	31
48	0.737296	0.729568	−0.01437	0.712532	0.737161	1	0.952498	−0.04987	0.864452	0.999399	0.7373	48	29

18750 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2050

BS Model	ENV Eff 2050	In: Fuel cost 2050, All emissions	Out: TEU-mile										
DMUs	result_crs.score	result_crs.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	result_vrs.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.542333	0.538113	−0.01446	0.527772	0.542271	0.542337	0.515962	−0.09426	0.4299	0.541856	1	43	47
2	0.553157	0.547437	−0.01889	0.534572	0.55307	0.553161	0.517577	−0.12429	0.436714	0.55267	1	37	46
3	0.660119	0.653836	−0.01456	0.633798	0.659749	0.660136	0.637786	−0.05308	0.548107	0.65993	1	31	37
4	1	0.959117	−0.04263	0.816718	0.999234	1	0.847129	−0.18046	0.686674	0.997751	1	5	18
5	0.784032	0.776402	−0.01253	0.744425	0.783472	0.784047	0.752837	−0.05288	0.650719	0.783669	1	18	31
6	0.776213	0.768909	−0.01224	0.737661	0.775684	0.776228	0.746418	−0.05145	0.645844	0.77569	1	21	32
7	1	0.985901	−0.0143	0.952993	0.999278	1	0.923348	−0.08302	0.692897	0.998922	1	1	12
8	1	0.969294	−0.03168	0.823552	0.998081	1	0.846198	−0.18176	0.68541	0.998476	1	3	19
9	0.541577	0.537363	−0.01448	0.527036	0.541515	0.544723	0.539601	−0.01743	0.520992	0.544281	0.9942	44	44
10	0.552336	0.546624	−0.01892	0.533778	0.552249	0.555543	0.548045	−0.02463	0.525901	0.555093	0.9942	38	40
11	0.657578	0.651319	−0.01461	0.631358	0.65721	0.669747	0.662904	−0.01541	0.653628	0.669497	0.9818	32	36
12	0.994303	0.953653	−0.04287	0.812065	0.993541	1	0.963293	−0.03811	0.836587	0.99917	0.9943	6	4
13	0.781792	0.774183	−0.01257	0.742298	0.781233	0.792624	0.786126	−0.01043	0.779504	0.791667	0.9863	19	28
14	0.774093	0.766809	−0.01227	0.735646	0.773566	0.785048	0.778736	−0.01033	0.771969	0.783908	0.986	23	30
15	0.990584	0.976618	−0.01444	0.94402	0.989869	1	0.971737	−0.02908	0.882669	0.99806	0.9906	2	1
16	0.963765	0.934171	−0.03287	0.793711	0.961916	1	0.93212	−0.07282	0.77702	0.998968	0.9638	11	10
17	0.540633	0.536426	−0.01451	0.526117	0.540571	0.547783	0.543067	−0.01585	0.536212	0.547492	0.9869	45	42
18	0.55131	0.545609	−0.01895	0.532786	0.551223	0.558599	0.55095	−0.02485	0.502498	0.5582	0.987	39	38
19	0.654401	0.648173	−0.01468	0.628308	0.654035	0.679407	0.67338	−0.01317	0.666683	0.67835	0.9632	33	35
20	0.987182	0.946823	−0.04318	0.806249	0.986426	1	0.966407	−0.03476	0.823268	0.999062	0.9872	8	3
21	0.778991	0.77141	−0.01262	0.739638	0.778434	0.799264	0.792326	−0.01096	0.785634	0.798332	0.9746	20	27
22	0.771443	0.764184	−0.01231	0.733128	0.770918	0.79211	0.785489	−0.01064	0.77885	0.791233	0.9739	25	29
23	0.978814	0.965014	−0.01461	0.932803	0.978107	1	0.970654	−0.03023	0.876485	0.997801	0.9788	4	2
24	0.918471	0.890268	−0.03449	0.756409	0.916709	1	0.937614	−0.06654	0.802395	0.998553	0.9185	15	8
25	0.539688	0.535489	−0.01453	0.525198	0.539626	0.550935	0.544101	−0.0228	0.49232	0.550703	0.9796	46	41
26	0.550283	0.544593	−0.01899	0.531794	0.550197	0.561746	0.55009	−0.03772	0.48532	0.561486	0.9796	40	39
27	0.651225	0.645026	−0.01476	0.625258	0.65086	0.688331	0.683116	−0.01109	0.677426	0.68723	0.9461	34	33
28	0.98006	0.939993	−0.04349	0.800433	0.97931	1	0.955364	−0.04672	0.779068	0.9984	0.9801	10	6
29	0.77619	0.768636	−0.01266	0.736979	0.775635	0.808687	0.801922	−0.01043	0.794233	0.80789	0.9598	22	23
30	0.768793	0.761559	−0.01236	0.730609	0.76827	0.801607	0.795154	−0.01012	0.788444	0.800737	0.9591	26	26
31	0.967044	0.95341	−0.01479	0.921586	0.966346	1	0.961876	−0.03964	0.84452	0.998132	0.967	7	5
32	0.873177	0.846365	−0.03628	0.719107	0.871502	1	0.941504	−0.06213	0.810239	0.998539	0.8732	16	7
33	0.538744	0.534552	−0.01456	0.524279	0.538682	0.554278	0.537682	−0.05569	0.466416	0.55376	0.972	47	45
34	0.549257	0.543577	−0.01902	0.530803	0.54917	0.565083	0.540214	−0.08147	0.46889	0.564711	0.972	41	43
35	0.648048	0.64188	−0.01483	0.622208	0.647685	0.694512	0.68256	−0.02521	0.63765	0.693377	0.9331	35	34
36	0.972939	0.933162	−0.04381	0.794617	0.972194	1	0.929838	−0.07546	0.742734	0.998449	0.9729	12	11
37	0.773389	0.765862	−0.01271	0.734319	0.772836	0.816489	0.801823	−0.0224	0.73535	0.81559	0.9472	24	24
38	0.766143	0.758934	−0.0124	0.728091	0.765622	0.80964	0.795664	−0.02169	0.731033	0.808818	0.9463	28	25
39	0.955274	0.941806	−0.01497	0.91037	0.954584	1	0.936038	−0.06833	0.790075	0.998362	0.9553	9	9
40	0.827884	0.802462	−0.03827	0.681805	0.826295	1	0.917772	−0.0896	0.750512	0.999427	0.8279	17	13
41	0.536855	0.532678	−0.01461	0.522441	0.536793	1	0	Inf	0.686651	0.999696	0.5369	48	48
42	0.547204	0.541546	−0.0191	0.528819	0.547118	1	0.872453	−0.14619	0.688418	0.999748	0.5472	42	15
43	0.641695	0.635587	−0.01497	0.616108	0.641336	0.857343	0.816643	−0.05813	0.65508	0.85605	0.7485	36	22
44	0.958697	0.919502	−0.04446	0.782984	0.957962	1	0.859842	−0.163	0.6871	0.99907	0.9587	13	17
45	0.767787	0.760315	−0.0128	0.729	0.767238	1	0.908907	−0.10022	0.697362	0.999002	0.7678	27	14
46	0.760844	0.753684	−0.01248	0.723054	0.760326	1	0.862496	−0.15943	0.687286	0.998966	0.7608	29	16
47	0.931734	0.918598	−0.01535	0.887936	0.931061	1	0.837411	−0.19416	0.687377	0.998429	0.9317	14	21
48	0.737296	0.714656	−0.04297	0.607202	0.735881	1	0.842222	−0.18734	0.686798	0.998655	0.7373	30	20

