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INTERSESSIONAL MEETING OF THE WORKING GROUP ON REDUCTION OF GHG EMISSIONS FROM SHIPS
16th session
Agenda item 2

ISWG-GHG 16/2/2
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FURTHER CONSIDERATION OF THE DEVELOPMENT OF CANDIDATE MID-TERM MEASURE(S) IN THE CONTEXT OF PHASE III OF THE WORK PLAN FOR THE DEVELOPMENT OF MID- AND LONG-TERM MEASURES

Updated economic impact assessment on States of a mandatory GHG contribution by ships to a Zero Emission Shipping Fund

Submitted by ICS

SUMMARY

Executive summary:	In support of the modified fund and reward (feebate) proposal, set out in document ISWG-GHG 16/2/3, whereby ships will make a contribution per tonne of CO_2e emitted to a Zero Emission Shipping Fund (ZESF), ICS has commissioned an update of an initial impact assessment that ICS originally submitted in document ISWG-GHG 12/3/8. This update explores the impact of contribution quanta ranging from \$6.25 to \$100 per tonne of CO_{2e} (an approximate increase in bunker fuel costs of \$20 to \$314 per tonne). In response to comments that extreme fuel price volatility during the pandemic may have affected the conclusions of that initial assessment, this updated analysis uses data up until December 2023. It also examines the impact on trades to and from developed countries, in addition to developing countries. This update is provided without prejudice to the conclusions of the MEPC-mandated Comprehensive Impact Assessment now being undertaken of proposals for mid-term measures, but is intended to be complementary and to provide assurance that the economic impact on States – in terms of prices of delivered cargo – of a contribution quantum set between \$6.25 and \$100 per tonne of CO_{2e} emitted would be unlikely to have disproportionately negative impacts on States, as these would fall within the average monthly volatility in the price of delivered cargo.
Strategic direction, if applicable:	3
Output:	3.2
Action to be taken:	Paragraph 15
Related documents:	Resolution MEPC.377(80); ISWG-GHG 16/2/1, ISWG-GHG 16/2/3; ISWG-GHG 14/3; ISWG-GHG 12/3/8

Introduction

1 The *2023 IMO Strategy on reduction of GHG emissions from Ships* (2023 IMO GHG Strategy) adopted by resolution MEPC.377(80) identifies the development and finalization of a basket of mid-term measure(s) including an economic element, namely a maritime GHG emissions pricing mechanism to narrow the cost gap between conventional fuel oil and zero/near-zero GHG fuels.

2 Prior to MEPC 80, ICS submitted document ISWG-GHG 14/3 providing possible draft amendments to MARPOL Annex VI to implement a fund and reward (feebate) mechanism. To take account of the 2023 IMO GHG Strategy, ICS has further elaborated upon this proposal in document ISWG-GHG 16/2/3.

3 The ICS proposal, alongside a similar proposal submitted to previous sessions by Japan (as well as related proposals submitted to previous sessions by Austria et al. and by the Marshall Islands and Solomon Islands) requires ships to make mandatory contributions per tonne of CO_2e emitted to an IMO fund, which ICS now refers to in its latest proposal as the "Zero Emission Shipping Fund (ZESF)".

4 In document ISWG-GHG 12/3/8, ICS submitted an initial assessment on the impact on States of a flat rate contribution mechanism, prepared with the assistance of Clarksons Research. When assessed in terms of their impact on the price of delivered cargoes, which is of direct relevance to the economies of States, all of the contribution quanta analysed, regardless of the trades and/or cargo types to which they applied, generally seemed to fall within the average monthly volatility in the price of delivered cargo during 2021.

5 In response to comments from some Member States, ICS has commissioned Clarksons Research to update its previous assessment of the impact of a contribution mechanism on States. In response to questions as to whether extreme fuel price volatility during the pandemic may have affected the conclusions of the initial assessment, this updated analysis uses data up until December 2023.

6 Also, as requested by some Member States, this updated analysis examines the impact on various trades and cargo types to and from developed countries, in addition to trades to and from developing countries, including SIDS, which was the focus of the aforementioned initial impact assessment.

7 This updated impact assessment explores the impact of contribution quanta ranging from \$6.25 to \$100 per tonne of CO_2e (this is equivalent to an approximate increase in bunker fuel oil costs of \$20 to \$314 per tonne, although the exact equivalent cost per tonne of fuel oil will depend on the conversion factors for liquid fuel oil agreed for CO_2e by the LCA Guidelines, as amended). ICS estimates that the funds that would be raised by setting the contribution quanta within this range would be between about \$5 billion per year and almost \$80 billion per year (although these figures would vary in the future subject to the rate of uptake of zero and near-zero fuels by international shipping).

8 This updated analysis is provided as information to the Group without prejudice to the conclusions that will be reached by the Comprehensive Impact Assessment, initiated by MEPC 80, which is now being undertaken of the various proposals for mid-term GHG reduction measures.

9 The updated impact assessment, as prepared by Clarksons Research, is included in the annex to this document.

Clarksons Research

10 Clarkson Research Services Limited (Clarksons Research) is a leading provider of maritime trade data and intelligence. Its clients include UNCTAD to which Clarksons Research provides shipping data used to help compile the annual *UNCTAD Review of Maritime Transport.* As part of the Clarksons Group which, inter alia, provides shipbroking and financial services to all sectors of the global shipping industry, Clarksons Research has access to authoritative information on all aspects of shipping including extensive trade and commercial data. Whilst Clarksons Research has been contracted to assist with the preparation of data used in this impact assessment, this constitutes neither an endorsement nor recommendation by Clarksons Research of the specific policies or strategies advocated by ICS with respect to its proposal for a fund and reward (feebate) mechanism.

Discussion

11 Based on the updated Clarksons Research analysis, the impacts of the contribution quanta examined would generally fall within the average monthly volatility of delivered cargo prices during 2023, as well as falling within the typical range of marine bunker price volatility during the preceding 5 year and 10 year periods.

12 The following are just a few examples of the information contained in the updated analysis:

.1 The delivered price of crude oil in the United States imported from the Middle East would increase by between 0.06% ($6.25 per tonne CO_2e contribution) and 1% ($100 per tonne CO_2e contribution). This compares to the average month-to-month movement in delivered Middle Eastern crude prices in the United States in 2023 of 4%;

.2 The impact on overall freight costs for refined oil products transported from the United States to Brazil on a medium range (MR) products tanker varies from $0.5/t or $0.0003/litre ($6.25/t CO_2e contribution) to $8.6/t or $0.0047/litre ($100/t CO_2e contribution). This compares to the average month-to-month movement in delivered gasoline prices in Brazil in 2023 (transported from the United States) of $46/t or $0.04/litre;

.3 As example of the impact on SIDS, the estimated impact on the delivered cost of gasoline in Fiji, transported by an MR product tanker from Singapore would be between 0.06% ($6.25/t CO_2e contribution) and 0.95% ($100/t CO_2e contribution) of the average delivered gasoline price in Fiji in 2023;

.4 In price-sensitive iron ore trades, the impact on the price of delivered iron ore in China imported from Brazil on a Capesize bulk carrier would be an increase of between 0.3% (US$6.25/t CO_2e contribution) and 5.1% ($100/t CO_2e contribution). This compares to the average month-to-month movement in delivered Brazilian iron ore prices in China in 2023 of 6%;

.5 The cost of transporting a laden 40-foot equivalent unit (FEU) container from China to the United States would increase by $6.5 ($6.25/t CO_2e contribution) to $104 ($100/tCO_2e contribution). This compares to the average month-to-month movement in China/U.S trades in 2023 of $160 per FEU; and

.6 The impact on the delivered cost ($/mm BTU) of LNG transported from the United States to Europe would be between 0.1% ($6.25/t CO_2e contribution) and 1.6% ($100/t CO_2e contribution). This compares to the average month-to-month variation in the delivered European LNG price in 2023 of 15%. (NB: The impact might be smaller if the agreed contribution required to be made by LNG carriers using LNG as bunker fuel is, as proposed by ICS, lower per tonne of fuel consumed than for liquid fuel oil.)

Conclusion

13 This updated impact assessment is provided as information to the Group without prejudice to the conclusions that will be reached by the Comprehensive Impact Assessment now being undertaken of various proposals for mid-term GHG reduction measures. Nevertheless, this updated assessment, prepared by Clarksons Research, should provide assurance that the impact on States, in terms of delivered cargo prices, of a contribution quantum set between $6.25 and $100 per tonne of CO_2e would be unlikely to have disproportionately negative impacts on States.

14 Based on Clarkson's analysis, the impacts of the contribution quanta examined would generally fall within the average monthly volatility of delivered cargo prices during 2023, as well as falling within the typical range of marine bunker price volatility during the preceding 5 year and 10-year periods.

Action requested of the Working Group

15 The Working Group is invited to consider the information contained in this document including the accompanying updated economic impact assessment on States of a contribution per tonne of CO_{2e} emitted, as set out in the annex to this document, and take action as appropriate.

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ANNEX

CLARKSONS RESEARCH

Updated Impact Assessment of GHG Pricing Mechanism:
Based on contribution by ships per tonne of CO2e to a Zero Emission Shipping Fund

December 2023

Prepared for ICS
Clarksons Research

Contents

Impact Assessment Of Marine Fuel GHG Contribution

Executive Summary

Impact Assessment Of Marine Fuel GHG Contribution

- **Overview:** This updated impact assessment has been prepared by Clarksons Research following a request by the International Chamber of Shipping (ICS) to evaluate the impact on freight and cargo prices of a GHG contribution on marine fuels, looking at five potential scenarios (\$6.25/t CO_2e, \$12.50/t CO_2e, \$25/t CO_2e, \$50/t CO_2e, and \$100/t CO_2e). Clarksons Research has explained to ICS that this study should not be considered comprehensive, and that the study is provided as a draft for further discussion only. The study does not endorse or recommend any specific policies or strategies.

- **Bunker Prices:** The potential GHG contribution would have an impact on fuel costs. The GHG contribution could lead to an increase in fuel oil costs of \$19.6/t (under a \$6.25/t CO_2e contribution) to \$314/t (under a \$100/t CO_2e contribution). The average bunker price in Oct-23 (basis Singapore VLSFO) was c.\$665/t, with the average month to month movement in prices across Jan-Oct 2023 standing at \$25/t. *(see pages 5-9)*.

- **Iron Ore:** The impact of a potential GHG contribution on overall freight costs for iron ore transported on a Capesize bulkcarrier varies depending on the level of the contribution. The impact on freight and delivered costs on the Brazil-China route ranges from \$0.4/t (\$6.25/t CO_2e contribution) to \$6/t (\$100/t CO_2e contribution). The impact based on the \$100/t CO_2e contribution stands in line with the average month to month movement in delivered iron ore prices in China seen across 2023 so far (\$7/t) *(see pages 10-14)*.

- **Containers:** The impact on transportation costs of containerized items including foodstuffs (for example a container moved on a c.9,500 TEU containership operating on the Mainlane Transpacific liner service varies from \$6.50/FEU or \$0.5 per tonne (\$6.25/t CO_2e contribution) to \$104/FEU or \$7.4 per tonne (\$100/t CO_2e contribution). *(see pages 15-19)*.

- **Oil:** The impact on overall freight costs for refined oil products transported from the US to Brazil on an MR products tanker varies from \$0.5/t or \$0.0003/litre (\$6.25/t CO_2e contribution) to \$8.6/t or \$0.0047/litre (\$100/t CO_2e contribution). This compares to the average month to month movement in delivered gasoline prices in 2023 of \$46/t or \$0.04/litre *(see pages 20-29)*.

- **Gas:** The impact of a potential GHG contribution on the transportation cost of LNG ranges from \$0.01/mm BTU (\$6.25/t CO_2e contribution) to \$0.2/mm BTU (\$100/t CO_2e contribution), which compares with an average month of month move in the delivered cost of LNG of \$3/mm BTU (*see page 31*).

GHG Contribution Scenarios: Impact Summary (1)

Impact of contribution scenarios variable but generally within avg monthly volatility in delivered cargo prices

GHG contribution Scenarios: Bunker Price, Freight Rate & Delivered Cargo Price Impacts

Impact	Basis	2023 Avg	Avg Monthly Change In 2023	Scenario 1 \$6.25/t CO_2e \$19.625/t fuel oil	Scenario 2 \$12.50/t CO_2e \$39.25/t fuel oil	Scenario 3 \$25/t CO_2e \$78.50/t fuel oil	Scenario 4 \$50/t CO_2e \$157/t fuel oil	Scenario 5 \$100/t CO_2e \$314/t fuel oil
Bunker Price	**\$/t, VLSFO Singapore**	**\$665**	**\$25**	**\$684.6**	**\$704.3**	**\$743.5**	**\$822.3**	**\$979.0**
Capesize Iron Ore Freight Rate	**\$/t, Brazil-China**	**\$20**	**\$2**	**\$0.4**	**\$0.8**	**\$1.5**	**\$3.0**	**\$6.0**
Delivered Chinese Iron Ore Price	%, from Brazil, basis 2023 Avg	\$118	\$7 (6%)	+0.3%	+0.6%	+1.3%	+2.6%	+5.1%
Panamax Coal Freight Rate	**\$/t, S.Africa-India**	**\$16**	**\$2**	**\$0.3**	**\$0.5**	**\$1.1**	**\$2.1**	**\$4.2**
Delivered Indian Coal Price	%, from S.Africa, basis 2023 Avg	\$140	\$16 (11%)	+0.2%	+0.4%	+0.8%	+1.5%	+3.0%
VLCC Crude Freight Rate	**\$/tonne, Middle East Gulf-China**	**\$14**	**\$3**	**\$0.2**	**\$0.4**	**\$0.8**	**\$1.6**	**\$3.1**
	\$/bbl, Middle East Gulf-China	**\$2**	**\$0.4**	**\$0.03**	**\$0.05**	**\$0.11**	**\$0.21**	**\$0.43**
Delivered Chinese Crude Oil Price	%, from MEG, basis 2023 Avg	\$84/bbl	\$4/bbl (4%)	+0.03%	+0.06%	+0.13%	+0.25%	+51%
MR Products Tanker Freight Rate	**\$/tonne, Singapore-Australia**	**\$47**	**\$2**	**\$0.5**	**\$1.0**	**\$1.9**	**\$3.9**	**\$7.8**
	\$/bbl, Singapore-Australia	**\$5.6**	**\$0.2**	**\$0.06**	**\$0.12**	**\$0.24**	**\$0.47**	**\$0.93**
Delivered Australia Gasoline Price	%, from Singapore, basis 2023	\$103/bbl	\$5/bbl (5%)	+0.06%	+0.11%	+0.23%	+0.45%	+0.91%
Container Freight Rate	**\$/TEU, basis S.America-Asia**			**\$17.9**	**\$35.8**	**\$71.6**	**\$143.2**	**\$286.3**
	\$/t, basis S.America-Asia			**\$1.5**	**\$3**	**\$6**	**\$12**	**\$24**

Source: Clarksons Research

GHG Contribution Scenarios: Impact Summary (2)

Impact of contribution scenarios variable but generally within avg monthly volatility in delivered cargo prices

GHG contribution Scenarios: Bunker Price, Freight Rate & Delivered Cargo Price Impacts

Impact	Basis	2023 Avg	Avg Monthly Change In 2023	Scenario 1 \$6.25/t CO_2e \$19.625/t fuel oil	Scenario 2 \$12.50/t CO_2e \$39.25/t fuel oil	Scenario 3 \$25/t CO_2e \$78.50/t fuel oil	Scenario 4 \$50/t CO_2e \$157/t fuel oil	Scenario 5 \$100/t CO_2e \$314/t fuel oil
Bunker Price	**\$/t, VLSFO Singapore**	**\$665**	**\$25**	**\$684.6**	**\$704.3**	**\$743.5**	**\$822.3**	**\$979.0**
VLCC Crude Freight Rate	**\$/tonne, Middle East Gulf-US**	**\$17**	**\$4**	**\$0.4**	**\$0.8**	**\$1.5**	**\$3.0**	**\$6.1**
	\$/bbl, Middle East Gulf-US	**\$2**	**\$0.4**	**\$0.05**	**\$0.1**	**\$0.2**	**\$0.4**	**\$0.8**
Delivered US Crude Oil Price	%, from MEG, basis 2023 Avg	\$85/bbl	\$4/bbl (4%)	+0.06%	+0.1%	+0.2%	+0.5%	+1.0%
LR Products Tanker Freight Rate	**\$/tonne, US-Japan**	**\$49**	**\$5**	**\$0.8**	**\$1.6**	**\$3.1**	**\$6.2**	**\$12.5**
	\$/bbl, US-Japan	**\$5.9**	**\$0.6**	**\$0.1**	**\$0.2**	**\$0.4**	**\$0.8**	**\$1.5**
Delivered Japan Gasoline Price	%, from US, basis 2023 Avg	\$118/bbl	\$6/bbl (5%)	+0.08%	+0.16%	+0.3%	+0.6%	+1.3%
LNG Carrier Spot Rate	**\$/day, Atlantic**	**\$88,000**	**\$33,400**	**\$1,200**	**\$2,500**	**\$4,900**	**\$9,800**	**\$19,700**
Delivered European LNG Price	**\$/mm BTU,** basis 2023 Avg	\$12.9	\$3.0 (15%)	+0.1%	+0.2%	+0.4%	+0.8%	+1.6%
Container Freight Rate	**\$/FEU, China-US**	**\$1,549**	**\$160**	**\$6.5**	**\$13**	**\$26**	**\$52**	**\$104**
	\$/t, China-US	**\$111**	**\$11**	**\$0.5**	**\$0.9**	**\$1.9**	**\$3.7**	**\$7.4**

Source: Clarksons Research

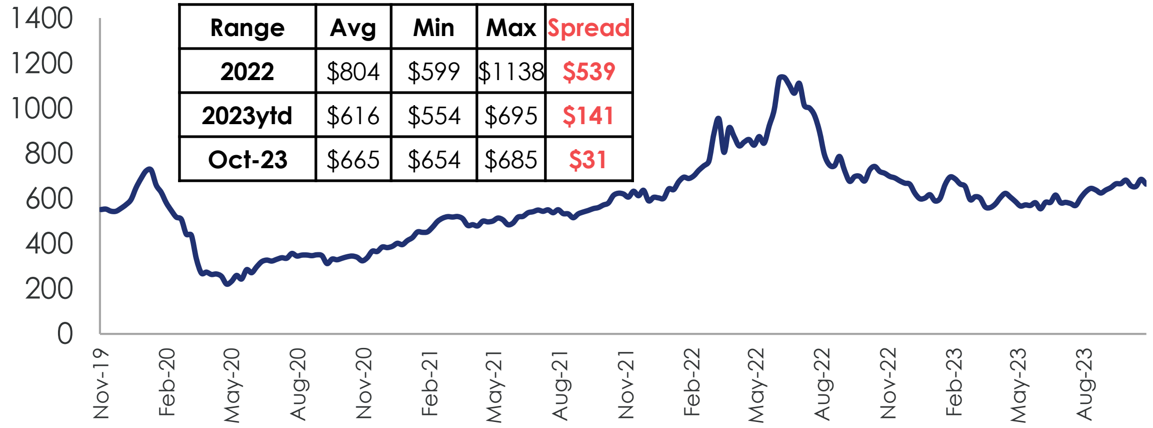
Impact Assessment

Bunker Price

Bunker Price Volatility: Short Term View

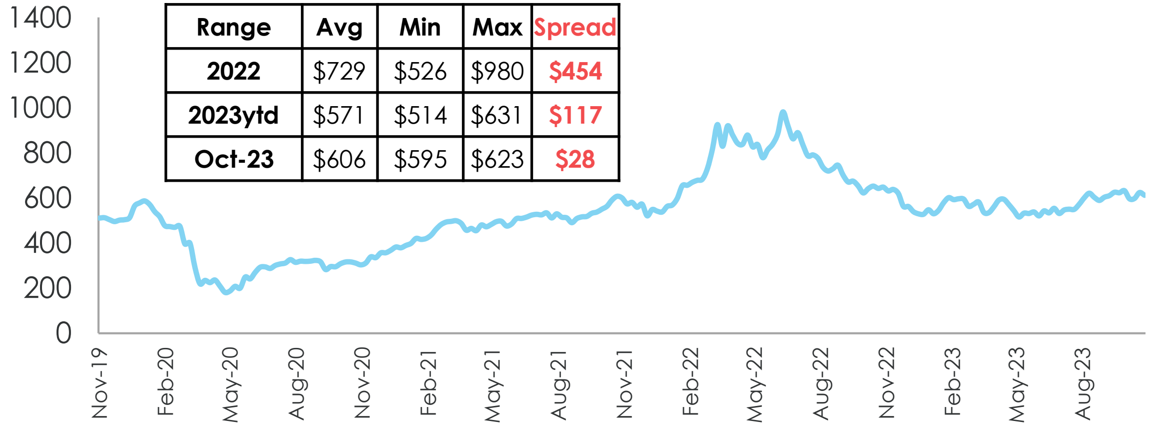
VLSFO fuel price varied by c.$400-$550/t over the course of 2022-23 alone

Singapore, $/tonne



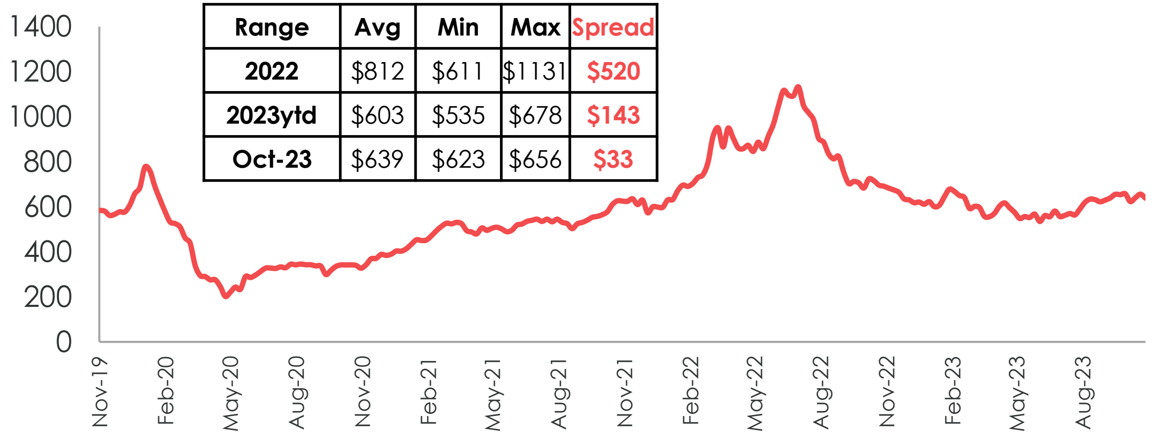
Range	Avg	Min	Max	Spread
2022	$804	$599	$1138	$539
2023ytd	$616	$554	$695	$141
Oct-23	$665	$654	$685	$31

Rotterdam, $/tonne



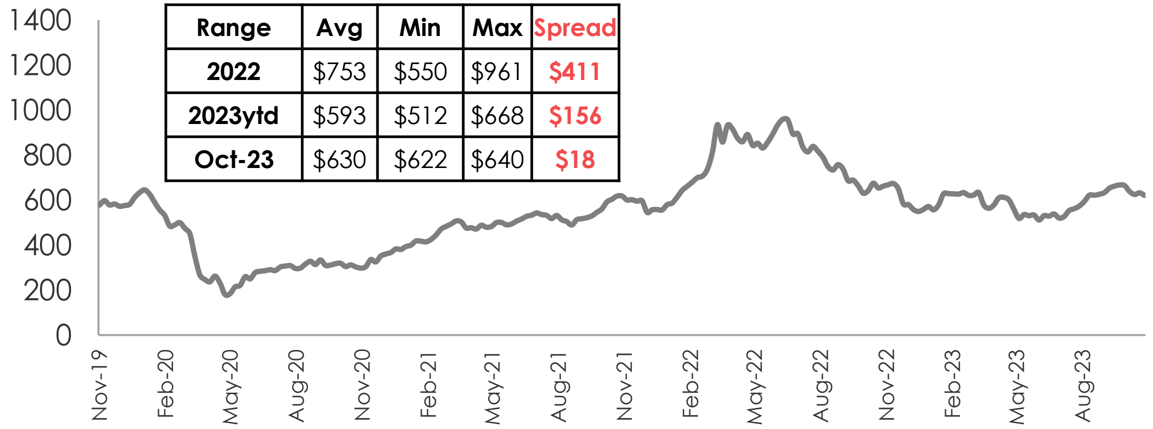
Range	Avg	Min	Max	Spread
2022	$729	$526	$980	$454
2023ytd	$571	$514	$631	$117
Oct-23	$606	$595	$623	$28

Fujairah, $/tonne



Range	Avg	Min	Max	Spread
2022	$812	$611	$1131	$520
2023ytd	$603	$535	$678	$143
Oct-23	$639	$623	$656	$33

Houston, $/tonne



Range	Avg	Min	Max	Spread
2022	$753	$550	$961	$411
2023ytd	$593	$512	$668	$156
Oct-23	$630	$622	$640	$18

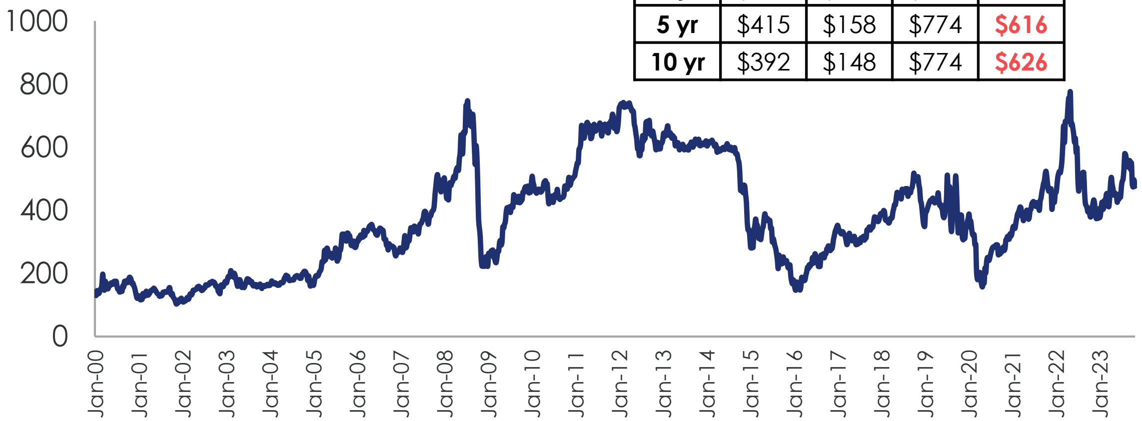
Source: Clarksons Research. VLSFO = "Very Low Sulphur Fuel Oil"; bunker fuel grade with maximum 0.5% sulphur content. VLSFO has been the main fuel grade consumed by merchant vessels since the start of 2020, following the introduction of the 'IMO 2020' 0.5% global sulphur cap, limiting the maximum sulphur content of marine fuel to 0.5% globally for any vessels not equipped with emissions abatement technology.

Bunker Price Volatility: Longer-Term View

HSFO fuel prices varied by c.$600/t over the last 10 years, and c.$180/t in the last year alone

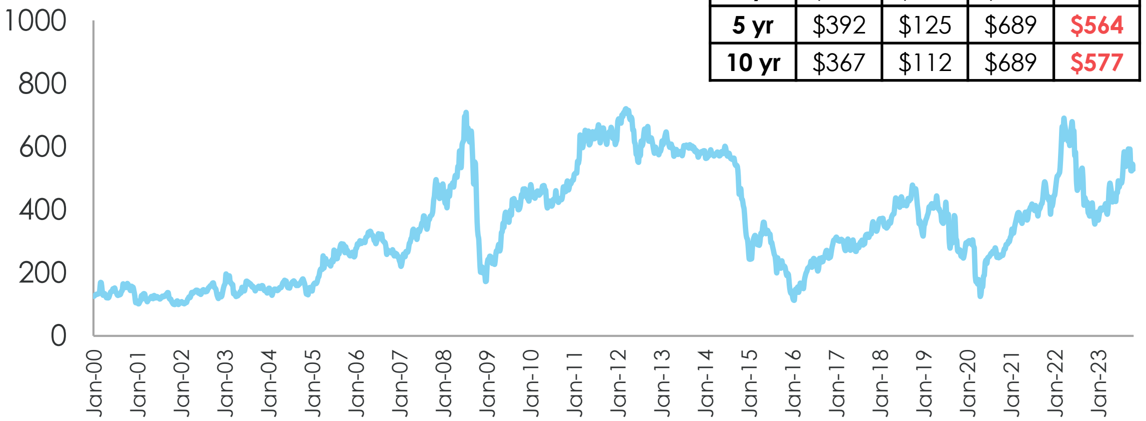
Singapore, $/tonne

Range	Avg	Min	Max	Spread
1 yr	$472	$378	$580	$202
5 yr	$415	$158	$774	$616
10 yr	$392	$148	$774	$626



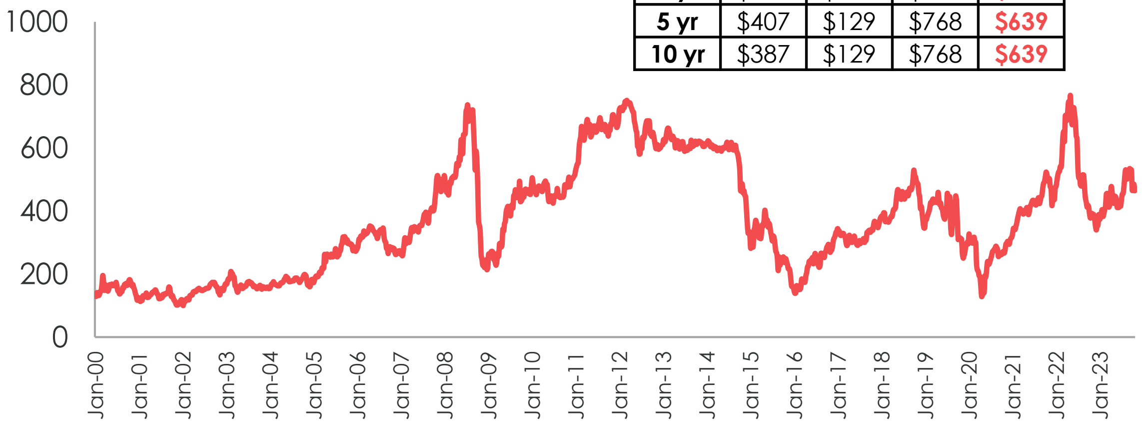
Rotterdam, $/tonne

Range	Avg	Min	Max	Spread
1 yr	$472	$367	$592	$225
5 yr	$392	$125	$689	$564
10 yr	$367	$112	$689	$577



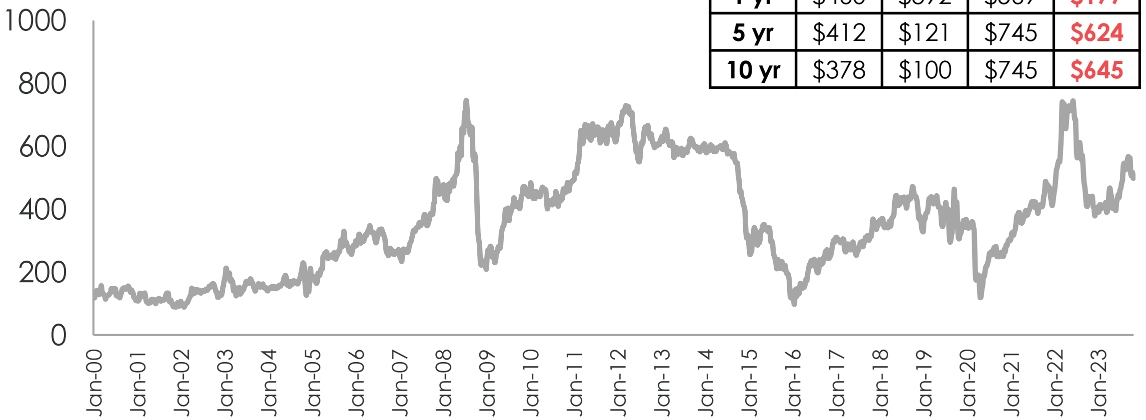
Fujairah, $/tonne

Range	Avg	Min	Max	Spread
1 yr	$451	$374	$535	$161
5 yr	$407	$129	$768	$639
10 yr	$387	$129	$768	$639



Houston, $/tonne

Range	Avg	Min	Max	Spread
1 yr	$460	$392	$569	$177
5 yr	$412	$121	$745	$624
10 yr	$378	$100	$745	$645



Source: Clarksons Research. *HSFO = "High Sulphur Fuel Oil", bunker grade with a maximum 3.5% sulphur content. HSFO was the principal bunker fuel in the shipping industry prior to start 2020, but is now mainly consumed by merchant vessels equipped with SOx scrubber technology.