23500 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2021

23500		BS Model	ECO Eff 2021	In: Fuel cost 2021	Out: TEU-mile										
Day	Fuel	DMUs	result_crs.score	result_crs.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	result_vrs.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1 day	VLSFO	1	0.897835	0.894507	−0.00414	0.886875	0.897739	0.897836	0.875689	−0.02817	0.772772	0.897617	1	13	16
	MGO	2	0.819636	0.816598	−0.00454	0.809631	0.819549	0.819637	0.799417	−0.03086	0.705464	0.819428	1	19	22
	Methanol	3	0.42626	0.42468	−0.00873	0.421057	0.426215	0.426363	0.415854	−0.05927	0.366945	0.426111	0.9998	30	34
	Ammonia	4	0.441423	0.439787	−0.00843	0.436035	0.441376	0.441727	0.430919	−0.05678	0.380218	0.441509	0.9993	25	28
	LNG	5	1	0.996293	−0.00372	0.987793	0.999894	1	0.975237	−0.02539	0.860579	0.99941	1	1	5
	LPG	6	0.953262	0.949728	−0.0039	0.941625	0.95316	0.953262	0.929666	−0.02662	0.820368	0.952729	1	7	10
	H2 Liq	7	0.147819	0.147271	−0.02517	0.146015	0.147803	0.148054	0.144463	−0.16792	0.127472	0.147981	0.9984	39	42
	H2 Gas	8	0.159673	0.159081	−0.0233	0.157724	0.159656	0.160966	0.157197	−0.14898	0.138852	0.160912	0.992	37	37
5 day	VLSFO	9	0.896619	0.893296	−0.00415	0.885674	0.896524	0.899128	0.892351	−0.00845	0.878759	0.898771	0.9972	14	15
	MGO	10	0.818454	0.81542	−0.00455	0.808463	0.818366	0.820743	0.814557	−0.00925	0.802147	0.820419	0.9972	20	21
	Methanol	11	0.424666	0.423091	−0.00876	0.419482	0.42462	0.425848	0.422636	−0.01785	0.416168	0.425681	0.9972	31	30
	Ammonia	12	0.438979	0.437352	−0.00848	0.433621	0.438932	0.440201	0.436881	−0.01726	0.430172	0.44003	0.9972	26	25
	LNG	13	0.997223	0.993526	−0.00373	0.98505	0.997116	1	0.992456	−0.0076	0.977296	0.999604	0.9972	2	3
	LPG	14	0.950732	0.947207	−0.00391	0.939126	0.95063	0.953381	0.946189	−0.00797	0.931739	0.953002	0.9972	8	8
	H2 Liq	15	0.146466	0.145924	−0.0254	0.144679	0.146451	0.146874	0.145765	−0.0518	0.143513	0.146815	0.9972	41	40
	H2 Gas	16	0.154052	0.153481	−0.02415	0.152171	0.154035	0.154476	0.153291	−0.05005	0.150825	0.154431	0.9973	38	38
10 day	VLSFO	17	0.8951	0.891782	−0.00416	0.884173	0.895004	0.900763	0.894684	−0.00754	0.884663	0.900477	0.9937	15	12
	MGO	18	0.816976	0.813947	−0.00455	0.807003	0.816889	0.822142	0.816594	−0.00826	0.807448	0.821882	0.9937	21	19
	Methanol	19	0.422672	0.421105	−0.0088	0.417513	0.422627	0.425327	0.422456	−0.01598	0.417728	0.425212	0.9938	33	31
	Ammonia	20	0.435924	0.434308	−0.00854	0.430603	0.435878	0.438655	0.435699	−0.01547	0.430829	0.43855	0.9938	27	26
	LNG	21	0.993751	0.990067	−0.00374	0.98162	0.993645	1	0.993244	−0.0068	0.982122	0.999698	0.9938	3	1
	LPG	22	0.947569	0.944057	−0.00393	0.936002	0.947468	0.953531	0.94709	−0.00713	0.936484	0.953241	0.9937	9	6
	H2 Liq	23	0.144776	0.144239	−0.0257	0.143009	0.14476	0.145678	0.144697	−0.04653	0.143086	0.145633	0.9938	42	41
	H2 Gas	24	0.147025	0.14648	−0.02531	0.14523	0.147009	0.147904	0.146908	−0.04585	0.14533	0.147815	0.9941	40	39
15 day	VLSFO	25	0.89358	0.890268	−0.00416	0.882672	0.893485	0.902421	0.895706	−0.00831	0.882932	0.902052	0.9902	16	11
	MGO	26	0.815498	0.812475	−0.00456	0.805543	0.815411	0.823562	0.817437	−0.0091	0.805786	0.823233	0.9902	22	18
	Methanol	27	0.420679	0.419119	−0.00884	0.415544	0.420634	0.424797	0.421665	−0.01749	0.415754	0.424656	0.9903	34	32
	Ammonia	28	0.43287	0.431265	−0.0086	0.427586	0.432823	0.437086	0.433881	−0.0169	0.427877	0.43695	0.9904	28	27
	LNG	29	0.990279	0.986608	−0.00376	0.978191	0.990174	1	0.992596	−0.00746	0.978592	0.999666	0.9903	4	2
	LPG	30	0.944407	0.940906	−0.00394	0.932878	0.944306	0.953684	0.946621	−0.00782	0.933265	0.953363	0.9903	10	7
	H2 Liq	31	0.143085	0.142555	−0.026	0.141339	0.14307	0.144465	0.143414	−0.05069	0.141485	0.14441	0.9905	43	43
	H2 Gas	32	0.139998	0.13948	−0.02658	0.13829	0.139984	0.141234	0.140252	−0.04957	0.138465	0.141076	0.9912	45	45
20 day	VLSFO	33	0.892061	0.888754	−0.00417	0.881171	0.891965	0.904126	0.892738	−0.01411	0.866557	0.903287	0.9867	17	14
	MGO	34	0.81402	0.811002	−0.00457	0.804083	0.813933	0.825022	0.814674	−0.0154	0.790797	0.824257	0.9867	23	20
	Methanol	35	0.418685	0.417133	−0.00889	0.413575	0.418641	0.424261	0.419397	−0.02733	0.407271	0.423929	0.9869	35	33
	Ammonia	36	0.429815	0.428222	−0.00866	0.424568	0.429769	0.435495	0.430768	−0.0252	0.419313	0.435134	0.987	29	29
	LNG	37	0.986807	0.983149	−0.00377	0.974762	0.986702	1	0.988142	−0.012	0.95957	0.999245	0.9868	5	4
	LPG	38	0.941244	0.937755	−0.00395	0.929754	0.941144	0.95384	0.942483	−0.01263	0.915183	0.953118	0.9868	11	9
	H2 Liq	39	0.141394	0.14087	−0.02631	0.139668	0.141379	0.143234	0.141739	−0.07362	0.138159	0.143123	0.9872	44	44
	H2 Gas	40	0.132972	0.132479	−0.02798	0.131349	0.132958	0.13447	0.133305	−0.06497	0.131069	0.134271	0.9889	47	47
30 day	VLSFO	41	0.889021	0.885726	−0.00419	0.878169	0.888927	1	0.741444	−0.25234	0.534076	0.998077	0.889	18	24
	MGO	42	0.811064	0.808057	−0.00459	0.801163	0.810978	0.907101	0.741646	−0.24594	0.491671	0.906034	0.8941	24	23
	Methanol	43	0.414699	0.413162	−0.00897	0.409637	0.414655	0.423176	0.387464	−0.2178	0.275818	0.42206	0.98	36	36
	Ammonia	44	0.423705	0.422135	−0.00878	0.418533	0.42366	0.432278	0.40359	−0.16444	0.297712	0.432	0.9802	32	35
	LNG	45	0.979864	0.976232	−0.0038	0.967903	0.979759	1	0.893411	−0.11931	0.637629	0.991569	0.9799	6	13
	LPG	46	0.934919	0.931453	−0.00398	0.923507	0.934819	0.96266	0.852854	−0.13375	0.613848	0.959478	0.9712	12	17
	H2 Liq	47	0.138013	0.137501	−0.02696	0.136328	0.137998	0.140746	0.133988	−0.35835	0.120724	0.140667	0.9806	46	46
	H2 Gas	48	0.118919	0.118478	−0.03129	0.117467	0.118906	0.120793	0.117727	−0.21559	0.11221	0.120506	0.9845	48	48

23500 TEU results/ CRS and VRS scores with ranks/ ECO efficiency 2050

BS Model	ECO Eff 2050	In: Fuel cost 2050	Out: TEU-mile										
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.542316	0.538995	−0.01136	0.532564	0.542228	0.54232	0.520009	−0.07912	0.392844	0.541633	1	25	31
2	0.553141	0.549753	−0.01114	0.543193	0.55305	0.553145	0.530386	−0.07757	0.400683	0.552444	1	19	29
3	0.464632	0.461786	−0.01326	0.456276	0.464556	0.464633	0.445424	−0.09282	0.336527	0.463967	1	33	39
4	1	0.993876	−0.00616	0.982017	0.999837	1	0.958394	−0.04341	0.72418	0.998229	1	1	4
5	0.618417	0.614629	−0.00996	0.607296	0.618316	0.61842	0.592927	−0.06952	0.447935	0.61764	1	7	18
6	0.607603	0.603881	−0.01014	0.596676	0.607503	0.607606	0.582565	−0.07074	0.440105	0.606839	1	12	20
7	0.44211	0.439403	−0.01394	0.43416	0.442038	0.442509	0.424165	−0.09773	0.320492	0.44174	0.9991	40	44
8	0.487556	0.48457	−0.01264	0.478788	0.487476	0.491167	0.471051	−0.08694	0.356012	0.490609	0.9926	31	32
9	0.541582	0.538265	−0.01138	0.531843	0.541494	0.544637	0.539774	−0.01654	0.529432	0.544329	0.9944	26	26
10	0.552343	0.54896	−0.01116	0.54241	0.552252	0.555458	0.550497	−0.01622	0.53995	0.555144	0.9944	20	23
11	0.462894	0.460059	−0.01331	0.454569	0.462818	0.465485	0.461315	−0.01942	0.45248	0.465234	0.9944	34	36
12	0.994464	0.988373	−0.0062	0.97658	0.994301	1	0.99101	−0.00907	0.972043	0.999431	0.9945	2	2
13	0.616699	0.612922	−0.00999	0.605609	0.616598	0.620163	0.614615	−0.01455	0.602841	0.619829	0.9944	8	13
14	0.60599	0.602279	−0.01017	0.595092	0.605891	0.609395	0.603944	−0.01481	0.592374	0.609064	0.9944	13	16
15	0.438065	0.435382	−0.01407	0.430187	0.437993	0.440501	0.436523	−0.02069	0.428195	0.440242	0.9945	41	40
16	0.470391	0.467511	−0.0131	0.461932	0.470315	0.472985	0.468555	−0.01999	0.459841	0.472667	0.9945	32	33
17	0.540664	0.537353	−0.0114	0.530941	0.540576	0.547607	0.543116	−0.0151	0.533881	0.547352	0.9873	27	25
18	0.551345	0.547969	−0.01118	0.54143	0.551255	0.558423	0.553843	−0.01481	0.544424	0.558165	0.9873	21	22
19	0.460721	0.457899	−0.01337	0.452436	0.460645	0.466577	0.46275	−0.01773	0.454863	0.466413	0.9874	35	34
20	0.987543	0.981495	−0.00624	0.969784	0.987382	1	0.991781	−0.00829	0.974861	0.999561	0.9875	3	1
21	0.614552	0.610789	−0.01003	0.603501	0.614452	0.622397	0.617294	−0.01328	0.60678	0.622149	0.9874	9	11
22	0.603974	0.600275	−0.0102	0.593113	0.603875	0.611688	0.606673	−0.01351	0.596341	0.61144	0.9874	15	14
23	0.433008	0.430356	−0.01423	0.425221	0.432937	0.438441	0.434875	−0.01871	0.427445	0.43823	0.9876	42	41
24	0.448936	0.446187	−0.01373	0.440863	0.448863	0.454341	0.45088	−0.01689	0.443154	0.454055	0.9881	39	37
25	0.539746	0.536441	−0.01142	0.53004	0.539658	0.550663	0.543346	−0.02446	0.510498	0.55023	0.9802	28	24
26	0.550348	0.546977	−0.0112	0.540451	0.550258	0.561474	0.554032	−0.02392	0.52058	0.561045	0.9802	22	21
27	0.458548	0.45574	−0.01344	0.450302	0.458473	0.467701	0.461711	−0.02774	0.43495	0.467331	0.9804	36	35
28	0.980623	0.974617	−0.00628	0.962988	0.980463	1	0.987409	−0.01275	0.932229	0.999041	0.9806	4	3
29	0.612405	0.608655	−0.01006	0.601392	0.612305	0.624695	0.616602	−0.02101	0.580208	0.624257	0.9803	10	12
30	0.601958	0.598272	−0.01024	0.591133	0.60186	0.614047	0.606078	−0.02141	0.570225	0.613623	0.9803	16	15
31	0.427951	0.425331	−0.0144	0.420256	0.427881	0.43632	0.431097	−0.02777	0.408884	0.435898	0.9808	43	42
32	0.427481	0.424863	−0.01441	0.419793	0.427411	0.435137	0.430896	−0.02262	0.423277	0.434516	0.9824	44	43
33	0.538829	0.535529	−0.01144	0.529139	0.538741	0.553899	0.524664	−0.1006	0.426746	0.553152	0.9728	29	30
34	0.549351	0.545986	−0.01122	0.539472	0.549261	0.564704	0.535059	−0.09811	0.435158	0.563952	0.9728	23	27
35	0.456375	0.45358	−0.0135	0.448168	0.456301	0.468891	0.446653	−0.10618	0.362882	0.468656	0.9733	37	38
36	0.973703	0.96774	−0.00633	0.956193	0.973544	1	0.954226	−0.04797	0.776518	0.999227	0.9737	5	5
37	0.610258	0.606521	−0.0101	0.599284	0.610158	0.627129	0.596448	−0.08203	0.484495	0.626762	0.9731	11	17
38	0.599943	0.596268	−0.01027	0.589154	0.599844	0.616545	0.586198	−0.08397	0.476212	0.6161	0.9731	17	19
39	0.422895	0.420305	−0.01457	0.41529	0.422826	0.434138	0.415476	−0.10346	0.339927	0.43378	0.9741	45	45
40	0.406025	0.403538	−0.01518	0.398723	0.405959	0.415375	0.404289	−0.06601	0.35585	0.414818	0.9775	47	46
41	0.536993	0.533704	−0.01148	0.527336	0.536905	1	0.72497	−0.37937	0.630566	0.999023	0.537	30	10
42	0.547356	0.544004	−0.01126	0.537513	0.547266	1	0.787692	−0.26953	0.642003	0.996288	0.5474	24	8
43	0.45203	0.449261	−0.01363	0.443901	0.451956	0.62923	0.531396	−0.29259	0.433715	0.626669	0.7184	38	28
44	0.959862	0.953984	−0.00642	0.942601	0.959705	1	0.779348	−0.28312	0.651892	0.997094	0.9599	6	9
45	0.605964	0.602253	−0.01017	0.595067	0.605865	0.955102	0.819006	−0.17398	0.657667	0.953389	0.6344	14	6
46	0.595911	0.592261	−0.01034	0.585195	0.595814	0.953188	0.812751	−0.18128	0.654439	0.948879	0.6252	18	7
47	0.412781	0.410253	−0.01493	0.405358	0.412714	0.429672	0.347218	−0.55268	0.286077	0.428635	0.9607	46	47
48	0.363114	0.36089	−0.01697	0.356584	0.363055	0.374947	0.333329	−0.33299	0.277391	0.374229	0.9684	48	48

23500 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2021

BS Model	ENV Eff 2021	In: Fuel cost 2021, All emissions	Out: TEU-mile								Cant Calculate		
DMUs	result_crs.score	result_crs.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	result_vrs.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.897835	0.893415	−0.00551	0.881037	0.897576	0.897836	0.887637	−0.0128	0.84727	0.897209	1	28	37
2	0.872784	0.868175	−0.00608	0.858295	0.872702	0.872785	0.863134	−0.01281	0.841019	0.871856	1	34	42
3	0.842178	0.839268	−0.00412	0.832174	0.841902	0.842182	0.833742	−0.01202	0.818172	0.841528	1	41	48
4	1	0.988595	−0.01154	0.942929	0.999669	1	0.960987	−0.0406	0.864839	0.998797	1	6	25
5	1	0.991352	−0.00872	0.974895	0.999349	1	0.97362	−0.02709	0.883884	0.998248	1	2	20
6	0.993254	0.989205	−0.00412	0.978483	0.992975	0.993254	0.977033	−0.01672	0.895853	0.992565	1	4	18
7	1	0.992875	−0.00718	0.98163	0.999735	1	0.97774	−0.02277	0.886126	0.998909	1	1	16
8	1	0.990158	−0.00994	0.96068	0.999625	1	0.947832	−0.05504	0.864265	0.999685	1	3	31
9	0.896619	0.892205	−0.00552	0.879844	0.896361	0.899128	0.893468	−0.00705	0.883751	0.898746	0.9972	29	36
10	0.871525	0.866923	−0.00609	0.857057	0.871443	0.874088	0.868813	−0.00695	0.862655	0.873757	0.9971	36	41
11	0.839027	0.836128	−0.00413	0.82906	0.838752	0.845888	0.841038	−0.00682	0.836494	0.845349	0.9919	42	47
12	0.994464	0.983122	−0.0116	0.937709	0.994134	1	0.985907	−0.01429	0.954608	0.999654	0.9945	11	11
13	0.997223	0.988599	−0.00875	0.972188	0.996573	1	0.989524	−0.01059	0.971275	0.999591	0.9972	5	1
14	0.990617	0.98658	−0.00413	0.975886	0.99034	0.99358	0.987601	−0.00609	0.979054	0.993212	0.997	7	7
15	0.99085	0.98379	−0.00724	0.972648	0.990587	1	0.985692	−0.01452	0.960251	0.999	0.9908	9	12
16	0.964795	0.955299	−0.0103	0.926859	0.964434	1	0.971958	−0.02885	0.885787	0.998703	0.9648	23	22
17	0.8951	0.890693	−0.00553	0.878353	0.894841	0.900763	0.895122	−0.007	0.883953	0.899973	0.9937	30	35
18	0.869951	0.865358	−0.0061	0.855509	0.869869	0.875737	0.870787	−0.00649	0.864499	0.875162	0.9934	37	40
19	0.835089	0.832203	−0.00415	0.825169	0.834815	0.84663	0.841292	−0.00749	0.835669	0.846172	0.9864	43	46
20	0.987543	0.976281	−0.01168	0.931183	0.987216	1	0.987785	−0.01237	0.967732	0.998471	0.9875	16	6
21	0.993751	0.985157	−0.00878	0.968803	0.993104	1	0.989237	−0.01088	0.967104	0.998598	0.9938	8	2
22	0.987322	0.983298	−0.00414	0.97264	0.987046	0.993853	0.987821	−0.00614	0.981293	0.993347	0.9934	10	5
23	0.979412	0.972434	−0.00733	0.961421	0.979153	1	0.98493	−0.0153	0.960345	0.997522	0.9794	17	13
24	0.920789	0.911726	−0.0108	0.884583	0.920444	1	0.970936	−0.02993	0.895675	0.998606	0.9208	27	23
25	0.89358	0.889181	−0.00554	0.876861	0.893322	0.902421	0.896657	−0.00712	0.887116	0.901839	0.9902	31	34
26	0.868377	0.863792	−0.00611	0.853962	0.868296	0.87741	0.87184	−0.00728	0.864467	0.876685	0.9897	38	39
27	0.831151	0.828279	−0.00417	0.821277	0.830878	0.850103	0.845368	−0.00659	0.83901	0.849077	0.9777	44	45
28	0.980623	0.969439	−0.01176	0.924658	0.980298	1	0.98605	−0.01415	0.923166	0.999374	0.9806	20	10
29	0.990279	0.981715	−0.00881	0.965419	0.989634	1	0.98886	−0.01127	0.960428	0.99905	0.9903	12	3
30	0.984027	0.980016	−0.00416	0.969393	0.983751	0.994128	0.987969	−0.00627	0.979749	0.99347	0.9898	13	4
31	0.967975	0.961078	−0.00741	0.950193	0.967718	1	0.983999	−0.01626	0.947869	0.999284	0.968	22	14
32	0.876783	0.868153	−0.01134	0.842307	0.876454	1	0.974181	−0.0265	0.901441	0.999294	0.8768	35	19
33	0.892061	0.887669	−0.00555	0.87537	0.891803	0.904126	0.896834	−0.00899	0.880056	0.90332	0.9867	32	33
34	0.866804	0.862227	−0.00612	0.852414	0.866722	0.879131	0.871945	−0.00938	0.856296	0.878278	0.986	39	38
35	0.827212	0.824354	−0.00419	0.817386	0.826941	0.85214	0.846707	−0.00753	0.835863	0.850963	0.9707	46	43
36	0.973703	0.962598	−0.01185	0.918133	0.97338	1	0.98016	−0.02024	0.902303	0.999437	0.9737	21	15
37	0.986807	0.978273	−0.00884	0.962034	0.986165	1	0.98748	−0.01268	0.947482	0.998715	0.9868	14	8
38	0.980732	0.976735	−0.00417	0.966147	0.980457	0.994556	0.987357	−0.00733	0.974262	0.994045	0.9861	15	9
39	0.956537	0.949722	−0.0075	0.938966	0.956284	1	0.977112	−0.02342	0.911276	0.99893	0.9565	24	17
40	0.832777	0.82458	−0.01194	0.800032	0.832465	1	0.967765	−0.03331	0.88279	0.999323	0.8328	45	24
41	0.889021	0.884645	−0.00556	0.872388	0.888765	1	0.896834	−0.03331	0.862792	0.994355	0.889	33	32
42	0.863656	0.859096	−0.00615	0.849319	0.863575	1	0.95579	−0.04626	0.866224	0.998673	0.8637	40	26
43	0.819335	0.816504	−0.00423	0.809603	0.819067	0.857343	0.845658	−0.01612	0.829099	0.856164	0.9557	47	44
44	0.959862	0.948915	−0.01202	0.905082	0.959544	1	0.95184	−0.0506	0.866532	0.999454	0.9599	25	28
45	0.979864	0.97139	−0.0089	0.955265	0.979226	1	0.97343	−0.0273	0.885782	0.999535	0.9799	18	21
46	0.974141	0.970171	−0.0042	0.959655	0.973868	1	0.949	−0.05374	0.866227	0.999147	0.9741	19	29
47	0.933662	0.92701	−0.00769	0.916511	0.933415	1	0.954954	−0.04717	0.863908	0.9984	0.9337	26	27
48	0.744764	0.737434	−0.01335	0.71548	0.744485	1	0.948457	−0.05434	0.86342	0.998826	0.7448	48	30