Bunker Price Volatility: Summary

Significant historical volatility across key bunker grades and port locations

Bunker Price, $/tonne

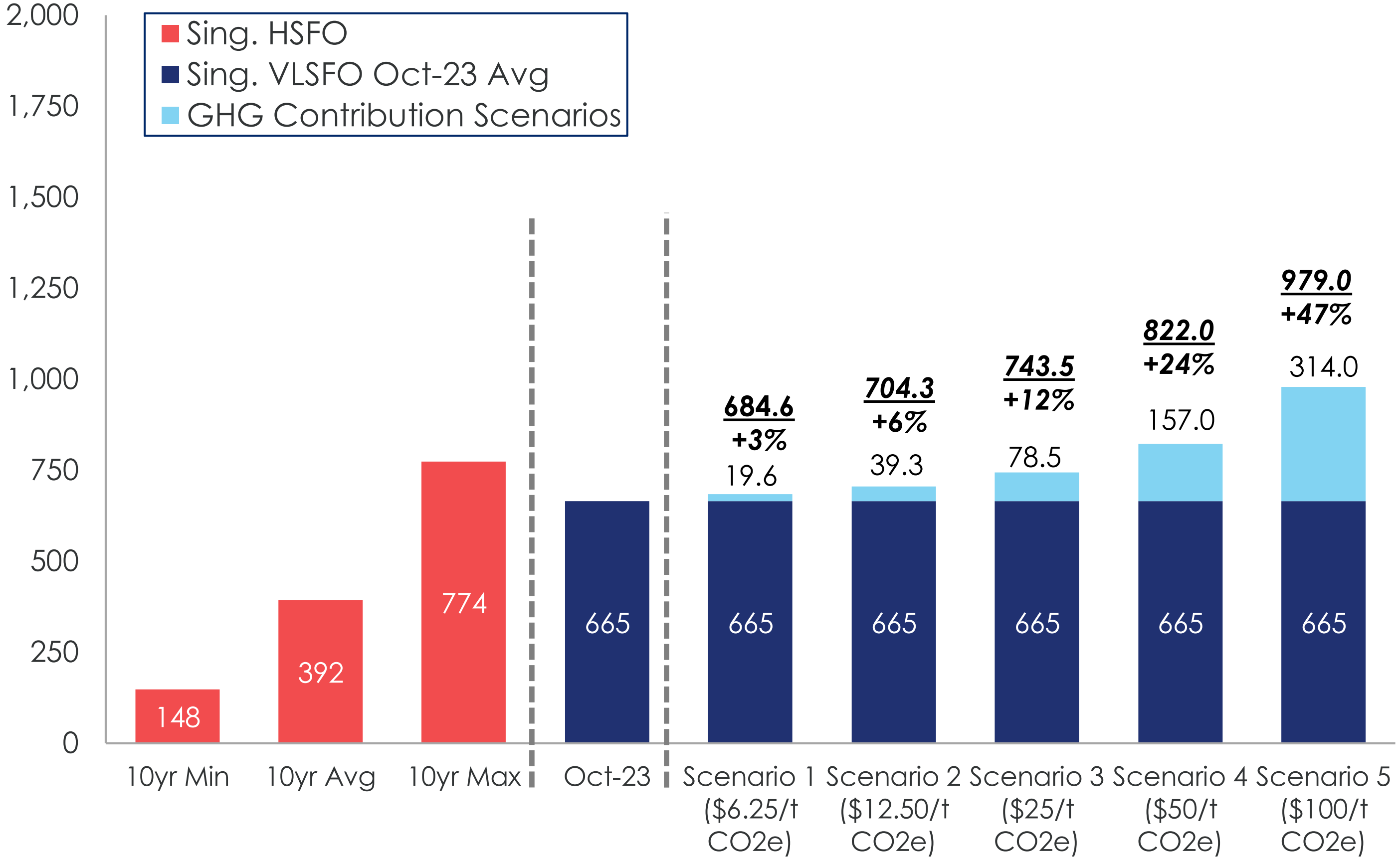
Port	Fuel	2022-23 Min	2022-23 Max	2022-23 Avg	5yr Avg*	10yr Avg	20yr Avg
Singapore	HSFO	374	774	501	415	392	416
	VLSFO	554	1138	719	579		
	MGO	655	1372	937	679	628	663
Rotterdam	HSFO	354	689	494	392	367	392
	VLSFO	514	980	658	531		
	MGO	638	1373	934	665	608	654
Fujairah	HSFO	340	768	496	407	387	414
	VLSFO	535	1131	718	581		
	MGO	787	1550	1115	802	742	749
Houston	HSFO	380	745	518	412	378	402
	VLSFO	512	961	681	550		
	MGO	686	1394	986	708	660	737

Source: Clarksons Research. HSFO = "High Sulphur Fuel Oil", bunker grade with a maximum 3.5% sulphur content. HSFO was the principal bunker fuel in the shipping industry prior to start 2020, but is now mainly consumed by merchant vessels equipped with SOx scrubber technology. VLSFO = "Very Low Sulphur Fuel Oil"; bunker fuel grade with maximum 0.5% sulphur content. VLSFO has been the main fuel grade consumed by merchant vessels since the start of 2020, following the introduction of the 'IMO 2020' 0.5% global sulphur cap, limiting the maximum sulphur content of marine fuel to 0.5% globally for any vessels not equipped with emissions abatement technology. MGO = Marine Gas Oil. *VLSFO 5 year average from September 2019

Marine Fuel GHG Contribution: Bunker Price Impact

GHG Contribution Scenarios of $6.25-$100/t Increase Bunker Prices by 3%-47%

GHG Contribution Impact On Bunker Prices (Basis Sing. VLSFO), $/tonne



GHG Contribution Scenarios Summary

Scenario	GHG Contribution $/t CO_2e	Fuel Price Contribution[1] $/t Fuel Oil	Est. Potential Bunker Price[2] $/t	% Inc. on Oct-23 Avg
Oct-23	-	-	$665.0	-
1	$6.25	+$19.6	$684.6	+3%
2	$12.50	+$39.3	$704.3	+6%
3	$25	+$78.5	$743.5	+12%
4	$50	+$157.0	$822.0	+24%
5	$100	+$314.0	$979.0	+47%

Source: Clarksons Research. 1: Fuel price contribution basis one tonne of fuel oil emits 3.14 tonnes of CO_2e. 2: Estimated potential bunker price basis Oct-23 average VLSFO price in Singapore plus GHG contribution in each scenario.

Impact Assessment

Iron Ore & Coal

Impact Examples: Brazilian & Australian Iron Ore Exports To China

Estimated impact of GHG contribution equivalent to $0.4-$6/t (Brazil-China) / $0.1-$2/t (Aus-China)

Australia-China (c.3,500 miles)

Scenario	Est. Additional Voyage Fuel Cost ($m)	Est. Cost Per Tonne Of Iron Ore Shipped ($)
1) $6.25/t CO_2e	$0.02m	$0.13
2) $12.50/t CO_2e	$0.04m	$0.26
3) $25/t CO_2e	$0.09m	$0.51
4) $50/t CO_2e	$0.18m	$1.02
5) $100/t CO_2e	$0.35m	$2.04

Brazil-China (c.11,000 miles)

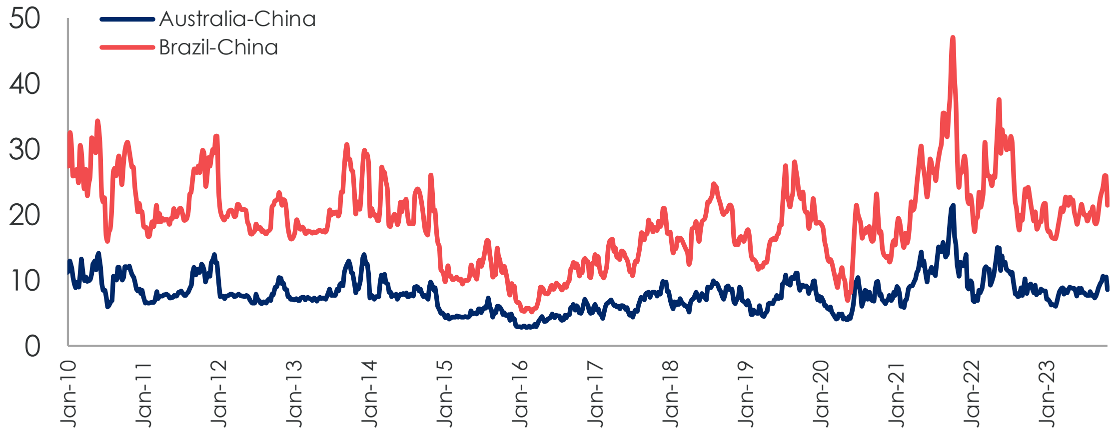
Scenario	Est. Additional Voyage Fuel Cost ($m)	Est. Cost Per Tonne Of Iron Ore Shipped ($)
1) $6.25/t CO_2e	$0.07m	$0.38
2) $12.50/t CO_2e	$0.13m	$0.75
3) $25/t CO_2e	$0.27m	$1.50
4) $50/t CO_2e	$0.53m	$3.00
5) $100/t CO_2e	$1.06m	$6.01

Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only. Basis standard c.2010-built Capesize bulkcarrier, consuming 43 tonnes of fuel per day at 12 knots laden, 13 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed on both routes). Calculations for Brazil-China basis 177,000t cargo from Tubarao to Qingdao, and for Australia-China basis 172,000t cargo from Dampier to Qingdao.

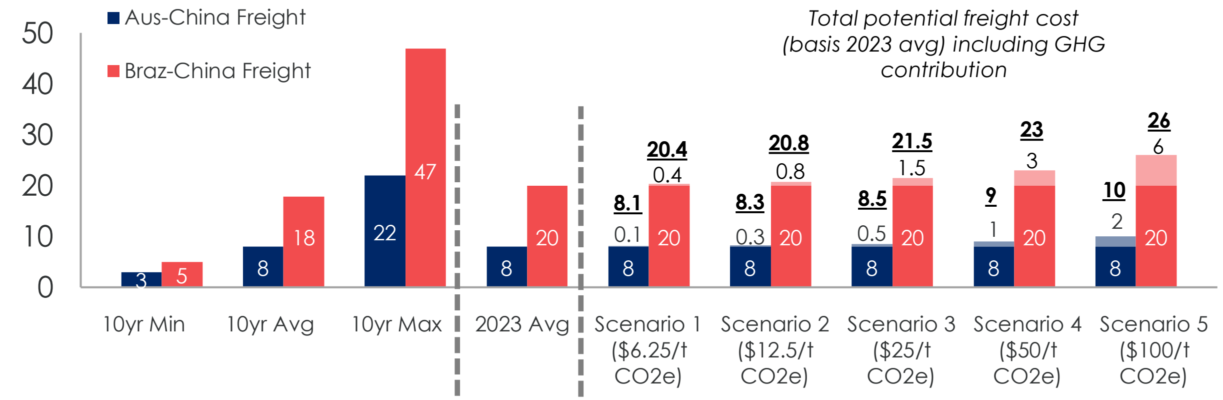
Impact On Iron Ore Freight Rates & Delivered Cargo Costs

Freight rates & cargo prices already highly volatile; estimated delivered cost impact of 0.1%-5.1%

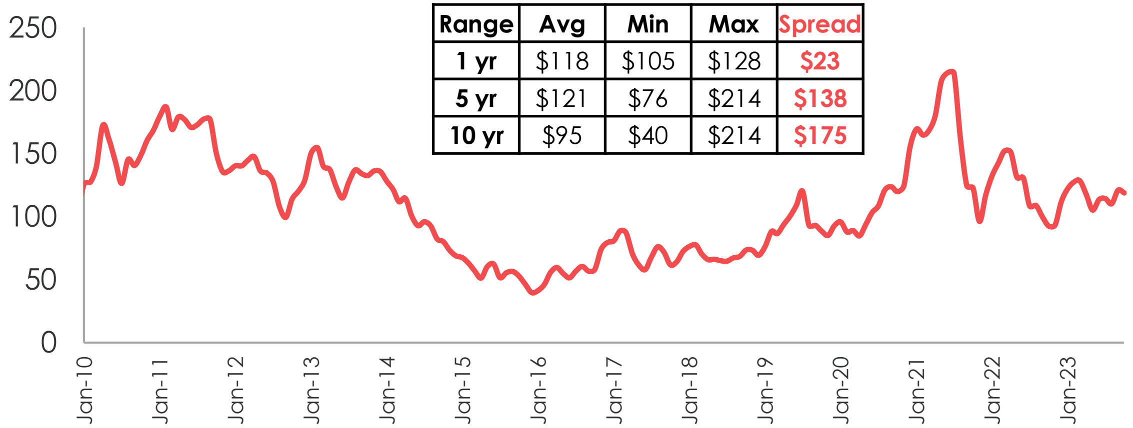
Iron Ore Spot Freight Rate, $/tonne



Estimated Impact Of GHG Contribution On Iron Ore Freight Rate, $/t

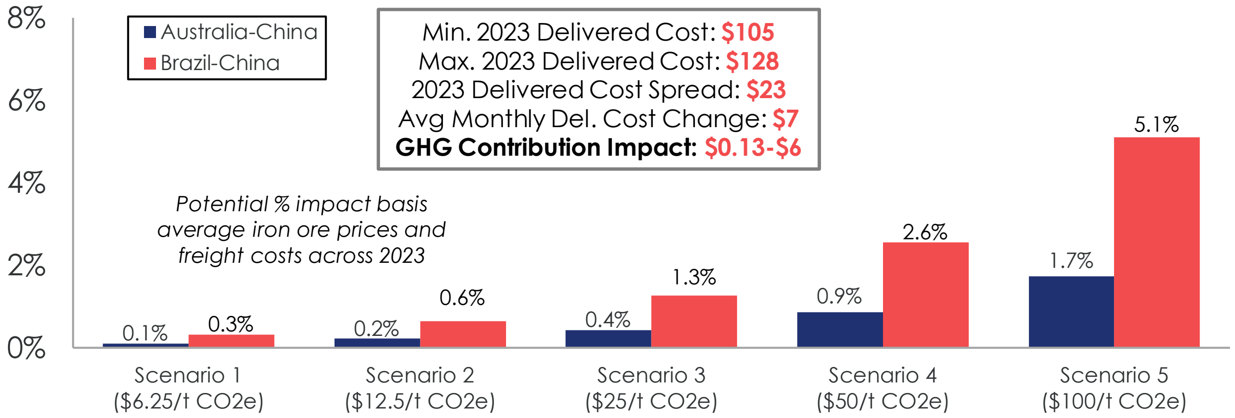


Monthly Average Delivered Iron Ore Price In China, $/tonne



Range	Avg	Min	Max	Spread
1 yr	$118	$105	$128	$23
5 yr	$121	$76	$214	$138
10 yr	$95	$40	$214	$175

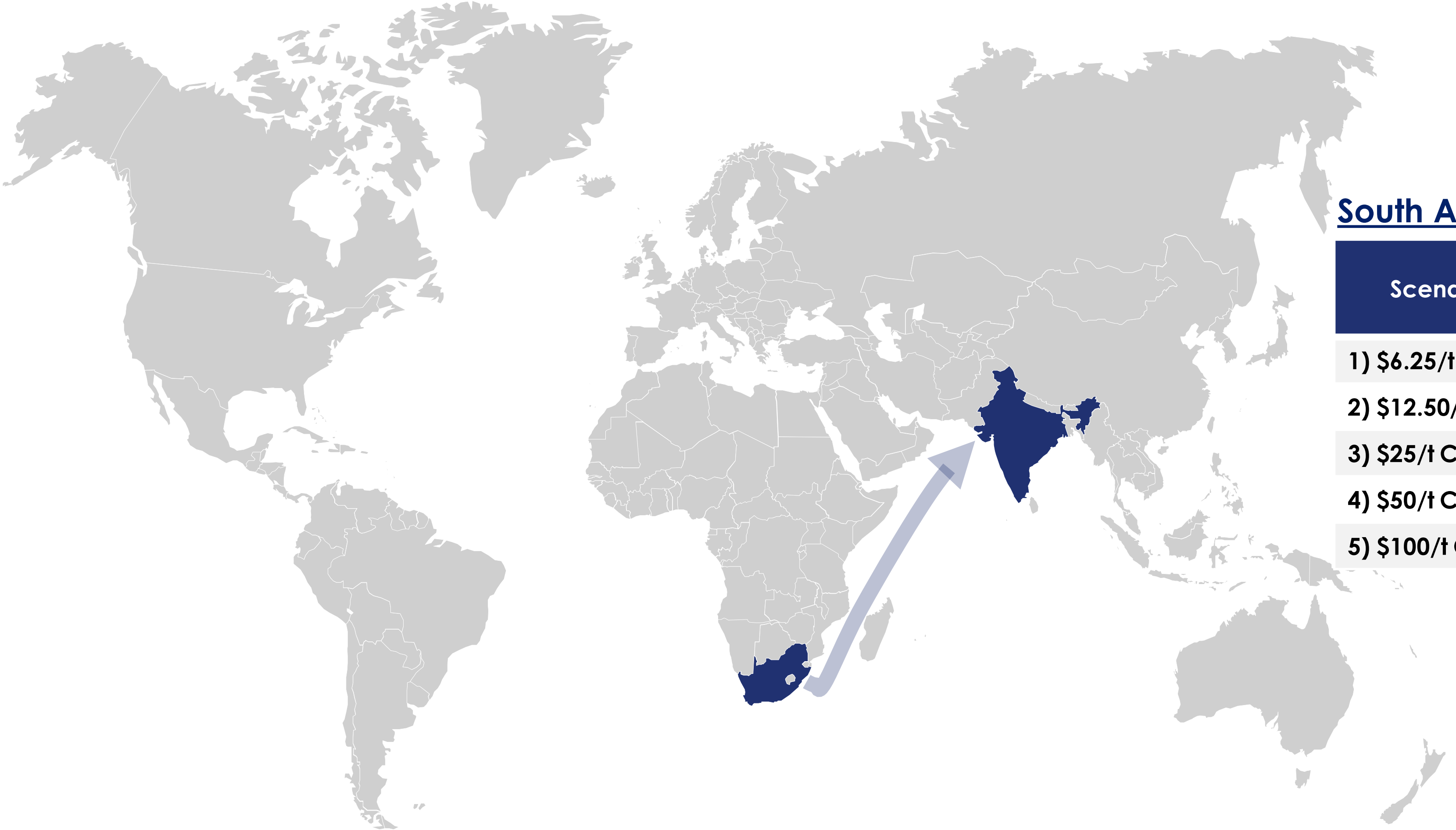
Est. % Impact Of GHG Contribution On Delivered Iron Ore Price



Source: Clarksons Research

Impact Example: South African Coal Exports To India

Estimated impact of GHG contribution equivalent to $0.27-$4.25/t



South Africa - India (c.5,000 miles)

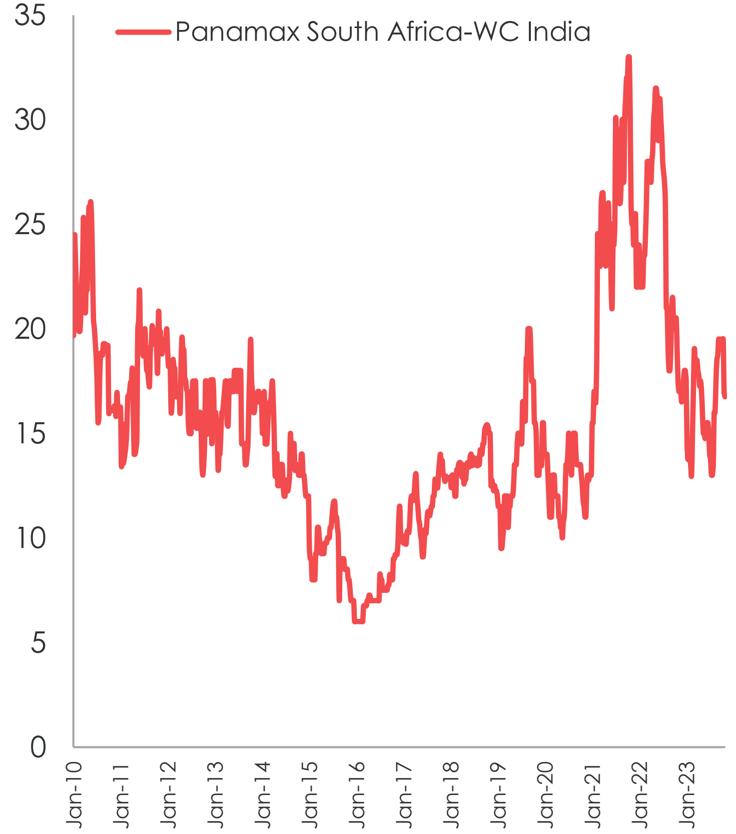
Scenario	Est. Additional Voyage Fuel Cost ($m)	Est. Cost Per Tonne Of Coal Shipped ($)
1) $6.25/t CO_2e	$0.02m	$0.27
2) $12.50/t CO_2e	$0.38m	$0.53
3) $25/t CO_2e	$0.76m	$1.06
4) $50/t CO_2e	$0.15m	$2.12
5) $100/t CO_2e	$0.30m	$4.25

Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only. Basis standard c.2010-built Panamax bulkcarrier, consuming 27 tonnes of fuel per day at 12 knots laden, and 26 tonnes of fuel per day at 12.5 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed). Calculations for South Africa-India basis 72,000t cargo from Richard's Bay to Mundra.

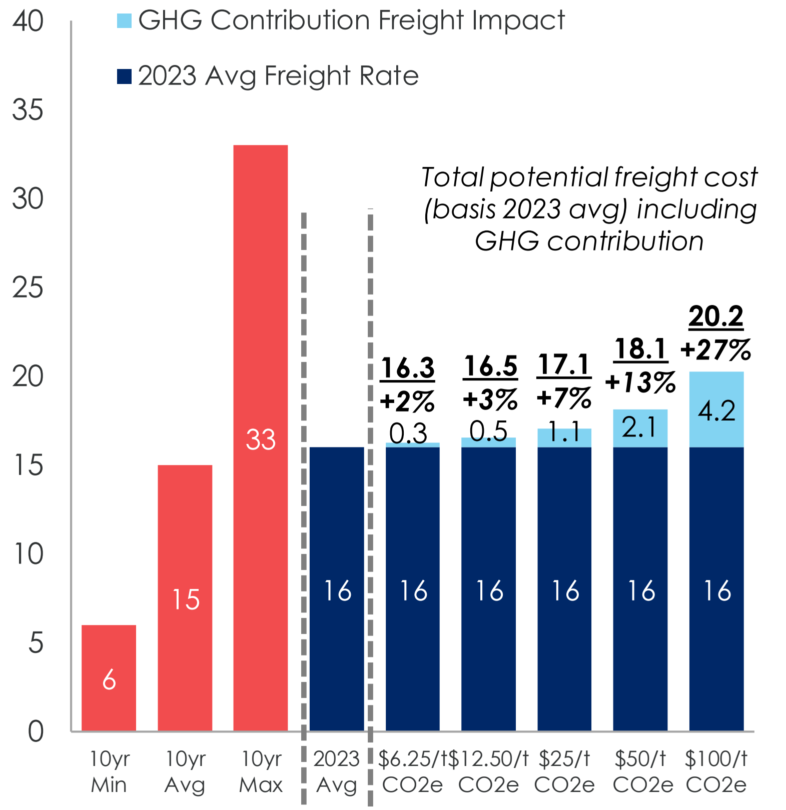
Impact On Coal Freight Rates & Prices

Example: South Africa to India

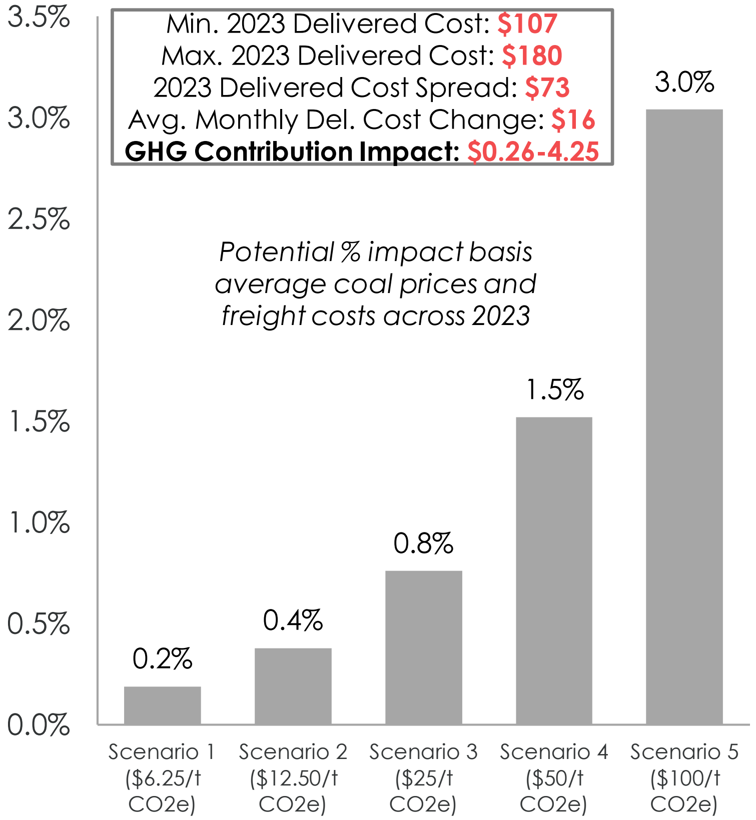
Panamax Bulker Spot Freight Rate, $/tonne



Est. Impact Of GHG Contribution On Freight, $/tonne



Est. % Impact On Delivered Coal Price, $/tonne



Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only. Basis standard c.2010-built Panamax bulkcarrier, consuming 27 tonnes of fuel per day at 12 knots laden, and 26 tonnes per day at 12.5 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed). Calculations basis 72,000t cargo from Richards Bay to Mundra.

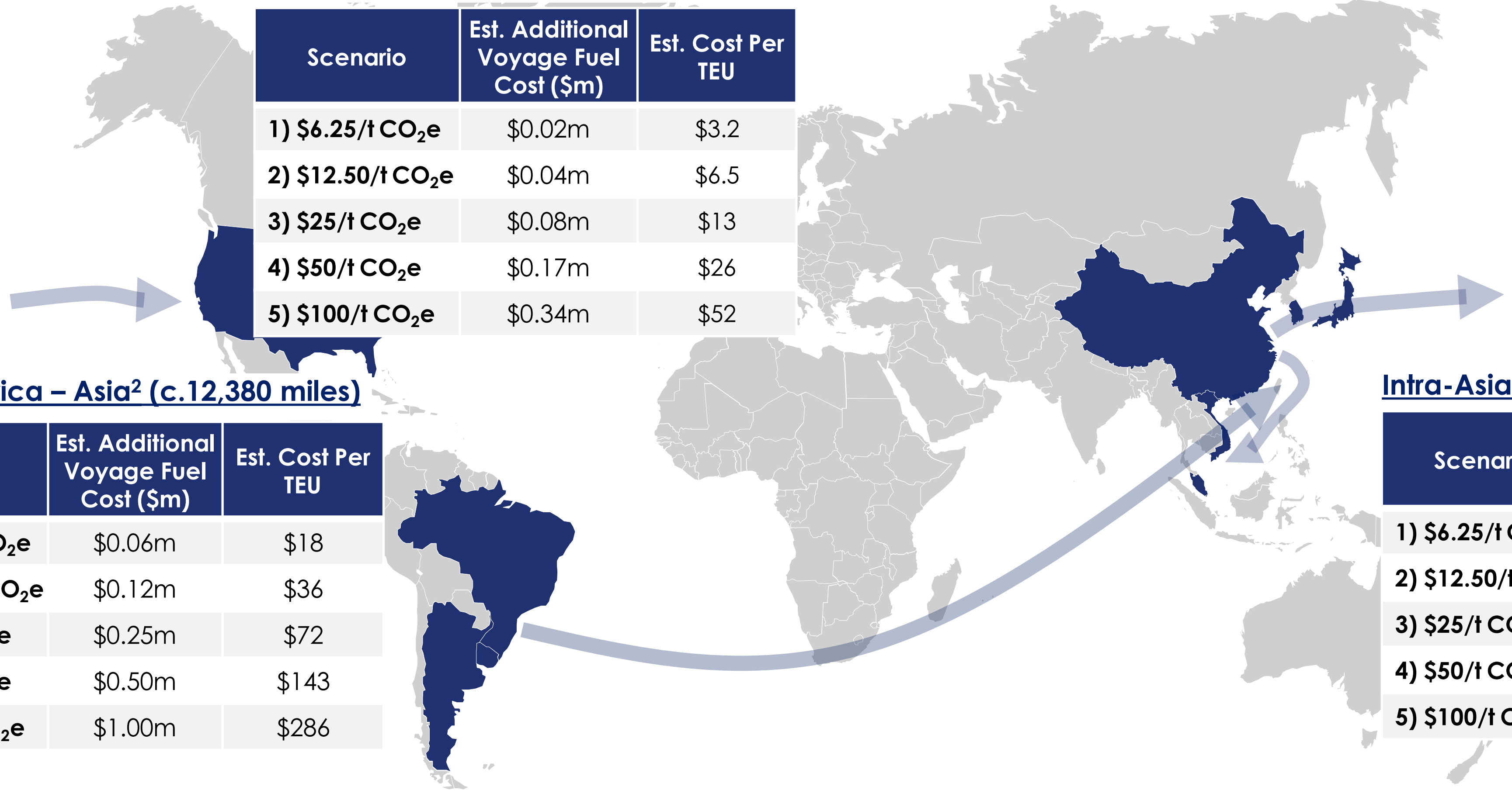
CLARKSONS RESEARCH

Impact Assessment

Container Cargo

Impact Examples: Transpacific, South America-Asia and Intra-Asia Containership Trades

Impact of GHG contribution c.$3-$52/TEU (Transpac.), c.$18-$286/TEU (ECSA-Asia) and $4-$72/TEU (Intra-Asia)



China- US West Coast[1] (c.6,080 miles)

Scenario	Est. Additional Voyage Fuel Cost ($m)	Est. Cost Per TEU
1) $6.25/t CO_2e	$0.02m	$3.2
2) $12.50/t CO_2e	$0.04m	$6.5
3) $25/t CO_2e	$0.08m	$13
4) $50/t CO_2e	$0.17m	$26
5) $100/t CO_2e	$0.34m	$52

South America – Asia[2] (c.12,380 miles)

Scenario	Est. Additional Voyage Fuel Cost ($m)	Est. Cost Per TEU
1) $6.25/t CO_2e	$0.06m	$18
2) $12.50/t CO_2e	$0.12m	$36
3) $25/t CO_2e	$0.25m	$72
4) $50/t CO_2e	$0.50m	$143
5) $100/t CO_2e	$1.00m	$286

Intra-Asia[3] (c.2,650 miles)

Scenario	Est. Additional Voyage Fuel Cost ($m)	Est. Cost Per TEU
1) $6.25/t CO_2e	$0.005m	$4.5
2) $12.50/t CO_2e	$0.01m	$9
3) $25/t CO_2e	$0.02m	$18
4) $50/t CO_2e	$0.04m	$36
5) $100/t CO_2e	$0.08m	$72

Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only. 1). Basis 9,500 TEU containership (homogenous at 14t: 7,200 TEU) on a mainlane Transpacific route with a one-way distance of c.6,080 miles. 2). Basis 8,500 TEU containership (homogenous at 14t: 6,330 TEU) on a backhaul South Asia-ECSA route with a one-way distance of c.12,380 miles. 3). Basis 1,700 TEU containership (homogenous at 14t: 1,240 TEU) on an Intra-Asia route from China to SE Asia with a one-way distance of c.2,650 miles.