23500 TEU results/ CRS and VRS scores with ranks/ ENV efficiency 2050

BS Model	ENV Eff 2050	In: Fuel cost 2050, All emissions	Out: TEU-mile										
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.542316	0.538231	−0.014	0.529483	0.542121	0.54232	0.521548	−0.07344	0.446451	0.541893	1	43	46
2	0.553141	0.547067	−0.02007	0.535317	0.552847	0.553145	0.513582	−0.13926	0.430513	0.552114	1	37	47
3	0.660054	0.654342	−0.01322	0.642871	0.659364	0.660069	0.640101	−0.04726	0.549158	0.65956	1	31	37
4	1	0.957742	−0.04412	0.819551	0.999199	1	0.834304	−0.1986	0.685999	0.996397	1	5	21
5	0.783974	0.778413	−0.00911	0.766883	0.783447	0.783988	0.760576	−0.03926	0.645758	0.783263	1	18	31
6	0.776153	0.771083	−0.00847	0.762235	0.775724	0.776167	0.75442	−0.03714	0.640605	0.77563	1	21	32
7	1	0.98093	−0.01944	0.880307	0.999538	1	0.924059	−0.08218	0.692792	0.997242	1	1	11
8	1	0.959332	−0.04239	0.818065	0.997933	1	0.86089	−0.16159	0.686887	0.999172	1	4	16
9	0.541582	0.537502	−0.01401	0.528766	0.541387	0.544637	0.538865	−0.01967	0.526901	0.544215	0.9944	44	43
10	0.552343	0.546278	−0.0201	0.534545	0.55205	0.555458	0.546463	−0.02963	0.529377	0.554762	0.9944	38	40
11	0.657584	0.651894	−0.01327	0.640466	0.656897	0.669398	0.661079	−0.0188	0.64926	0.66758	0.9824	32	36
12	0.994464	0.95244	−0.04437	0.815014	0.993667	1	0.95314	−0.04916	0.839151	0.998574	0.9945	6	6
13	0.781796	0.776251	−0.00914	0.764753	0.781271	0.792314	0.784017	−0.01336	0.7715	0.790768	0.9867	19	28
14	0.774093	0.769037	−0.00849	0.760212	0.773665	0.78473	0.776666	−0.01323	0.764159	0.783765	0.9864	23	30
15	0.99085	0.971955	−0.01962	0.872252	0.990392	1	0.971493	−0.02934	0.888066	0.998802	0.9908	2	2
16	0.964795	0.925559	−0.04394	0.789265	0.962801	1	0.927197	−0.07852	0.821932	0.997815	0.9648	12	10
17	0.540664	0.536591	−0.01404	0.52787	0.54047	0.547607	0.542681	−0.01658	0.534576	0.547364	0.9873	45	42
18	0.551345	0.545292	−0.02014	0.533579	0.551053	0.558423	0.550955	−0.02427	0.538456	0.558085	0.9873	39	38
19	0.654498	0.648834	−0.01334	0.63746	0.653813	0.678744	0.672244	−0.01425	0.662693	0.678361	0.9643	33	35
20	0.987543	0.945812	−0.04468	0.809342	0.986752	1	0.963344	−0.03805	0.830554	0.997457	0.9875	8	4
21	0.779075	0.773548	−0.00917	0.762091	0.778551	0.798741	0.790782	−0.0126	0.780408	0.798115	0.9754	20	27
22	0.771518	0.766478	−0.00852	0.757684	0.771091	0.791565	0.783968	−0.01224	0.77469	0.790789	0.9747	25	29
23	0.979412	0.960735	−0.01985	0.862183	0.97896	1	0.975943	−0.02465	0.90112	0.999119	0.9794	3	1
24	0.920789	0.883342	−0.04604	0.753265	0.918885	1	0.937885	−0.06623	0.811448	0.997471	0.9208	15	7
25	0.539746	0.535681	−0.01406	0.526974	0.539552	0.550663	0.54442	−0.02082	0.533477	0.550447	0.9802	46	41
26	0.550348	0.544305	−0.02017	0.532614	0.550056	0.561474	0.548549	−0.04196	0.482329	0.56112	0.9802	40	39
27	0.651411	0.645775	−0.0134	0.634454	0.65073	0.687596	0.681052	−0.01397	0.666147	0.687006	0.9474	34	34
28	0.980623	0.939184	−0.04499	0.803671	0.979837	1	0.956805	−0.04515	0.777127	0.999477	0.9806	9	5
29	0.776353	0.770846	−0.0092	0.759428	0.775831	0.807877	0.799573	−0.01285	0.7871	0.807285	0.961	22	24
30	0.768943	0.76392	−0.00855	0.755155	0.768518	0.800772	0.792778	−0.01259	0.782118	0.800173	0.9603	26	26
31	0.967975	0.949516	−0.02008	0.852115	0.967528	1	0.969786	−0.03116	0.853583	0.999234	0.968	7	3
32	0.876783	0.841126	−0.04835	0.717265	0.87497	1	0.932281	−0.07264	0.794255	0.998744	0.8768	16	8
33	0.538829	0.53477	−0.01409	0.526078	0.538635	0.553899	0.536153	−0.05976	0.45594	0.553657	0.9728	47	44
34	0.549351	0.543319	−0.02021	0.531649	0.549059	0.564704	0.534847	−0.09886	0.460327	0.563996	0.9728	41	45
35	0.648324	0.642715	−0.01346	0.631447	0.647647	0.694148	0.682863	−0.02381	0.637451	0.693303	0.934	35	33
36	0.973703	0.932556	−0.04531	0.797999	0.972923	1	0.9225	−0.08401	0.730379	0.997981	0.9737	11	12
37	0.773631	0.768144	−0.00923	0.756766	0.773111	0.816002	0.802228	−0.02104	0.738379	0.81508	0.9481	24	23
38	0.766368	0.761362	−0.00858	0.752626	0.765944	0.809136	0.795924	−0.02052	0.734499	0.808273	0.9471	28	25
39	0.956537	0.938296	−0.02032	0.842046	0.956096	1	0.930511	−0.07468	0.784074	0.998956	0.9565	10	9
40	0.832777	0.798909	−0.0509	0.681265	0.831055	1	0.900966	−0.10992	0.72394	0.997966	0.8328	17	14
41	0.536993	0.532948	−0.01413	0.524286	0.5368	1	0	Inf	0.685379	0.999274	0.537	48	48
42	0.547356	0.541346	−0.02028	0.529718	0.547065	1	0.861975	−0.16013	0.686433	0.99876	0.5474	42	15
43	0.642151	0.636595	−0.01359	0.625435	0.64148	0.857343	0.803839	−0.07764	0.600899	0.856505	0.749	36	22
44	0.959862	0.9193	−0.04597	0.786656	0.959093	1	0.857415	−0.1663	0.687541	0.998744	0.9599	13	17
45	0.768187	0.762739	−0.0093	0.751441	0.767672	1	0.909121	−0.09996	0.696987	0.998214	0.7682	27	13
46	0.761218	0.756246	−0.00864	0.747568	0.760797	1	0.853843	−0.17118	0.690646	0.999018	0.7612	29	18
47	0.933662	0.915857	−0.02082	0.821909	0.933231	1	0.851849	−0.17392	0.687021	0.998743	0.9337	14	19
48	0.744764	0.714476	−0.05692	0.609265	0.743225	1	0.842782	−0.18655	0.688264	0.999507	0.7448	30	20