Impact Of GHG Contribution On Container Cargo

Example: Transpacific trade

- Basis containership operating on Mainlane Transpacific liner service from China to US West Coast
- 9,500 TEU (modern, c.2010 blt) ship (homogenous @14t: 7,200 TEU), 16 knots at sea
- 16.3 days at sea (one way), 3.9 days in port (one way)
- 90% utilisation of homogenous capacity
- Total fuel consumption = 1,073 tonnes
- Potential impact of GHG contribution on fuel costs and freight rates of $1,500/FEU:

Scenario	Est. Additional Fuel Cost ($m)	Est. Cost Per FEU of Cargo[1] ($)	Est. Cost Per Tonne Of Cargo[2] ($)	% Of Ocean Freight Rate[3]
1 ($6.25/t CO_2e)	$0.02m	$6.5	$0.5	c.0.4%
2 ($12.50/t CO_2e)	$0.04m	$13	$0.9	c.0.9%
3 ($25/t CO_2e)	$0.08m	$26	$1.9	c.1.7%
4 ($50/t CO_2e)	$0.17m	$52	$3.7	c.3.5%
5 ($100/t CO_2e)	$0.34m	$104	$7.4	c.6.9%

- *Note: At higher levels of capacity utilisation the impact of fuel contribution per FEU would be reduced.*

Data source: Clarksons Research standard vessel and voyage assumptions

Notes: 1: Assuming contribution spread equally across cargo. 2: Assuming 7t of cargo per box. 3: Basis typical Shanghai-USWC freight rates over the last year. At a freight rate of $1,000/FEU, contribution would equate to ~0.7% / ~10% of the ocean freight rate (Scenario 1 / 5 respectively). At a freight rate of $2,500/FEU, contribution would equate to ~0.3% / ~4% of the ocean freight rates (Scenario 1 / 5 respectively).

Impact Of GHG Contribution On Container Cargo

Example: South America to Asia perishables trade

- Basis containership operating on ECSA via South Africa to Asia liner service
- 8,500 TEU (modern, c.2010 blt) ship (homogenous @14t: 6,330 TEU), 16 knots at sea
- 32.3 days at sea (one way), 8.1 days in port (one way)
- 50% utilisation of homogenous capacity (basis estimated imbalance of cargo vs Asia-S.Am leg)
- Total fuel consumption including reefer consumption (basis c.10% of cargo) = 3,175 tonnes
- Potential impact of GHG contribution on fuel costs and freight rates of $1,500/TEU:

Scenario	Est. Additional Fuel Cost ($m)	Est. Cost Per TEU of Cargo[1] ($)	Est. Cost Per Tonne Of Perishable Cargo[2] ($)	% Of Ocean Freight Rate[3]
1 ($6.25/t CO_2e)	$0.06m	$17.9	$1.5	c.1.2%
2 ($12.50/t CO_2e)	$0.12m	$35.8	$3	c.2.4%
3 ($25/t CO_2e)	$0.25m	$71.6	$6	c.4.8%
4 ($50/t CO_2e)	$0.50m	$143.2	$12	c.9.5%
5 ($100/t CO_2e)	$1.00m	$286.3	$24	c.19.1%

- *Note: At higher levels of capacity utilisation the impact of fuel contribution per TEU would be reduced.*

Data source: Clarksons Research standard vessel and voyage assumptions

Notes: 1: Assuming contribution spread equally across cargo. 2: Assuming 12t of cargo per box. 3: Basis estimated indicative global reefer cargo freight rate of around $1,500/TEU. At a freight rate of $1,000/TEU, contribution would equate to ~1.8% / ~29% of the ocean freight rate (Scenario 1 / 5 respectively). At a freight rate of $3,000/TEU, contribution would equate to ~0.6% / ~9.5% of the ocean freight rates (Scenario 1 / 5 respectively).

Impact Of GHG Contribution On Container Cargo

Example: Intra-Asia trade

- Basis containership operating Intra-Asia liner service from China to South East Asia
- 1,700 TEU (modern, c.2010 blt) ship (homogenous @14t: 1,240 TEU), 14 knots at sea
- 7.8 days at sea (one way), 2.3 days in port (one way)
- 90% utilisation of homogenous capacity
- Total fuel consumption including reefer consumption (basis c.6% of cargo) = 256 tonnes
- Potential impact of GHG contribution on fuel costs and freight rates of $170/TEU:

Scenario	Est. Additional Fuel Cost ($m)	Est. Cost Per TEU of Cargo[1] ($)	Est. Cost Per Tonne Of Cargo[2] ($)	% Of Ocean Freight Rate[2]
1 ($6.25/t CO_2e)	$0.005m	$4.5	$0.5	c.2.6%
2 ($12.50/t CO_2e)	$0.01m	$9	$0.9	c.5.3%
3 ($25/t CO_2e)	$0.02m	$18	$1.8	c.10.6%
4 ($50/t CO_2e)	$0.04m	$36	$3.6	c.21.2%
5 ($100/t CO_2e)	$0.08m	$72	$7.2	c.42.3%

- *Note: At higher levels of capacity utilisation the impact of fuel contribution per TEU would be reduced.*

Data source: Clarksons Research standard vessel and voyage assumptions

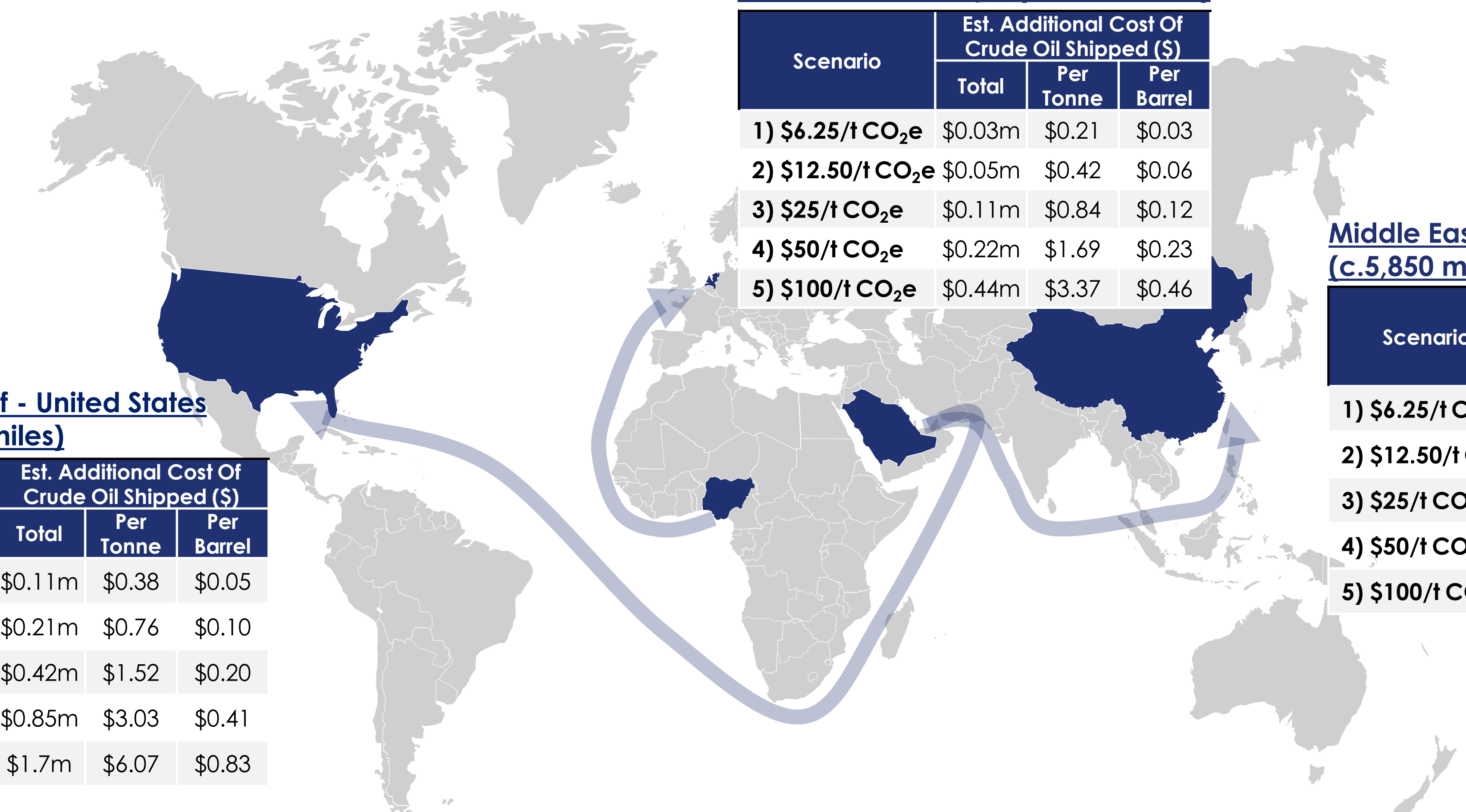
Notes: 1: Assuming contribution spread equally across cargo. 2: Assuming 10t of cargo per box. At a freight rate of $100/TEU, contribution would equate to ~4.5% / ~72% of the ocean freight rate (Scenario 1 / 5 respectively). At a freight rate of $320/TEU, contribution would equate to ~1.4% / ~22% of the ocean freight rates (Scenario 1 / 5 respectively).

Impact Assessment

Crude Oil & Oil Products

Impact Examples: Crude Oil – Mid. East Exports To China, US & West Africa Exports To Europe

Estimated impact of GHG contribution \$0.2-\$6/t depending on the route



West Africa – Europe (c.4,475 miles)

Scenario	Est. Additional Cost Of Crude Oil Shipped (\$)		
	Total	Per Tonne	Per Barrel
1) \$6.25/t CO_2e	\$0.03m	\$0.21	\$0.03
2) \$12.50/t CO_2e	\$0.05m	\$0.42	\$0.06
3) \$25/t CO_2e	\$0.11m	\$0.84	\$0.12
4) \$50/t CO_2e	\$0.22m	\$1.69	\$0.23
5) \$100/t CO_2e	\$0.44m	\$3.37	\$0.46

Middle East Gulf - China (c.5,850 miles)

Scenario	Est. Additional Cost Of Crude Oil Shipped (\$)		
	Total	Per Tonne	Per Barrel
1) \$6.25/t CO_2e	\$0.05m	\$0.20	\$0.03
2) \$12.50/t CO_2e	\$0.11m	\$0.39	\$0.05
3) \$25/t CO_2e	\$0.21m	\$0.78	\$0.11
4) \$50/t CO_2e	\$0.42m	\$1.56	\$0.21
5) \$100/t CO_2e	\$0.84m	\$3.12	\$0.43

Middle East Gulf - United States Gulf (c.12,300 miles)

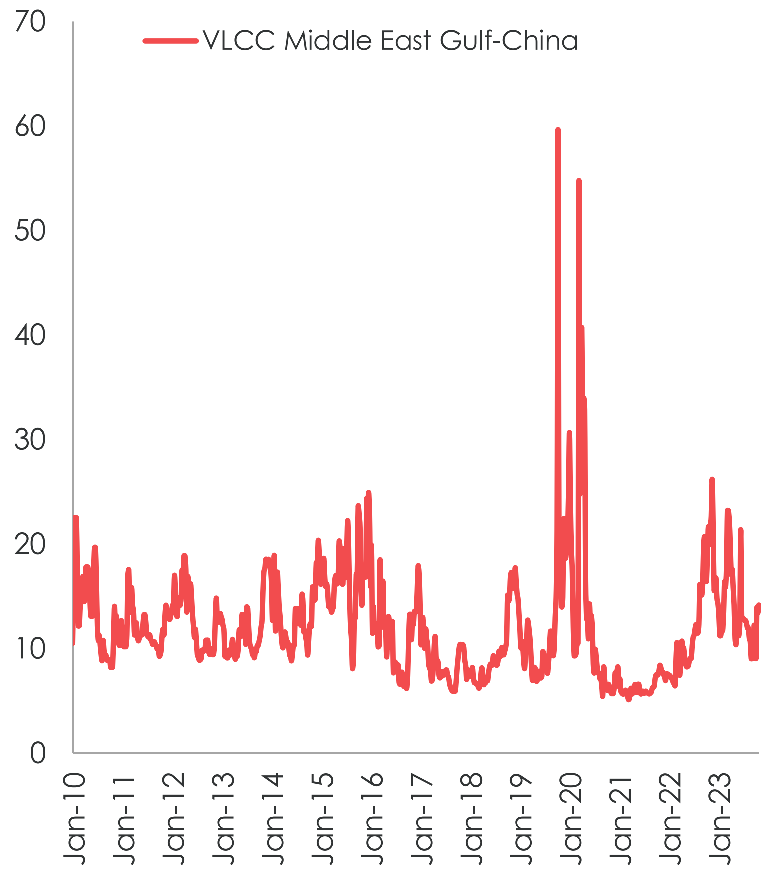
Scenario	Est. Additional Cost Of Crude Oil Shipped (\$)		
	Total	Per Tonne	Per Barrel
1) \$6.25/t CO_2e	\$0.11m	\$0.38	\$0.05
2) \$12.50/t CO_2e	\$0.21m	\$0.76	\$0.10
3) \$25/t CO_2e	\$0.42m	\$1.52	\$0.20
4) \$50/t CO_2e	\$0.85m	\$3.03	\$0.41
5) \$100/t CO_2e	\$1.7m	\$6.07	\$0.83

Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only. Middle East Gulf-United States Gulf and Middle East Gulf-China basis standard c.2010-built VLCC, consuming 67 tonnes of fuel per day at 12.5 knots laden, and 51 tonnes per day at 12 knots ballast. West Africa-Europe basis standard c.2010-built Suezmax, consuming 45 tonnes of fuel per day at 12.5 knots laden, and 35 tonnes per day at 12 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed on all routes). Calculations for Middle East Gulf-United States Gulf basis 280,000t cargo from Ras Tanura to LOOP, for Middle East Gulf-China basis 270,000t cargo from Ras Tanura to Ningbo and for West Africa-Europe basis 130,000t cargo from Bonny to Rotterdam.