350 TEU results/ Sensitivity analysis in conservative development scenario

BS Model	ENV Eff 2050 with reduction of Alternative fuels by 20-30%	In: Fuel cost 2050, All emissions	Out: TEU-mile											
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected	Rank Raw CRS
1	0.42301	0.41935	−0.0206	0.41062	0.42293	0.42301	0.40095	−0.1301	0.32517	0.42284	0.999993	42	46	43
2	0.43145	0.42328	−0.0447	0.39678	0.43136	0.43145	0.39982	−0.1833	0.32916	0.43128	0.999993	37	47	37
3	0.61116	0.6067	−0.012	0.5989	0.61083	0.61118	0.59114	−0.0555	0.48996	0.61069	0.999973	31	37	31
4	1	0.96099	−0.0406	0.75804	0.99888	1	0.84064	−0.1896	0.63778	0.99875	1	5	16	1
5	0.68253	0.67772	−0.0104	0.66871	0.68235	0.68255	0.66187	−0.0458	0.54187	0.68191	0.999976	19	31	19
6	0.67516	0.67056	−0.0102	0.66153	0.67488	0.67518	0.6552	−0.0451	0.53642	0.67472	0.999975	23	32	23
7	1	0.98673	−0.0135	0.9591	0.99932	1	0.91636	−0.0913	0.73099	0.99902	1	1	12	1
8	1	0.9702	−0.0307	0.83012	0.99929	1	0.83747	−0.1941	0.63516	0.99918	1	3	18	1
9	0.42243	0.41878	−0.0207	0.41006	0.42236	0.42482	0.41944	−0.0302	0.40082	0.42466	0.99439	44	45	44
10	0.43083	0.42267	−0.0448	0.39621	0.43074	0.43326	0.42523	−0.0436	0.40482	0.43295	0.994392	38	40	38
11	0.60887	0.60443	−0.0121	0.59666	0.60855	0.62091	0.61421	−0.0176	0.60212	0.62033	0.980616	32	36	32
12	0.99446	0.95567	−0.0408	0.75384	0.99335	1	0.95148	−0.051	0.80392	0.998	0.994464	6	5	4
13	0.68063	0.67584	−0.0104	0.66685	0.68046	0.69232	0.68595	−0.0134	0.67482	0.69189	0.983126	20	29	20
14	0.67337	0.66878	−0.0102	0.65977	0.67309	0.68511	0.67889	−0.0134	0.66768	0.68476	0.982862	25	30	25
15	0.99085	0.9777	−0.0136	0.95032	0.99018	1	0.97194	−0.0289	0.90747	0.99866	0.99085	2	2	5
16	0.9648	0.93604	−0.0318	0.8009	0.96411	1	0.92689	−0.0789	0.77332	0.99933	0.964795	11	9	11
17	0.42172	0.41807	−0.0207	0.40936	0.42164	0.42713	0.42282	−0.0239	0.4177	0.42681	0.987321	45	42	45
18	0.43005	0.42191	−0.0449	0.3955	0.42996	0.43557	0.42934	−0.0333	0.42361	0.43524	0.987326	39	39	39
19	0.60602	0.60159	−0.0121	0.59386	0.60569	0.63142	0.62595	−0.0139	0.61865	0.63055	0.959764	33	35	33
20	0.98754	0.94902	−0.0411	0.7486	0.98644	1	0.95909	−0.0427	0.77496	0.99919	0.987543	8	4	6
21	0.67826	0.67349	−0.0105	0.66453	0.67809	0.70197	0.69607	−0.0121	0.68628	0.7015	0.96623	21	27	21
22	0.67113	0.66655	−0.0102	0.65758	0.67085	0.69509	0.68938	−0.0119	0.6806	0.69456	0.965535	26	28	26
23	0.97941	0.96641	−0.0137	0.93935	0.97875	1	0.97574	−0.0249	0.90856	0.99898	0.979412	4	1	8
24	0.92079	0.89335	−0.0334	0.76437	0.92013	1	0.93327	−0.0715	0.76322	0.99906	0.920789	15	8	15
25	0.421	0.41736	−0.0207	0.40867	0.42093	0.42952	0.42522	−0.0235	0.42007	0.42935	0.980175	46	41	46
26	0.42927	0.42115	−0.0449	0.39478	0.42919	0.43795	0.42943	−0.0453	0.36961	0.43761	0.980184	40	38	40
27	0.60316	0.59876	−0.0122	0.59105	0.60283	0.64068	0.63587	−0.0118	0.6287	0.64024	0.94144	34	34	34
28	0.98062	0.94237	−0.0414	0.74335	0.97953	1	0.94416	−0.0591	0.76166	0.99882	0.980623	10	7	7
29	0.67589	0.67113	−0.0105	0.66221	0.67572	0.7117	0.70604	−0.0113	0.69833	0.71121	0.949695	22	24	22
30	0.66889	0.66433	−0.0103	0.65539	0.66862	0.70499	0.6996	−0.0109	0.69183	0.70443	0.948794	27	26	27
31	0.96797	0.95513	−0.0139	0.92838	0.96732	1	0.96861	−0.0324	0.84857	0.99774	0.967975	7	3	10
32	0.87678	0.85065	−0.035	0.72784	0.87616	1	0.91909	−0.088	0.74936	0.99798	0.876783	16	11	16
33	0.42029	0.41665	−0.0208	0.40797	0.42021	0.43204	0.41956	−0.0688	0.34012	0.43176	0.972792	47	44	47
34	0.42849	0.42038	−0.045	0.39407	0.42841	0.44047	0.42074	−0.1065	0.34036	0.4402	0.972811	41	43	41
35	0.6003	0.59592	−0.0123	0.58825	0.59998	0.64755	0.63837	−0.0222	0.60005	0.64707	0.92704	35	33	35
36	0.9737	0.93571	−0.0417	0.7381	0.97261	1	0.92069	−0.0861	0.74034	0.99809	0.973703	12	10	9
37	0.67352	0.66878	−0.0105	0.65989	0.67335	0.72001	0.70877	−0.022	0.64775	0.71951	0.935437	24	23	24
38	0.66665	0.6621	−0.0103	0.65319	0.66638	0.71336	0.70255	−0.0216	0.64335	0.7127	0.934517	29	25	29
39	0.95654	0.94384	−0.0141	0.91742	0.95589	1	0.9481	−0.0547	0.78854	0.99934	0.956537	9	6	13
40	0.83278	0.80796	−0.0369	0.69131	0.83218	1	0.87444	−0.1436	0.7048	0.99777	0.832777	17	14	17
41	0.41885	0.41523	−0.0208	0.40658	0.41878	1	0	Inf	0.63519	0.99913	0.418854	48	48	48
42	0.42694	0.41886	−0.0452	0.39263	0.42685	1	0.8174	−0.2234	0.63508	0.99866	0.426937	43	20	42
43	0.59458	0.59024	−0.0124	0.58265	0.59426	0.86316	0.81268	−0.072	0.64156	0.86277	0.688845	36	21	36
44	0.95986	0.92241	−0.0423	0.72761	0.95879	1	0.82359	−0.2142	0.63615	0.99866	0.959862	13	19	12
45	0.66879	0.66408	−0.0106	0.65525	0.66861	0.99799	0.90495	−0.103	0.6485	0.99753	0.670133	28	13	28
46	0.66217	0.65765	−0.0104	0.6488	0.6619	1	0.85235	−0.1732	0.64033	0.99844	0.66217	30	15	30
47	0.93366	0.92127	−0.0144	0.89548	0.93303	1	0.83867	−0.1924	0.63528	0.99875	0.933662	14	17	14
48	0.74476	0.72257	−0.0412	0.61825	0.74423	1	0.7921	−0.2625	0.63693	0.99784	0.744764	18	22	18

350 TEU results/ Sensitivity analysis in accelerated development scenario

BS Model	ENV Eff 2050 with reduction of Alternative fuels by 40-60%	In: Fuel cost 2050, All emissions	Out: TEU-mile										
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.38324	0.38061	−0.018	0.37315	0.38312	0.38324	0.36611	−0.1221	0.29129	0.38293	0.999993	43	46
2	0.39089	0.38601	−0.0323	0.37109	0.39077	0.39089	0.36276	−0.1983	0.2811	0.39057	0.999993	37	47
3	0.52538	0.52191	−0.0127	0.51447	0.52501	0.5254	0.50483	−0.0776	0.37177	0.52523	0.999968	31	37
4	1	0.95999	−0.0417	0.75953	0.99937	1	0.82309	−0.2149	0.62577	0.99901	1	4	17
5	0.54625	0.54267	−0.0121	0.53499	0.54596	0.54627	0.52584	−0.0711	0.38717	0.54585	0.999968	19	35
6	0.53852	0.535	−0.0122	0.52735	0.53831	0.53854	0.51832	−0.0725	0.3814	0.53791	0.999967	24	36
7	1	0.98673	−0.0135	0.96342	0.99918	1	0.88653	−0.128	0.62178	0.99928	1	1	13
8	1	0.94902	−0.0537	0.68488	0.99929	1	0.77594	−0.2888	0.61885	0.99798	1	7	22
9	0.38272	0.3801	−0.018	0.37264	0.38261	0.38488	0.38031	−0.0312	0.37299	0.38473	0.99439	44	43
10	0.39032	0.38545	−0.0324	0.37055	0.3902	0.39252	0.38642	−0.0403	0.3749	0.39237	0.994392	38	40
11	0.52342	0.51996	−0.0127	0.51254	0.52305	0.53543	0.52977	−0.0199	0.51959	0.53471	0.977571	32	34
12	0.99446	0.95467	−0.0419	0.75532	0.99384	1	0.94914	−0.0536	0.7418	0.99822	0.994464	6	5
13	0.54473	0.54116	−0.0121	0.5335	0.54444	0.55682	0.55124	−0.0182	0.5412	0.55657	0.978291	20	31
14	0.53709	0.53358	−0.0123	0.52595	0.53688	0.54917	0.54357	−0.0188	0.53355	0.54892	0.978014	25	32
15	0.99085	0.9777	−0.0136	0.95461	0.99004	1	0.96927	−0.0317	0.89786	0.99801	0.99085	2	2
16	0.9648	0.91561	−0.0557	0.66077	0.96411	1	0.91912	−0.088	0.74573	0.99874	0.964795	14	10
17	0.38207	0.37945	−0.0181	0.37201	0.38196	0.38697	0.38312	−0.026	0.37879	0.38678	0.987321	45	42
18	0.38962	0.38476	−0.0324	0.36988	0.3895	0.39462	0.38911	−0.0358	0.37804	0.3944	0.987326	39	39
19	0.52096	0.51752	−0.0128	0.51014	0.5206	0.54732	0.54317	−0.014	0.53619	0.54695	0.951844	33	33
20	0.98754	0.94803	−0.0422	0.75007	0.98692	1	0.95585	−0.0462	0.72998	0.99942	0.987543	8	4
21	0.54283	0.53927	−0.0122	0.53165	0.54255	0.56922	0.56499	−0.0131	0.55792	0.56905	0.953652	21	27
22	0.53531	0.5318	−0.0123	0.5242	0.53509	0.56175	0.5576	−0.0133	0.55057	0.56148	0.952924	26	29
23	0.97941	0.96641	−0.0137	0.94359	0.97861	1	0.97156	−0.0293	0.89608	0.99879	0.979412	3	1
24	0.92079	0.87384	−0.0583	0.63063	0.92014	1	0.93223	−0.0727	0.71671	0.99952	0.920789	15	7
25	0.38142	0.37881	−0.0181	0.37138	0.38131	0.38913	0.38451	−0.0309	0.37799	0.38889	0.980175	46	41
26	0.38891	0.38406	−0.0325	0.36921	0.38879	0.39677	0.39115	−0.0362	0.38441	0.39651	0.980184	40	38
27	0.51851	0.51508	−0.0128	0.50773	0.51814	0.55828	0.5535	−0.0155	0.54401	0.55776	0.928751	34	30
28	0.98062	0.94138	−0.0425	0.74481	0.98	1	0.94485	−0.0584	0.7203	0.99912	0.980623	10	6
29	0.54094	0.53739	−0.0122	0.52979	0.54065	0.58072	0.57575	−0.0149	0.56922	0.58022	0.9315	22	24
30	0.53352	0.53003	−0.0124	0.52245	0.53331	0.57347	0.56861	−0.0149	0.56002	0.57298	0.930334	28	26
31	0.96797	0.95512	−0.0139	0.93257	0.96719	1	0.95593	−0.0461	0.79197	0.99874	0.967975	5	3
32	0.87678	0.83208	−0.0613	0.60049	0.87616	1	0.92421	−0.082	0.70588	0.99899	0.876783	16	9
33	0.38077	0.37816	−0.0181	0.37075	0.38066	0.39142	0.37499	−0.112	0.30718	0.39101	0.972792	47	45
34	0.38821	0.38336	−0.0325	0.36854	0.38809	0.39906	0.38008	−0.1251	0.31282	0.39855	0.972811	41	44
35	0.51605	0.51264	−0.0129	0.50532	0.51568	0.56688	0.55968	−0.0227	0.54677	0.56595	0.910338	35	28
36	0.9737	0.93474	−0.0428	0.73955	0.97309	1	0.90896	−0.1002	0.70806	0.99856	0.973703	11	11
37	0.53904	0.53551	−0.0122	0.52793	0.53876	0.59038	0.58277	−0.0221	0.57257	0.58985	0.913035	23	23
38	0.53173	0.52825	−0.0124	0.5207	0.53152	0.58311	0.57547	−0.0228	0.56425	0.58226	0.911894	29	25
39	0.95654	0.94384	−0.0141	0.92155	0.95576	1	0.9245	−0.0817	0.6765	0.99756	0.956537	9	8
40	0.83278	0.79032	−0.0645	0.57035	0.83219	1	0.88298	−0.1325	0.68498	0.99788	0.832777	17	14
41	0.37947	0.37687	−0.0182	0.36948	0.37936	1	0	Inf	0.61859	0.99954	0.379474	48	48
42	0.3868	0.38197	−0.0327	0.36721	0.38668	1	0.80034	−0.2495	0.61925	0.99938	0.386797	42	18
43	0.51113	0.50776	−0.013	0.50051	0.51077	0.88806	0.8257	−0.085	0.60853	0.88698	0.575565	36	16
44	0.95986	0.92145	−0.0434	0.72904	0.95926	1	0.78939	−0.2668	0.61878	0.99937	0.959862	12	21
45	0.53525	0.53174	−0.0123	0.52422	0.53497	0.99678	0.88697	−0.1242	0.6242	0.99601	0.53698	27	12
46	0.52816	0.5247	−0.0125	0.5172	0.52795	1	0.83471	−0.198	0.62111	0.99852	0.528162	30	15
47	0.93366	0.92127	−0.0144	0.89951	0.9329	1	0.79355	−0.2602	0.61931	0.99876	0.933662	13	20
48	0.74476	0.70679	−0.0721	0.51008	0.74424	1	0.80021	−0.2497	0.62053	0.99895	0.744764	18	19