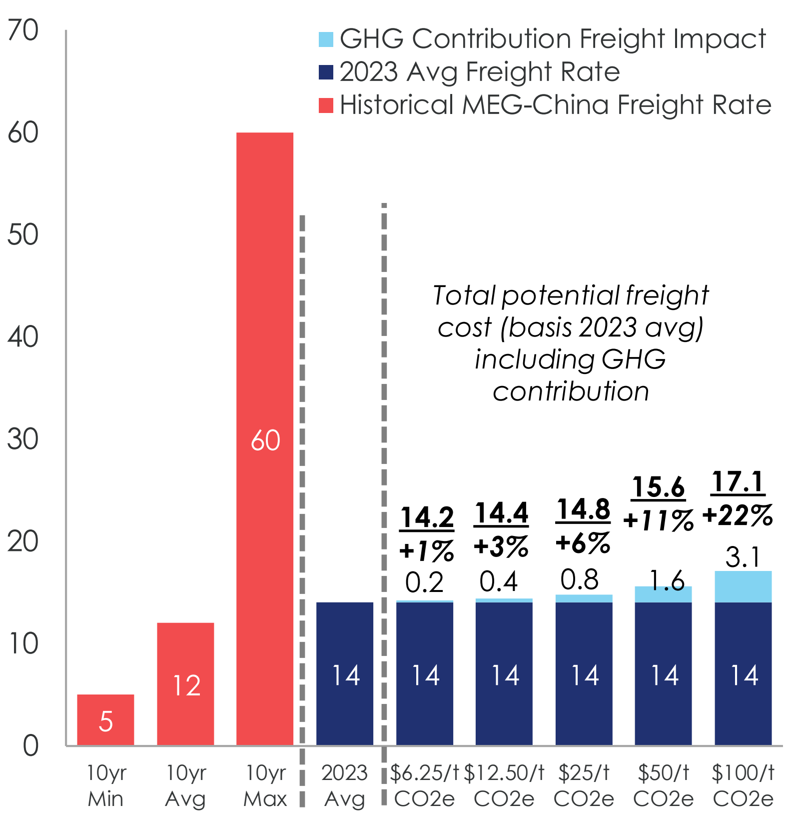
Impact On Crude Oil Freight Rates & Prices

Example: Middle East Gulf – China

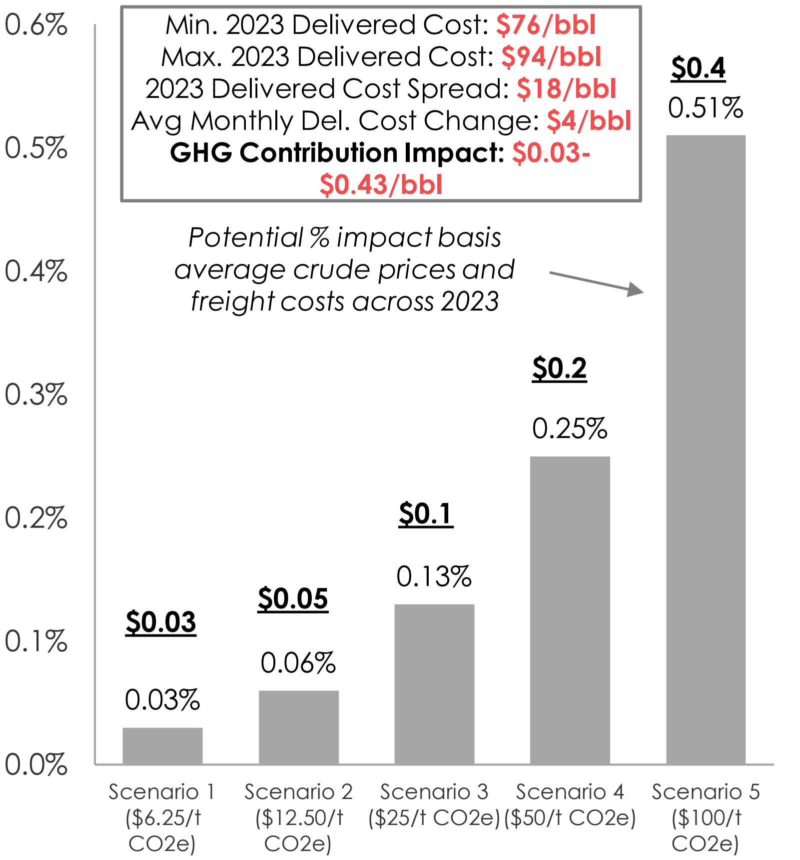
Crude Tanker Spot Freight Rate, $/tonne



Est. Impact Of GHG Contribution On Freight, $/tonne



Est. % Impact On Delivered Crude Price, $/bbl

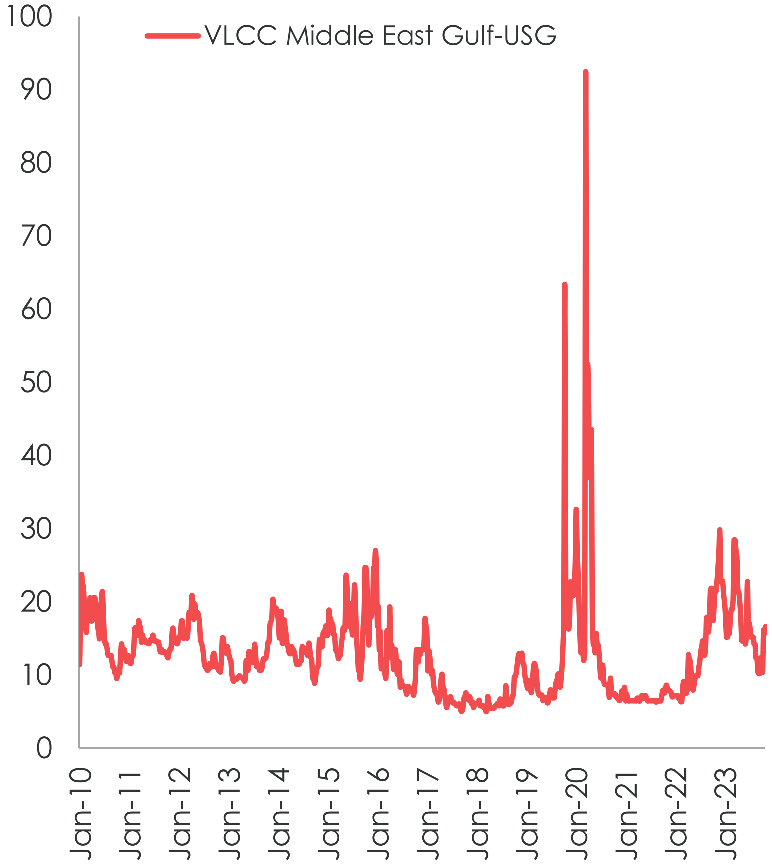


Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only. Basis standard c.2010-built VLCC, consuming 67 tonnes of fuel per day at 12.5 knots laden, and 51 tonnes per day at 12 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed). Calculations basis 270,000t cargo from Ras Tanura to Ningbo. Freight rate data prior to August 2018 basis Ras Tanura-Chiba.

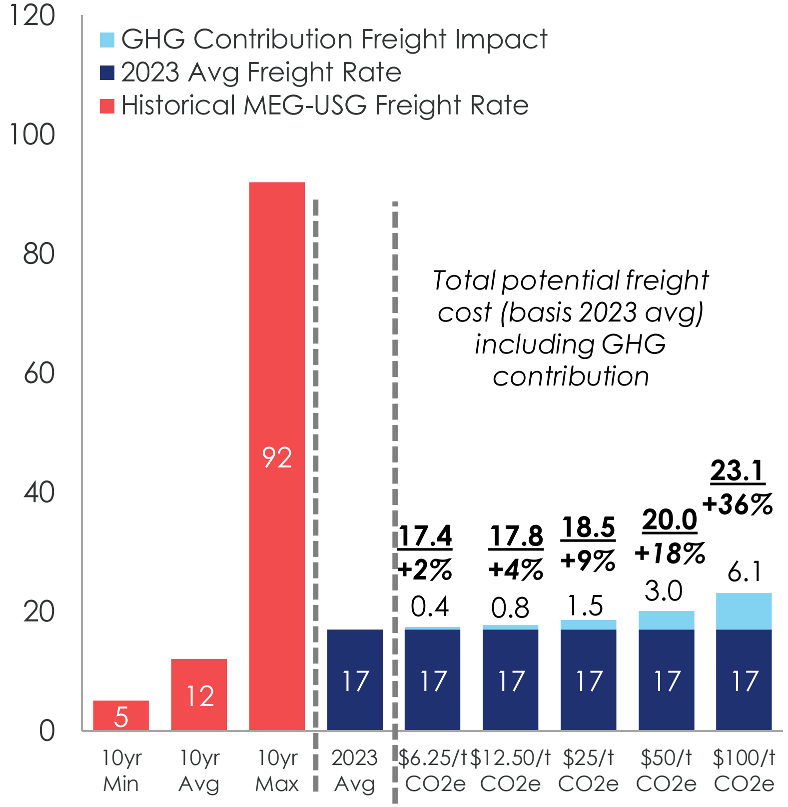
Impact On Crude Oil Freight Rates & Prices

Example: Middle East Gulf – United States Gulf

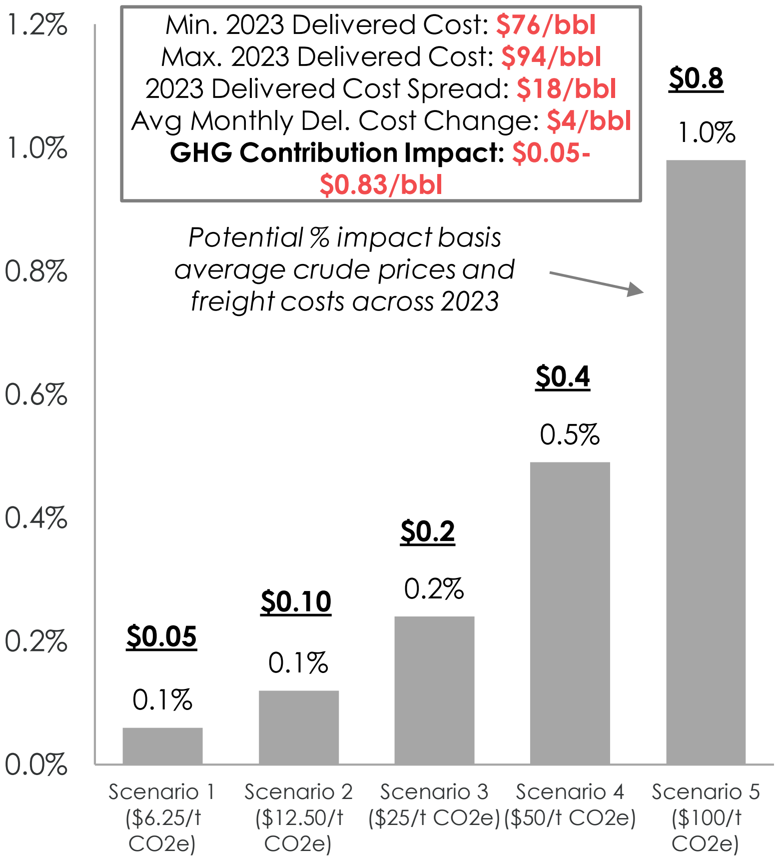
Crude Tanker Spot Freight Rate, $/tonne



Est. Impact Of GHG Contribution On Freight, $/tonne



Est. % Impact On Delivered Crude Price, $/bbl

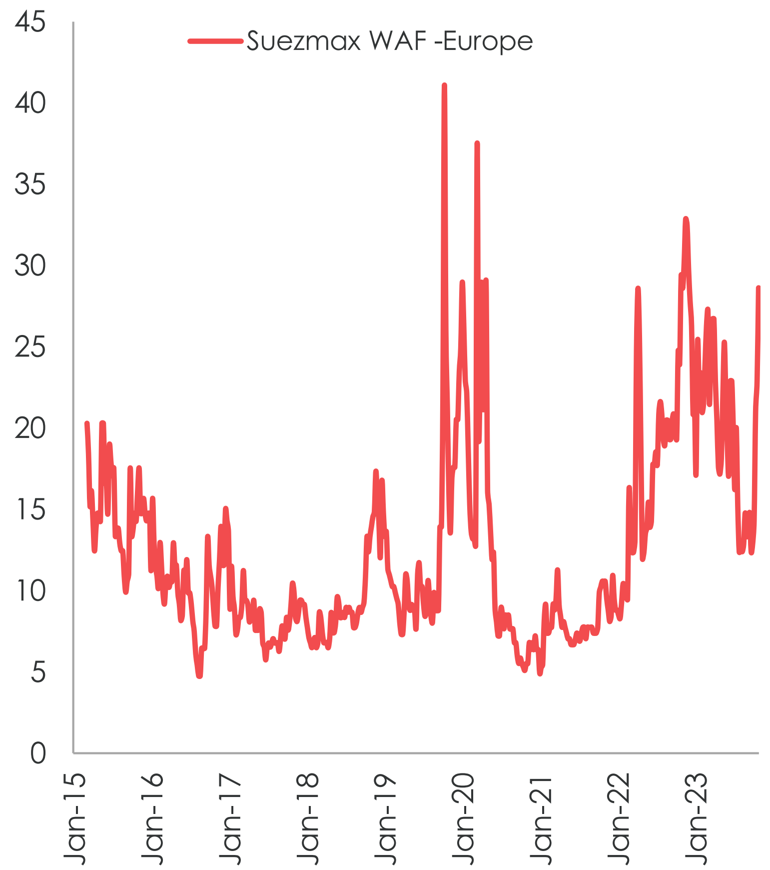


Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only. Basis standard c.2010-built VLCC, consuming 67 tonnes of fuel per day at 12.5 knots laden, and 51 tonnes per day at 12 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed). Calculations basis 270,000t cargo from Ras Tanura to Loop.

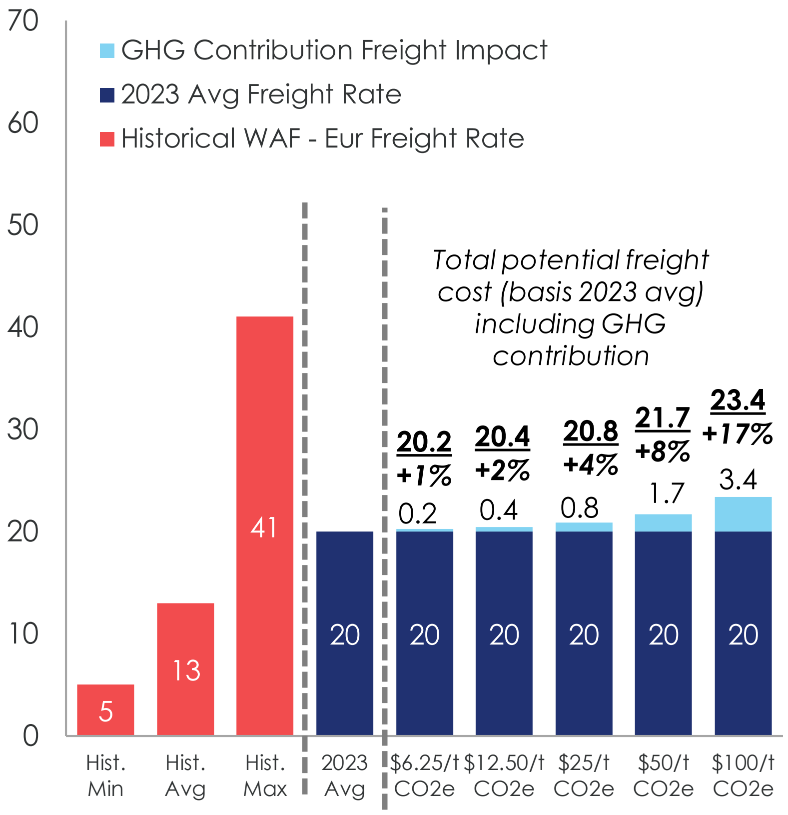
Impact On Crude Oil Freight Rates & Prices

Example: West Africa – Europe

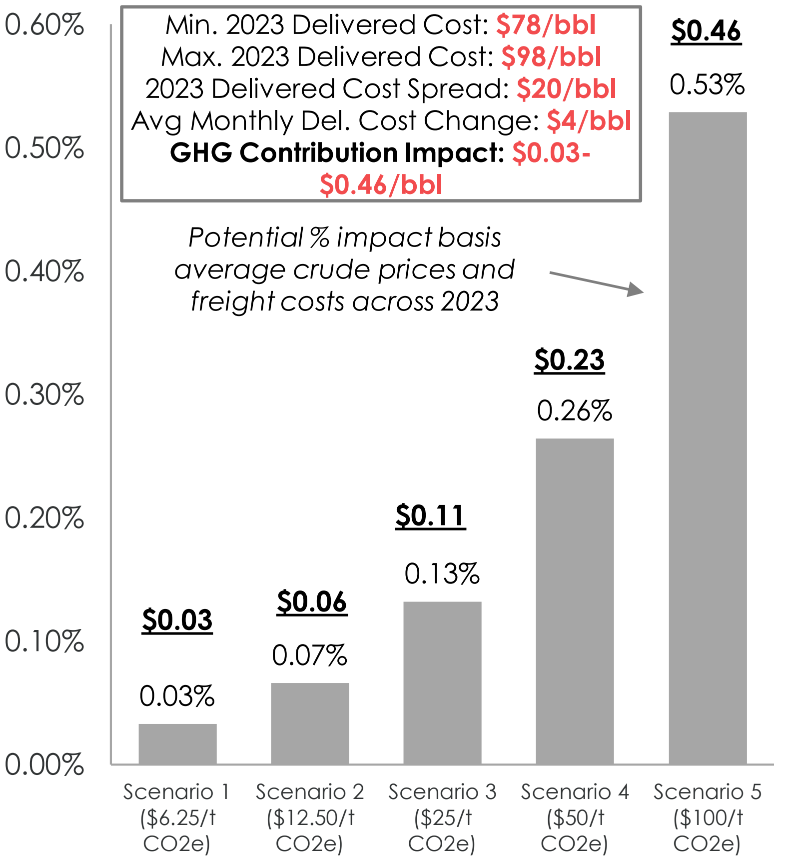
Crude Tanker Spot Freight Rate, $/tonne



Est. Impact Of GHG Contribution On Freight, $/tonne



Est. % Impact On Delivered Crude Price, $/bbl



Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only. Basis standard c.2010-built Suezmax, consuming 45 tonnes of fuel per day at 12.5 knots laden, and 35 tonnes per day at 12 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed). Calculations basis 130,000t cargo from Bonny to Rotterdam.