23500 TEU results/ Sensitivity analysis in conservative development scenario

BS Model	ENV Eff 2050 with 20-30% price reduction	In: Fuel cost 2050, All emissions	Out: TEU-mile										
DMUs	**result_crs.score**	**result_crs.score_bc**	**result_crs.bias**	**CI_low**	**CI_up**	**result_vrs.score**	**result_vrs.score_bc**	**result_vrs.bias**	**CI_low**	**CI_up**	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.424165	0.413228	−0.0624	0.370011	0.423785	0.424206	0.401687	−0.13215	0.324703	0.424126	0.999903	36	46
2	0.432606	0.415262	−0.09655	0.345651	0.432021	0.432647	0.39874	−0.19655	0.32595	0.432397	0.999905	35	47
3	0.617371	0.607	−0.02767	0.581213	0.61646	0.617593	0.601144	−0.04431	0.545826	0.61727	0.999639	28	36
4	1	0.914449	−0.09355	0.749508	0.997987	1	0.836313	−0.19572	0.65834	0.999228	1	4	14
5	0.688768	0.677913	−0.02325	0.6475	0.687774	0.688992	0.670653	−0.03969	0.596866	0.688503	0.999676	15	31
6	0.681504	0.671116	−0.02271	0.641604	0.680922	0.681731	0.66432	−0.03844	0.591824	0.681014	0.999667	16	32
7	1	0.963779	−0.03758	0.879812	0.998914	1	0.88513	−0.12978	0.640455	0.998304	1	1	11
8	1	0.924067	−0.08217	0.754927	0.996326	1	0.833181	−0.20022	0.636724	0.999547	1	3	15
9	0.42209	0.411206	−0.06271	0.3682	0.421712	0.431172	0.423809	−0.04029	0.398744	0.430959	0.978936	38	45
10	0.430351	0.413097	−0.09705	0.343849	0.429769	0.439601	0.428213	−0.0605	0.401409	0.438982	0.978957	37	44
11	0.609011	0.59878	−0.02805	0.573342	0.608112	0.646776	0.638429	−0.02021	0.625807	0.646484	0.94161	29	35
12	0.979937	0.896103	−0.09547	0.734471	0.977965	1	0.933834	−0.07085	0.784191	0.998934	0.979937	5	6
13	0.681848	0.671102	−0.02348	0.640995	0.680864	0.71897	0.70949	−0.01858	0.69564	0.718182	0.948369	17	28
14	0.674961	0.664674	−0.02293	0.635445	0.674386	0.712272	0.703169	−0.01818	0.689469	0.711596	0.947617	18	29
15	0.966763	0.931746	−0.03887	0.85057	0.965713	1	0.940885	−0.06283	0.837656	0.999072	0.966763	2	3
16	0.869894	0.803841	−0.09446	0.656707	0.866698	1	0.87802	−0.13893	0.723553	0.99886	0.869894	12	13
17	0.419495	0.408678	−0.0631	0.365937	0.41912	0.44076	0.43424	−0.03407	0.418933	0.440438	0.951753	40	43
18	0.427531	0.41039	−0.09769	0.341596	0.426953	0.449174	0.438841	−0.05242	0.414293	0.448341	0.951817	39	42
19	0.598561	0.588506	−0.02854	0.563505	0.597678	0.658563	0.650284	−0.01933	0.635869	0.657846	0.908888	30	34
20	0.954859	0.87317	−0.09798	0.715675	0.952937	1	0.941208	−0.06246	0.785828	0.997941	0.954859	7	2
21	0.673198	0.662588	−0.02379	0.632863	0.672227	0.734595	0.725268	−0.01751	0.708376	0.734075	0.916421	19	26
22	0.666783	0.656621	−0.02321	0.627746	0.666215	0.72834	0.71933	−0.0172	0.703556	0.727642	0.915484	20	27
23	0.925217	0.891705	−0.04062	0.814017	0.924212	1	0.94633	−0.05671	0.800578	0.999059	0.925217	6	1
24	0.707262	0.653558	−0.11618	0.533932	0.704664	1	0.88577	−0.12896	0.711823	0.998227	0.707262	22	10
25	0.416901	0.406151	−0.06349	0.363674	0.416528	0.451509	0.44294	−0.04285	0.393688	0.450723	0.92335	42	39
26	0.424712	0.407684	−0.09834	0.339344	0.424138	0.459905	0.445004	−0.07281	0.370019	0.458884	0.923478	41	38
27	0.588111	0.578232	−0.02905	0.553667	0.587243	0.672017	0.663456	−0.0192	0.6477	0.671317	0.875143	31	33
28	0.929781	0.850238	−0.10062	0.696879	0.927909	1	0.93537	−0.0691	0.765637	0.997077	0.929781	9	5
29	0.664549	0.654075	−0.0241	0.624732	0.66359	0.752367	0.743576	−0.01571	0.726236	0.751938	0.883278	21	24
30	0.658605	0.648567	−0.0235	0.620047	0.658044	0.746621	0.738198	−0.01528	0.721707	0.746044	0.882114	23	25
31	0.88367	0.851663	−0.04253	0.777464	0.882711	1	0.928577	−0.07692	0.783273	0.999117	0.88367	8	7
32	0.54463	0.503275	−0.15088	0.411156	0.542629	1	0.936208	−0.06814	0.777048	0.999367	0.54463	34	4
33	0.414306	0.403623	−0.06389	0.361411	0.413936	0.465006	0.442091	−0.11147	0.362163	0.46469	0.890969	44	40
34	0.421893	0.404978	−0.099	0.337091	0.421322	0.47338	0.439759	−0.16151	0.35499	0.47209	0.891234	43	41
35	0.577661	0.567957	−0.02958	0.543829	0.576808	0.689282	0.676734	−0.0269	0.65444	0.68701	0.838061	32	30
36	0.904703	0.827305	−0.10341	0.678082	0.902881	1	0.912841	−0.09548	0.705589	0.998832	0.904703	10	8
37	0.655899	0.645561	−0.02441	0.6166	0.654952	0.775079	0.762185	−0.02183	0.71836	0.773492	0.846235	24	22
38	0.650427	0.640514	−0.0238	0.612347	0.649873	0.769995	0.756879	−0.02251	0.715206	0.768296	0.844717	25	23
39	0.842124	0.811622	−0.04463	0.740911	0.84121	1	0.901271	−0.10954	0.674121	0.999594	0.842124	11	9
40	0.381998	0.352992	−0.21511	0.288381	0.380595	0.629314	0.585734	−0.11823	0.475277	0.628962	0.607008	47	37
41	0.409118	0.398568	−0.0647	0.356884	0.408751	1	0.812014	−0.23151	0.636997	0.998898	0.409118	46	18
42	0.416254	0.399566	−0.10034	0.332586	0.415692	1	0.785831	−0.27254	0.539073	0.999044	0.416254	45	21
43	0.556761	0.547408	−0.03069	0.524153	0.555939	0.863161	0.797744	−0.095	0.656833	0.860716	0.645025	33	20
44	0.854547	0.78144	−0.10948	0.64049	0.852826	1	0.802813	−0.24562	0.634503	0.997827	0.854547	13	19
45	0.638599	0.628534	−0.02508	0.600337	0.637677	0.99799	0.882768	−0.13079	0.692206	0.996448	0.639885	26	12
46	0.634072	0.624407	−0.02441	0.596949	0.633531	1	0.826083	−0.21053	0.660506	0.996882	0.634072	27	16
47	0.759031	0.731539	−0.04951	0.667805	0.758207	1	0.820361	−0.21898	0.593214	0.998545	0.759031	14	17
48	0.056734	0.052426	-1.44837	0.04283	0.056526	0.061279	0.055455	-1.71374	0.044741	0.061221	0.925833	48	48

23500 TEU results/ Sensitivity analysis in accelerated development scenario

BS Model	ENV Eff 2050 with 40-60% price reduction	In: Fuel cost 2050, All emissions	Out: TEU-mile										
DMUs	result_crs.score	result_crs.score_bc	result_crs.bias	CI_low	CI_up	result_vrs.score	result_vrs.score_bc	result_vrs.bias	CI_low	CI_up	Scale Efficiency	Rank CRS Corrected	Rank VRS Corrected
1	0.384286	0.376704	−0.05238	0.340586	0.384214	0.384323	0.364091	−0.14459	0.284679	0.384202	0.999903	37	46
2	0.391933	0.379382	−0.08441	0.327792	0.39186	0.391971	0.35788	−0.24302	0.285214	0.39182	0.999905	35	47
3	0.531774	0.524806	−0.02497	0.505873	0.531415	0.532004	0.50977	−0.08198	0.388858	0.531815	0.999568	23	37
4	1	0.938105	−0.06598	0.75023	0.999731	1	0.803992	−0.24379	0.621589	0.998164	1	2	15
5	0.552975	0.545925	−0.02336	0.528911	0.552493	0.553217	0.530649	−0.07688	0.404658	0.552687	0.999563	16	35
6	0.545298	0.538332	−0.02373	0.520551	0.544944	0.545541	0.523317	−0.07784	0.398811	0.544996	0.999554	18	36
7	1	0.961875	−0.03964	0.88984	0.998867	1	0.848356	−0.17875	0.679645	0.997408	1	1	12
8	1	0.912642	−0.09572	0.685792	0.998028	1	0.801681	−0.24738	0.623855	0.999533	1	5	16
9	0.382406	0.374861	−0.05263	0.338919	0.382334	0.390634	0.383842	−0.0453	0.367185	0.390389	0.978936	39	45
10	0.38989	0.377404	−0.08485	0.326083	0.389817	0.398271	0.387655	−0.06876	0.365446	0.397954	0.978957	36	44
11	0.524573	0.517699	−0.02531	0.499023	0.524219	0.567134	0.560444	−0.02105	0.547752	0.566525	0.924954	26	34
12	0.979937	0.919284	−0.06733	0.735178	0.979674	1	0.935667	−0.06876	0.768593	0.999323	0.979937	4	2
13	0.54742	0.54044	−0.02359	0.523598	0.546942	0.590438	0.5839	−0.01896	0.570379	0.589795	0.927142	17	29
14	0.540063	0.533165	−0.02396	0.515554	0.539712	0.583085	0.576593	−0.01931	0.563266	0.582873	0.926217	20	31
15	0.966763	0.929905	−0.041	0.860265	0.965668	1	0.927171	−0.07855	0.799439	0.998707	0.966763	3	4
16	0.869894	0.793902	−0.11004	0.596567	0.868179	1	0.842018	−0.18762	0.664313	0.998675	0.869894	13	13
17	0.380055	0.372557	−0.05296	0.336836	0.379984	0.399321	0.394511	−0.03053	0.382153	0.399128	0.951753	40	42
18	0.387336	0.374932	−0.08541	0.323946	0.387264	0.406944	0.399479	−0.04592	0.381906	0.406682	0.951817	38	40
19	0.515572	0.508816	−0.02575	0.49046	0.515224	0.578551	0.571519	−0.02127	0.556219	0.577732	0.891143	28	32
20	0.954859	0.895758	−0.0691	0.716364	0.954602	1	0.951004	−0.05152	0.73002	0.998829	0.954859	6	1
21	0.540475	0.533584	−0.0239	0.516955	0.540003	0.605083	0.597918	−0.0198	0.582205	0.60478	0.893225	19	26
22	0.533519	0.526705	−0.02425	0.509307	0.533173	0.598039	0.590875	−0.02027	0.575258	0.597377	0.892115	22	27
23	0.925217	0.889943	−0.04284	0.823295	0.924169	1	0.925103	−0.08096	0.719876	0.999213	0.925217	7	5
24	0.707262	0.645477	−0.13534	0.485035	0.705867	1	0.857752	−0.16584	0.698023	0.99877	0.707262	15	11
25	0.377705	0.370252	−0.05329	0.334753	0.377634	0.409059	0.403093	−0.03618	0.38317	0.408222	0.92335	42	39
26	0.384782	0.372459	−0.08598	0.32181	0.38471	0.416666	0.406087	−0.06252	0.348408	0.415335	0.923478	41	38
27	0.506571	0.499933	−0.02621	0.481898	0.506229	0.591634	0.583255	−0.02428	0.572065	0.590695	0.856223	31	30
28	0.929781	0.872232	−0.07096	0.69755	0.929531	1	0.933046	−0.07176	0.730739	0.998749	0.929781	8	3
29	0.533531	0.526728	−0.02421	0.510313	0.533065	0.621848	0.613279	−0.02247	0.601106	0.621224	0.857976	21	24
30	0.526976	0.520245	−0.02455	0.503061	0.526634	0.615164	0.606471	−0.0233	0.594858	0.614628	0.856643	24	25
31	0.88367	0.84998	−0.04485	0.786326	0.88267	1	0.912625	−0.09574	0.68949	0.998277	0.88367	9	6
32	0.54463	0.497052	−0.17575	0.373503	0.543556	1	0.908836	−0.10031	0.735976	0.999135	0.54463	32	7
33	0.375354	0.367948	−0.05362	0.33267	0.375284	0.421287	0.397907	−0.13947	0.320833	0.420958	0.890969	44	41
34	0.382228	0.369987	−0.08656	0.319674	0.382156	0.428874	0.391574	−0.22211	0.32201	0.428454	0.891234	43	43
35	0.49757	0.49105	−0.02669	0.473335	0.497234	0.608507	0.588629	−0.0555	0.510551	0.608054	0.81769	33	28
36	0.904703	0.848706	−0.07293	0.678735	0.904459	1	0.893912	−0.11868	0.680981	0.998183	0.904703	10	8
37	0.526586	0.519872	−0.02453	0.503671	0.526126	0.643441	0.620808	−0.05666	0.536228	0.642692	0.818391	25	22
38	0.520432	0.513785	−0.02486	0.496814	0.520095	0.637231	0.613776	−0.05997	0.531312	0.63675	0.816709	27	23
39	0.842124	0.810018	−0.04707	0.749356	0.84117	1	0.880991	−0.13509	0.681356	0.99866	0.842124	11	9
40	0.381998	0.348628	−0.25058	0.261971	0.381245	0.629314	0.564554	−0.18228	0.453898	0.628412	0.607008	47	33
41	0.370653	0.36334	−0.0543	0.328503	0.370584	1	0.795964	−0.25634	0.619697	0.996741	0.370653	46	18
42	0.377119	0.365042	−0.08773	0.315402	0.377049	1	0.773067	−0.29355	0.618294	0.998508	0.377119	45	21
43	0.479568	0.473283	−0.02769	0.456209	0.479244	0.888057	0.815126	−0.10075	0.621113	0.885841	0.540019	34	14
44	0.854547	0.801654	−0.07721	0.641106	0.854316	1	0.787699	−0.26952	0.61871	0.997698	0.854547	12	20
45	0.512697	0.50616	−0.02519	0.490386	0.51225	0.996776	0.867126	−0.15	0.634668	0.995096	0.514356	29	10
46	0.507345	0.500865	−0.0255	0.484321	0.507016	1	0.801528	−0.24762	0.628206	0.997684	0.507345	30	17
47	0.759031	0.730093	−0.05222	0.675417	0.758172	1	0.794371	−0.25886	0.618581	0.998347	0.759031	14	19
48	0.056734	0.051778	−1.68717	0.038908	0.056622	0.061279	0.053069	−2.52463	0.042018	0.061141	0.925833	48	48

Slack based measure ENV efficiency calculations for 350 TEU , 2050

SBM	ENV eff 2050	In: Fuel cost, All Emissions Out: TEU - mile	CRS Slacks					VRS SLACKS							
DMUs	efficiencies .result_crs_ sbm.	efficiencies .result_vrs_ sbm.	slack_input. Fuelcost.2050	slack_input. SOx	slack_input. GWP100	slack_input. PM10	TEU.Mle	slack_input. Fuelcost.2050.1	slack_input. SOx.1	slack_input. GWP100.1	slack_input. PM10.1	TEU.Mle.1	SE	Rank CRS	Rank VRS
1	0.20736	0.20738	0	0.2482161	47.565474	0.0755851	103461.3	18579.939	0.2492708	58.323458	0.0833899	0	0.9999	42	47
2	0.27367	0.27369	0	0.0428282	44.645373	0.0120356	99028.256	17783.79	0.0438377	54.942378	0.019506	0	0.9999	36	42
3	0.31156	0.31295	0	0.0112016	65.573501	0.0078123	3413.284	1084.129	0.0112369	65.520066	0.0078511	0	0.9956	30	37
4	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1
5	0.432	0.43226	0	0.0112513	55.373328	0.004406	0	0	0.0112508	55.36253	0.0043984	0	0.9994	17	31
6	0.42485	0.42512	0	0.0112503	56.679879	0.0046117	0	0	0.0112497	56.668581	0.0046037	0	0.9994	19	32
7	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1
8	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1
9	0.20635	0.21079	0	1.2410805	237.82737	0.3779255	520323.89	91080.982	1.246251	290.56424	0.4161856	0	0.9789	43	46
10	0.27224	0.27809	0	0.2141409	223.22686	0.0601779	498355.91	87138.784	0.2190874	273.68115	0.096782	0	0.979	37	41
11	0.30735	0.35875	0	0.0560082	327.8675	0.0390615	25398.608	0	0.0562156	310.18563	0.0342175	0	0.8567	31	36
12	0.97701	1	0	0.0001225	2.349297	0.0016515	0	0	0	0	0	0	0.977	4	1
13	0.42632	0.46526	0	0.056318	278.04604	0.0228589	0	0	0.0562327	264.96475	0.0176713	0	0.9163	18	29
14	0.41944	0.45949	0	0.0563101	284.52646	0.0238507	0	0	0.0562265	270.94402	0.0184981	0	0.9128	20	30
15	0.79897	1	24700.97	0	11.586935	0	5990.11	0	0	0	0	0	0.799	10	1
16	0.86989	1	0	0	0	0	77796.762	0	0	0	0	0	0.8699	8	1
17	0.20508	0.21548	0	2.4821611	475.65474	0.7558511	1048191.2	177154.63	2.492217	578.22917	0.8302678	0	0.9517	44	45
18	0.27046	0.28415	0	0.4282818	446.45373	0.1203558	1004748.4	169376.36	0.4378966	544.52445	0.1915052	0	0.9518	38	40
19	0.30207	0.37251	0	0.1120164	655.73501	0.078123	71627.691	0	0.1120994	615.02525	0.0643208	0	0.8109	32	35
20	0.94827	1	0	0.0005513	10.571835	0.0074319	0	0	0	0	0	0	0.9483	5	1
21	0.41923	0.47763	0	0.1127898	559.04058	0.0477906	0	0	0.1121705	525.17942	0.031687	0	0.8777	21	27
22	0.41268	0.4724	0	0.1127671	571.87058	0.0496823	0	0	0.1121447	536.92187	0.0331743	0	0.8736	22	28
23	0.76463	1	49401.95	0	23.17387	0	62858.822	0	0	0	0	0	0.7646	11	1
24	0.70726	1	0	0	0	0	350085.43	0	0	0	0	0	0.7073	13	1
25	0.20381	0.22073	0	3.7232416	713.48211	1.1337766	1583601.9	257312.58	3.737848	862.46886	1.241865	0	0.9233	45	44
26	0.26868	0.29094	0	0.6424227	669.68059	0.1805337	1519177.4	245823.61	0.6563771	812.0151	0.283796	0	0.9235	39	39
27	0.2968	0.38838	0	0.1680246	983.60251	0.1171844	138687.25	0	0.1675751	913.28992	0.0893641	0	0.7642	33	34
28	0.91953	1	0	0.0012863	24.667616	0.017341	0	0	0	0	0	0	0.9195	6	1
29	0.41214	0.49107	0	0.1694154	842.98363	0.0747951	0	0	0.1677758	780.03366	0.0415775	0	0.8393	23	25
30	0.40592	0.48641	0	0.1693711	862.03235	0.0774946	0	0	0.1677152	797.29543	0.0435375	0	0.8345	24	26
31	0.7303	1	74102.92	0	34.760804	0	170606.14	0	0	0	0	0	0.7303	12	1
32	0.54463	1	0	0	0	0	816866	0	0	0	0	0	0.5446	16	1
33	0.20254	0.22733	0	4.9643221	951.30949	1.5117021	2126556.1	328986.2	4.982997	1141.796	1.649898	0	0.891	46	43
34	0.26689	0.29946	0	0.8565636	892.90745	0.2407116	2041643.1	313966.35	0.8743862	1074.6973	0.3725984	0	0.8912	40	38
35	0.29152	0.4067	0	0.2240328	1311.47	0.1562459	226577.29	0	0.2225499	1203.4815	0.1081945	0	0.7168	34	33
36	0.89079	1	0	0.0023276	44.636639	0.031379	0	0	0	0	0	0	0.8908	7	1
37	0.40505	0.50732	0	0.2261947	1129.8752	0.1038723	0	0	0.2229267	1027.5687	0.0458352	0	0.7984	25	23
38	0.39916	0.50335	0	0.226122	1155.0118	0.1072877	0	0	0.2228108	1050.0168	0.0480118	0	0.793	26	24
39	0.69596	1	98803.9	0	46.347739	0	329232.05	0	0	0	0	0	0.696	14	1
40	0.382	0.55725	0	0	0	0	1478138.5	423202.01	0.0119798	7.748151	0.0131778	0	0.6855	29	22
41	0.20001	1	0	7.4464832	1426.9642	2.2675532	3235094.6	0	1.665E-13	0	6.161E-14	0	0.2	47	1
42	0.26332	1	0	1.2848455	1339.3612	0.3610675	3110684	0	0	0	0	0	0.2633	41	1
43	0.28098	0.74207	0	0.3360493	1967.205	0.2343689	464848.78	496727.97	0.1276166	688.36044	0	0	0.3786	35	21
44	0.83331	1	0	0.005329	102.19441	0.0718414	0	0	0	0	0	0	0.8333	9	1
45	0.39086	1	0	0.3402145	1712.5038	0.168245	0	0	0	0	0	0	0.3909	27	1
46	0.38564	1	0	0.3400645	1749.4236	0.1728161	0	0	0	0	0	0	0.3856	28	1
47	0.62729	1	148205.85	0	69.521609	0	799119.68	0	0	0	0	0	0.6273	15	1
48	0.05673	0.06128	0	0	0	0	3384159.1	1265228.4	0.0352764	31.748782	0.0388041	0	0.9258	48	48