Impact Example: Oil Products – US Gasoline Exports To S.Am. & Japan, Sing.-Australia

Estimated impact of GHG contribution an additional \$0.5-\$12.5/t route dependent

United States Gulf – Brazil (c.5,430 miles)

Scenario	Est. Additional Cost Of Gasoline Shipped (\$)		
	Total	Per Tonne	Per Litre
1) \$6.25/t CO_2e	\$0.021m	\$0.54	\$0.0004
2) \$12.50/t CO_2e	\$0.041m	\$1.08	\$0.0008
3) \$25/t CO_2e	\$0.082m	\$2.16	\$0.0016
4) \$50/t CO_2e	\$0.164m	\$4.32	\$0.0033
5) \$100/t CO_2e	\$0.329m	\$8.65	\$0.0065

United States Gulf – Japan (c.9,280 miles)

Scenario	Est. Additional Cost Of Gasoline Shipped (\$)		
	Total	Per Tonne	Per Litre
1) \$6.25/t CO_2e	\$0.046m	\$0.78	\$0.0006
2) \$12.50/t CO_2e	\$0.093m	\$1.56	\$0.0012
3) \$25/t CO_2e	\$0.187m	\$3.12	\$0.0023
4) \$50/t CO_2e	\$0.374m	\$6.24	\$0.0047
5) \$100/t CO_2e	\$0.748m	\$12.47	\$0.0094

Singapore – Australia (c.4,470 miles)

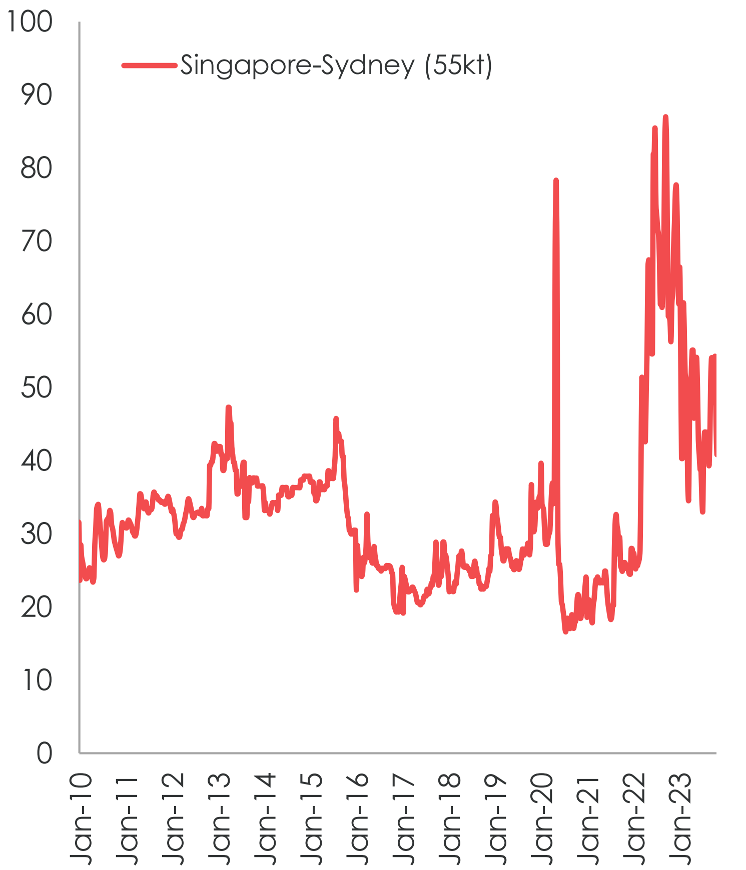
Scenario	Est. Additional Cost Of Gasoline Shipped (\$)		
	Total	Per Tonne	Per Litre
1) \$6.25/t CO_2e	\$0.017m	\$0.49	\$0.0004
2) \$12.50/t CO_2e	\$0.034m	\$0.97	\$0.0007
3) \$25/t CO_2e	\$0.068m	\$1.95	\$0.0015
4) \$50/t CO_2e	\$0.136m	\$3.89	\$0.0029
5) \$100/t CO_2e	\$0.273m	\$7.79	\$0.0059

Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only. United States Gulf-Japan basis standard c.2010-built LR1, consuming 38 tonnes of fuel per day at 12.5 knots laden, and 31 tonnes per day at 12 knots ballast. United States Gulf-Brazil and Singapore-Australia basis standard c.2010-built MR, consuming 27 tonnes of fuel per day at 12.5 knots laden, and 25 tonnes per day at 12 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed on all routes). Calculations for United States Gulf-Japan basis 60,000t cargo from Houston to Chiba, for United States Gulf-Brazil basis 38,000t cargo from Houston to Rio de Janeiro and for Singapore-Australia basis 38,000t cargo from Singapore to Sydney.

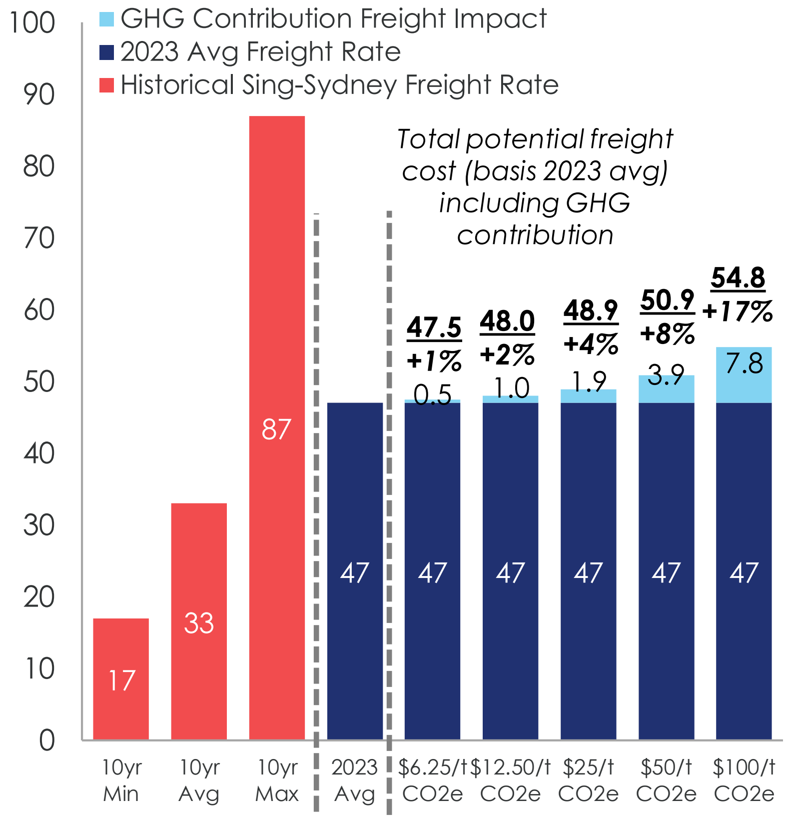
Impact On Petroleum Products Freight Rates & Prices

Example: Singapore - Sydney

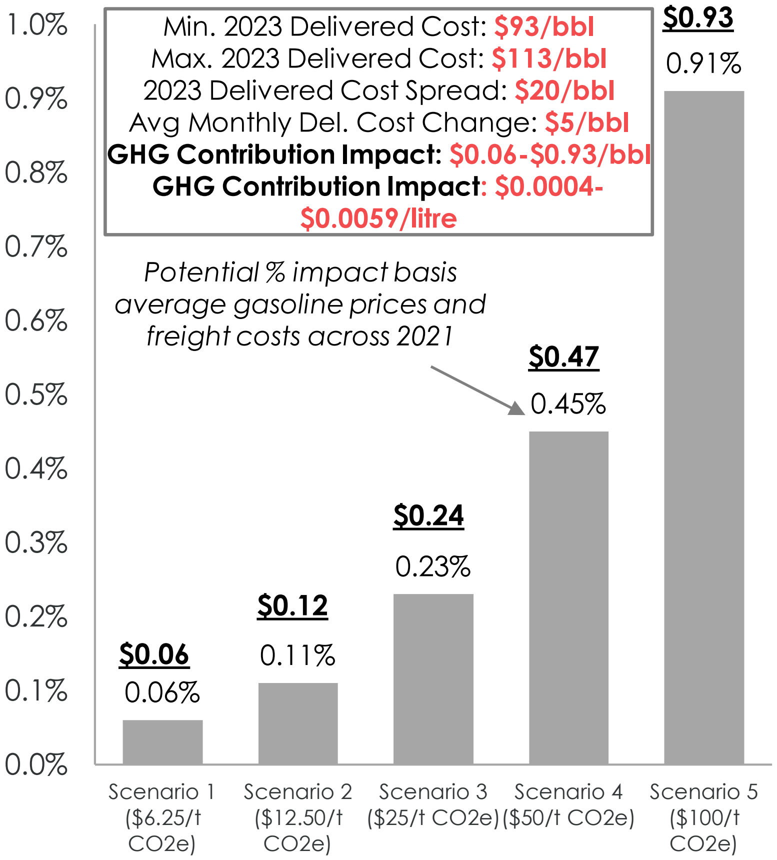
Clean Products Spot Freight Rate, $/tonne



Est. Impact Of GHG Contribution On Freight, $/t



Est. % Impact On Delivered Gasoline, $/bbl



Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only. Basis standard c.2010-built MR tanker, consuming 27 tonnes of fuel per day at 12.5 knots laden, and 25 tonnes per day at 12 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed). Calculations basis 35,000t cargo.

Impact On Petroleum Products Freight Rates & Prices

Example: Singapore - Fiji

- Basis MR products tanker on a round voyage from Singapore to Fiji
- c.2010-built standard 50,000 dwt vessel, consuming 27 tonnes per day at 12.5 knots laden, 25 tonnes per day at 12 knots ballast, plus estimate for in port consumption
- Basis 35,000t cargo from Singapore to Fiji, c.4,700 miles:

Scenario	Est. Additional Fuel Cost ($m)	Est. Cost Per Tonne Of Refined Oil Products Shipped ($)	Est. Cost Per Barrel Of Refined Oil Products Shipped ($)	Est. Cost Per Litre Of Refined Oil Products Shipped ($)	Est. Impact On Delivered Gasoline Cost (basis 2023 avg)
1 ($6.25/t CO_2e)	$0.018m	$0.51	$0.061	$0.0004	0.06%
2 ($12.50/t CO_2e)	$0.035m	$1.02	$0.122	$0.0008	0.12%
3 ($25/t CO_2e)	$0.071m	$2.04	$0.244	$0.0015	0.24%
4 ($50/t CO_2e)	$0.142m	$4.08	$0.489	$0.0031	0.48%
5 ($100/t CO_2e)	$0.285m	$8.17	$0.978	$0.0062	0.95%

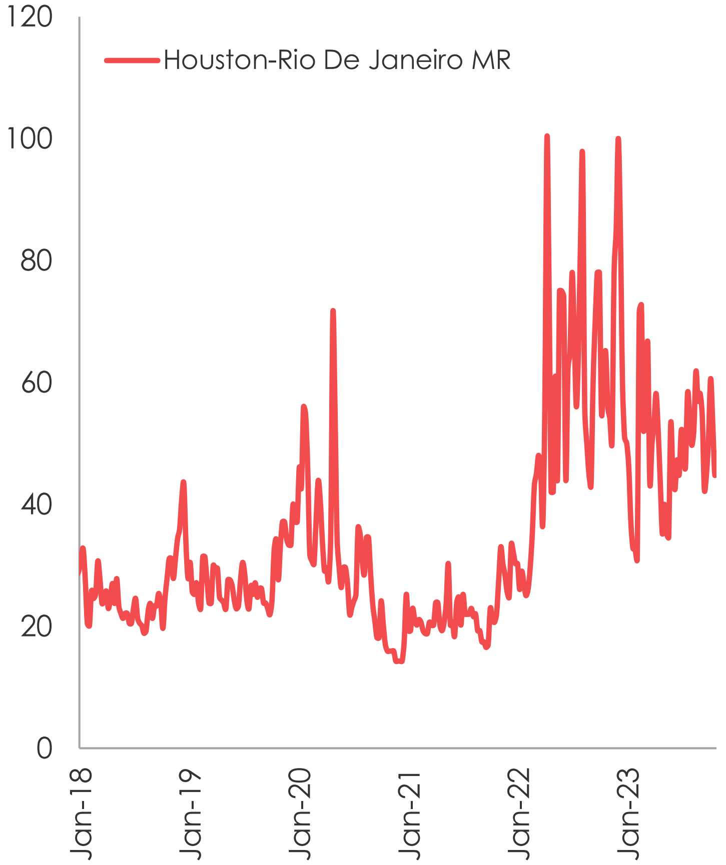
- Estimated impact of GHG contribution on delivered cargo cost of $0.50-$8/t
  - For comparison estimated freight costs on the Singapore-Sydney route have varied in a range of $70/t in the last ten years
  - Average monthly variation in delivered cargo costs through 2023 standing at $43/t

Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only.