Slack based measure ENV efficiency calculations for 23500 TEU , 2050

SBM 23500 TEU	ENV eff 2050	In: Fuel cost, All Emissions Out: TEU - mile	CRS Slacks					VRS SLACKS							
DMUs	efficiencies .result_crs_ sbm.	efficiencies .result_vrs_ sbm.	slack_input. Fuelcost.2050	slack_input. SOx	slack_input. GWP100	slack_input. PM10	TEU.Mle	slack_input. Fuelcost.2050.1	slack_input. SOx.1	slack_input. GWP100.1	slack_input. PM10.1	TEU.Mle.1	SE	Rank CRS	Rank VRS
1	0.2068	0.2068	0	4.761152	912.37612	1.449834	9620112	357589.68	4.781451	1119.424	1.600046	0	1	43	48
2	0.27294	0.27294	0	0.8215079	856.36425	0.2308603	9208592	342292.96	0.8409384	1054.556	0.3746461	0	1	37	43
3	0.30515	0.30526	0	0.2148641	1257.7967	0.1498514	562068.9	42540.53	0.2160501	1258.864	0.1511561	0	0.9996	31	38
4	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1
5	0.42455	0.42457	0	0.2161265	1068.0836	0.0886896	0	0	0.2161257	1068.068	0.0886783	0	1	19	32
6	0.41707	0.4171	0	0.2161209	1093.4209	0.0928295	0	0	0.2161201	1093.404	0.0928176	0	0.9999	23	33
7	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1
8	1	1	0	0	0	0	2.936E-06	0	0	0	8.182E-14	0	1	1	1
9	0.20652	0.20768	0	23.80576	4561.8806	7.24917	48177730	1778897	23.90674	5591.881	7.996426	0	0.9944	44	47
10	0.27254	0.27408	0	4.107539	4281.8213	1.154301	46125170	1702605.2	4.204189	5267.648	1.869509	0	0.9944	38	42
11	0.30401	0.31634	0	1.07432	6288.9834	0.749257	3023443	55021.19	1.075854	6290.364	0.7509445	0	0.961	32	37
12	0.99354	1	0	0.0006604	12.66507	0.0089034	0	0	0	0	3.382E-13	0	0.9935	4	1
13	0.42295	0.43607	0	1.080964	5346.7761	0.4479176	0	0	1.078237	5294.481	0.411155	0	0.9699	20	30
14	0.41555	0.4291	0	1.080921	5473.1805	0.4684187	0	0	1.078098	5419.036	0.4303557	0	0.9684	25	31
15	0.80486	1	473801.2	0	222.25454	0	153198.9	0	0	0	0	0	0.8049	13	1
16	0.9648	1	0	0	0	0	1989676	0	0	0	0	0	0.9648	8	1
17	0.20617	0.20882	0	47.61152	9123.7612	14.49834	96548390	3534590.2	47.81216	11170.33	15.9831	0	0.9873	45	46
18	0.27205	0.27554	0	8.215079	8563.6425	2.308603	92455880	3382498.5	8.407089	10522.15	3.729477	0	0.9873	39	41
19	0.30258	0.33738	0	2.148641	12577.967	1.498514	6579632	0	2.143546	12406.82	1.403922	0	0.8969	33	36
20	0.98546	1	0	0.0029719	56.99284	0.0400653	0	0	0	0	5.776E-13	0	0.9855	5	1
21	0.42096	0.44829	0	2.162757	10709.448	0.9070096	0	0	2.151393	10491.52	0.7538076	0	0.939	21	28
22	0.41365	0.44206	0	2.162635	10961.551	0.9475157	0	0	2.150792	10734.44	0.7878586	0	0.9357	26	29
23	0.79557	1	947602.4	0	444.50908	0	1607634	0	0	0	0	0	0.7956	14	1
24	0.92079	1	0	0	0	0	8953541	0	0	0	0	0	0.9208	10	1
25	0.20582	0.20998	0	71.41728	13685.642	21.74751	145112000	5266068.8	71.71621	16734.75	23.95961	0	0.9802	46	45
26	0.27156	0.27705	0	12.32262	12845.464	3.462904	138992100	5038690.2	12.60864	15762.92	5.579489	0	0.9802	40	40
27	0.30116	0.35327	0	3.222961	18866.95	2.247771	10668570	0	3.226862	18090.18	1.999985	0	0.8525	34	35
28	0.97738	1	0	0.0069345	132.98328	0.0934856	0	0	0	0	0	0	0.9774	6	1
29	0.41897	0.45793	0	3.245379	16088.014	1.377276	0	0	3.224101	15577.19	1.054168	0	0.9149	22	26
30	0.41175	0.45224	0	3.245141	16465.112	1.437291	0	0	3.224008	15917.16	1.102065	0	0.9105	28	27
31	0.78628	1	1421403.6	0	666.76362	0	4363304	0	0	0	0	0	0.7863	15	1
32	0.87678	1	0	0	0	4.899E-14	20891600	0	0	0	0	0	0.8768	11	1
33	0.20547	0.21121	0	95.22304	18247.522	28.99668	193868500	6970862.9	95.61874	22283.73	31.92491	0	0.9728	47	44
34	0.27107	0.27864	0	16.43016	17127.285	4.617205	185733900	6668763.1	16.80871	20988.57	7.41853	0	0.9728	41	39
35	0.29973	0.35993	0	4.297281	25155.934	2.997028	15290250	0	4.311326	23793.42	2.610771	0	0.8327	35	34
36	0.96931	1	0	0.0125481	240.63642	0.1691644	0	0	0	0	5.043E-13	0	0.9693	7	1
37	0.41697	0.46553	0	4.32883	21482.477	1.858716	0	0	4.307054	20432.54	1.342102	0	0.8957	24	24
38	0.40985	0.45987	0	4.328438	21983.862	1.937745	0	0	4.306854	20884.52	1.404994	0	0.8912	29	25
39	0.77699	1	1895204.9	0	889.01816	0	8420210	0	0	0	0	0	0.777	16	1
40	0.83278	1	0	3.412E-14	0	4.6E-13	37803840	0	0	0	0	0	0.8328	12	1
41	0.20477	1	0	142.8346	27371.284	43.49502	291960300	0	3.257E-12	0	1.011E-12	0	0.2048	48	1
42	0.27008	1	0	24.64524	25690.928	6.925808	279834100	0	0	0	0	0	0.2701	42	1
43	0.29687	0.74207	0	6.445922	37733.901	4.495542	26131840	9527976.9	2.447875	13203.77	0	0	0.4001	36	23
44	0.95315	1	0	0.0287286	550.93074	0.3872974	0	0	0	0	0	0	0.9532	9	1
45	0.41299	1	0	6.498219	32319.087	2.85512	0	0	0	0	0	0	0.413	27	1
46	0.40605	1	0	6.49741	33066.933	2.970688	0	0	0	-5.38E-10	0	0	0.4061	30	1
47	0.75841	1	2842807.3	0	1333.5272	0	20437730	0	0	0	0	0	0.7584	17	1
48	0.74476	1	0	0	0	9.794E-14	86550900	0	0	0	0	0	0.7448	18	1

Table: Share of various fuel types in maritime transport

Type of Fuel	Share in fuel mix
Heavy Fuel Oil (HFO)	72.11 %
Marine Gas Oil (MGO)	12.46 %
Light Fuel Oil (LFO)	7.63 %
Marine Diesel Oil (MDO)	4.02 %
Liquified Natural Gas	3.17 %
Other	0.60 %
Methanol	0.01 %
Liquefied Petroleum Gas (LPG) - Butane	0.00 %
Total	100.00 %

Source: 2018 EU MRV