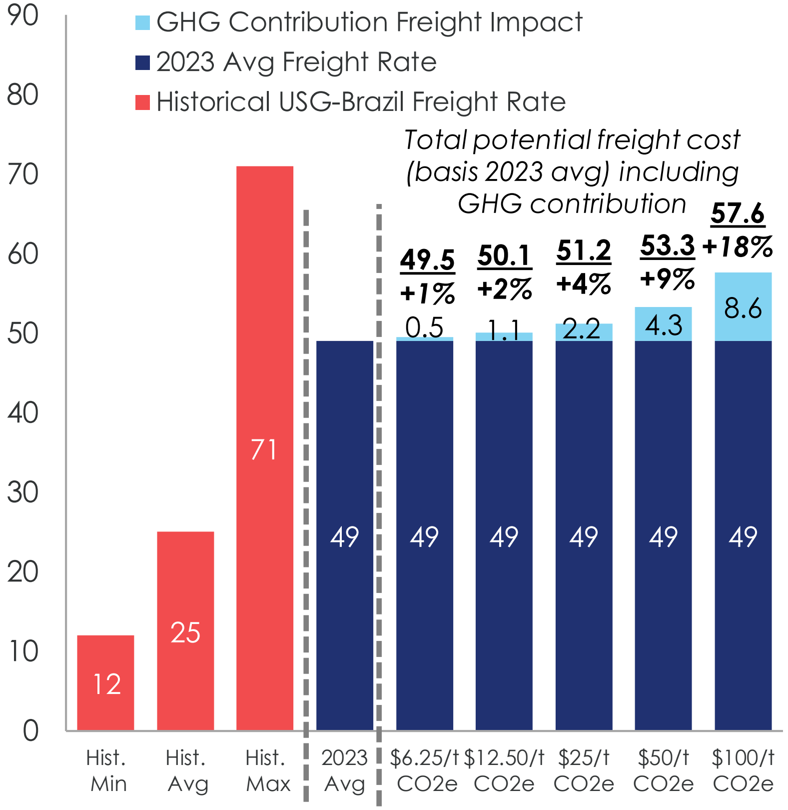
Impact On Petroleum Products Freight Rates & Prices

Example: United States Gulf - Brazil

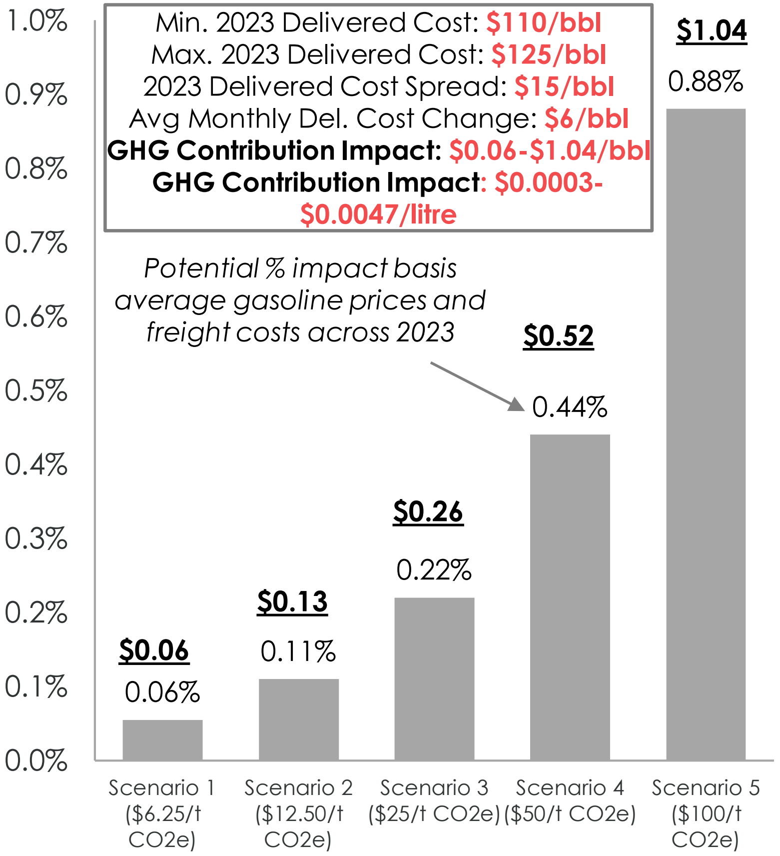
Clean Products Spot Freight Rate, $/tonne



Est. Impact Of GHG Contribution On Freight, $/t



Est. % Impact On Delivered Gasoline, $/bbl

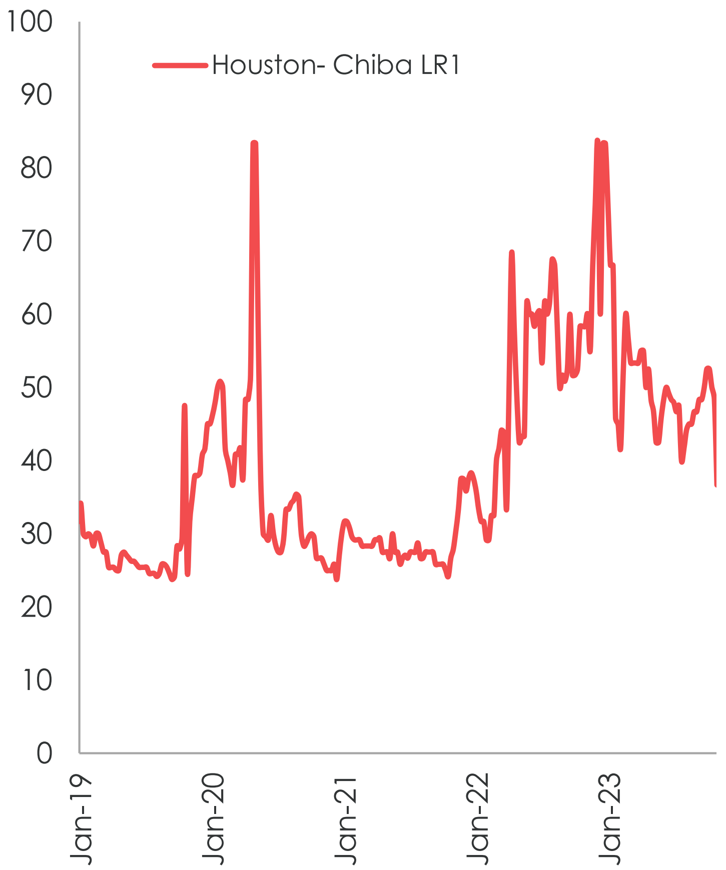


Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only. Basis standard c.2010-built MR tanker, consuming 27 tonnes of fuel per day at 12.5 knots laden, and 25 tonnes per day at 12 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed). Calculations basis 38,000t cargo.

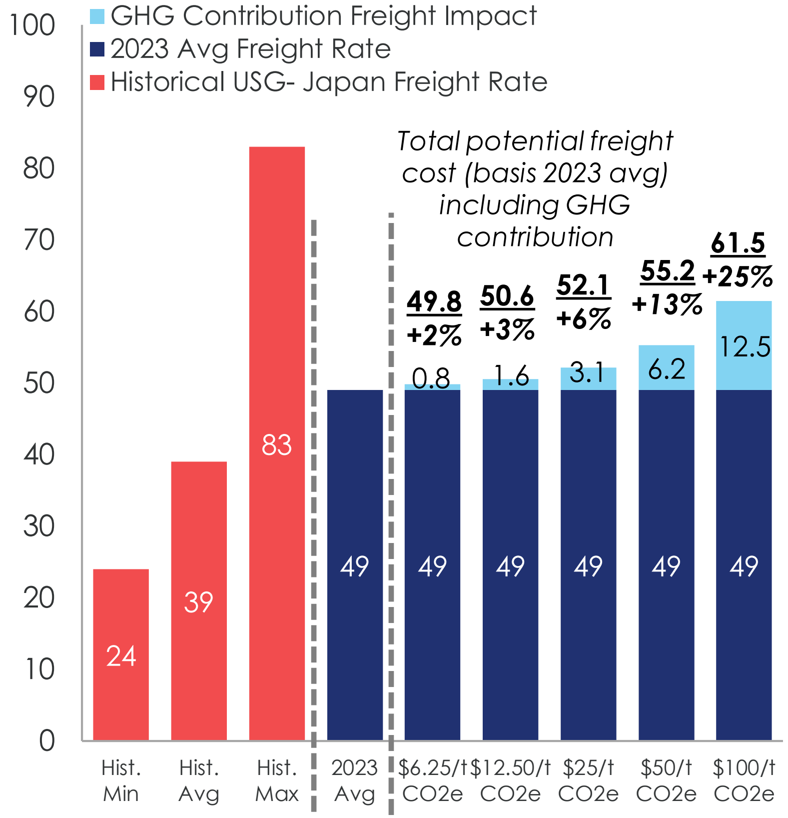
Impact On Petroleum Products Freight Rates & Prices

Example: United States Gulf - Asia

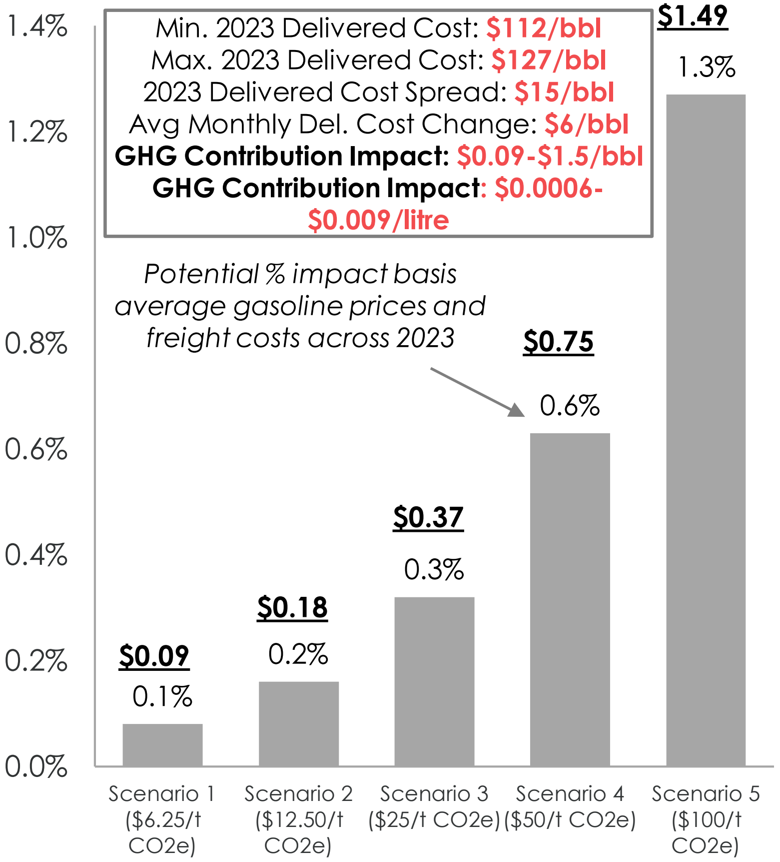
Clean Products Spot Freight Rate, $/tonne



Est. Impact Of GHG Contribution On Freight, $/t



Est. % Impact On Delivered Gasoline, $/bbl



Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only from Houston- Chiba. Basis standard c.2010-built LR1 tanker, consuming 38 tonnes of fuel per day at 12.5 knots laden, and 31 tonnes per day at 12 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed). Calculations basis 60,000t cargo.

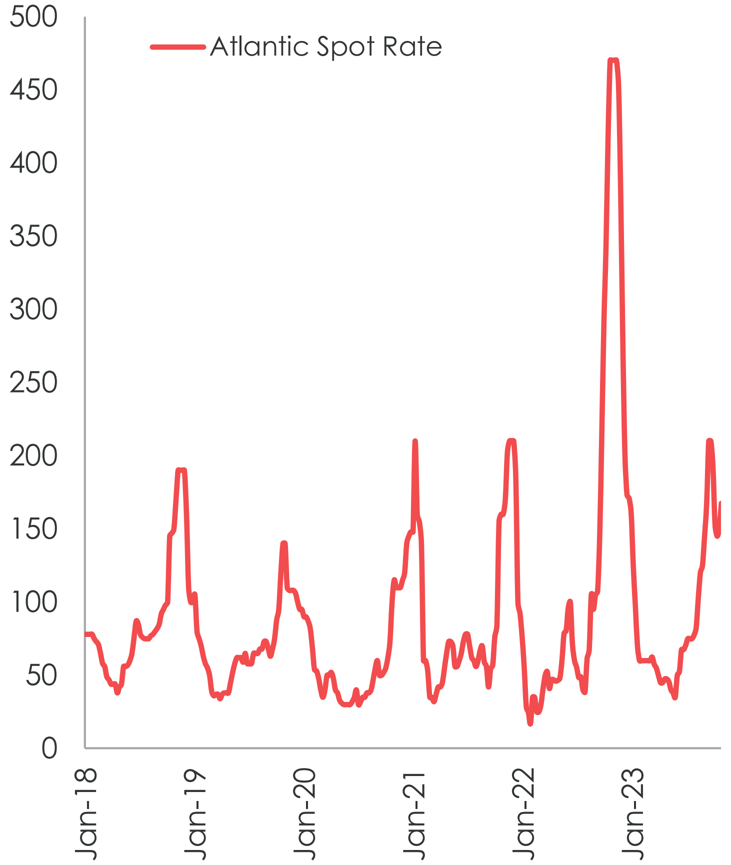
Impact Assessment

Liquefied Natural Gas

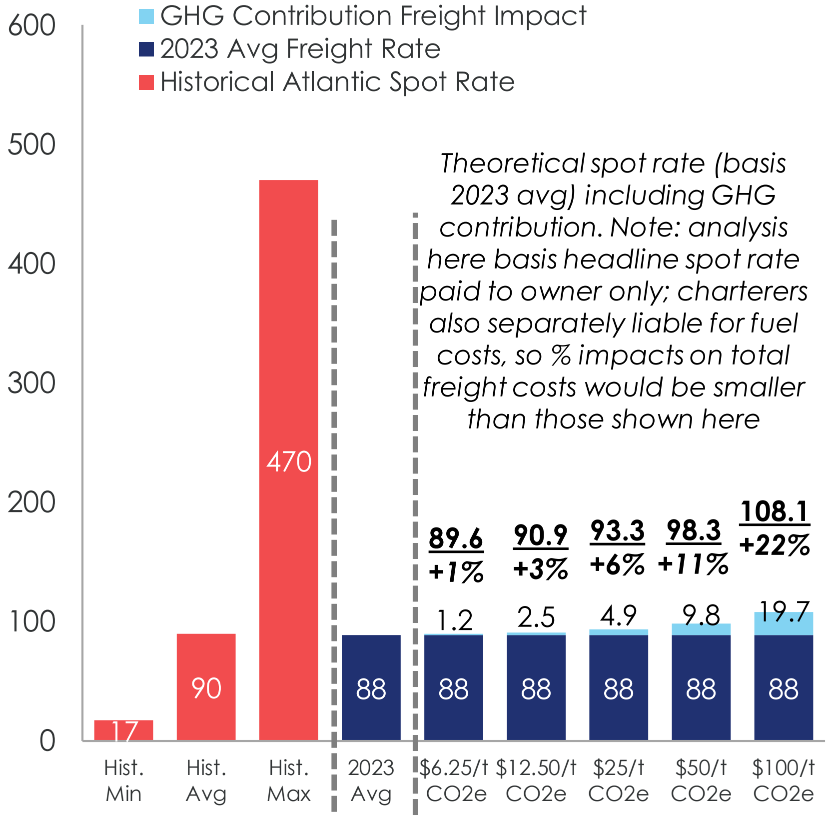
Impact On LNG Freight Rates & Prices

Example: United States Gulf - Europe

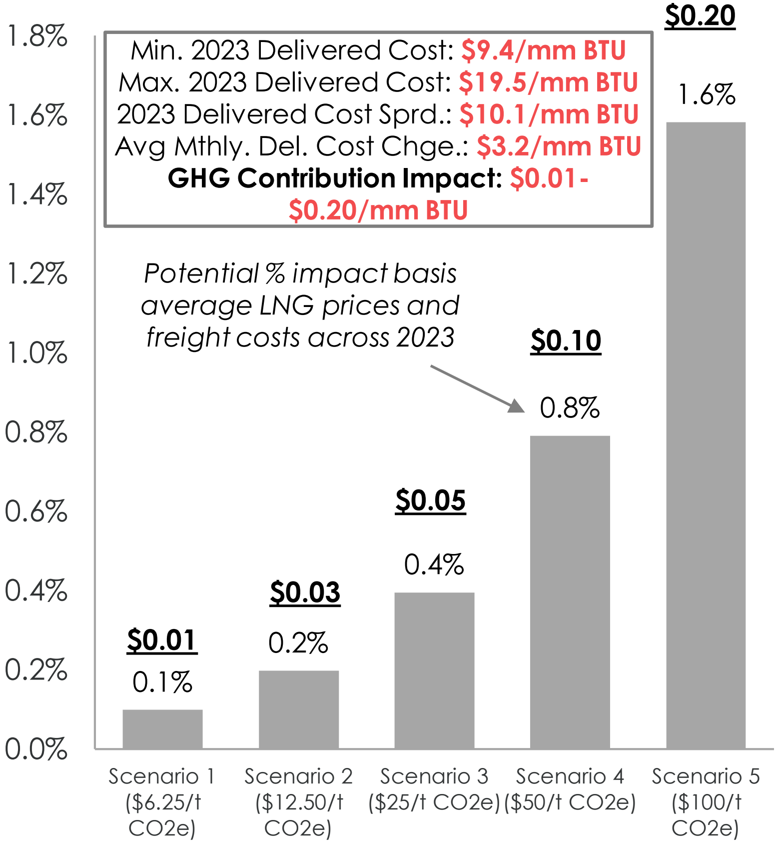
LNG Spot Rate, $000/day



Est. Impact Of GHG Contribution On Spot Rate, $000/day



Est. % Impact On Delivered LNG, $/mm BTU (million British Thermal Units)



Source: Clarksons Research. Estimated additional fuel cost due to GHG contribution basis standard vessel and voyage assumptions, and CO_2 emissions only from Sabine Pass-Zeebrugge. Basis standard c.2010-built 160,000 cbm DFDE LNG carrier, consuming 82.25 tonnes of fuel per day at 16 knots laden, and 77.5 tonnes per day at 16 knots ballast. Figures include estimate for consumption in port and on ballast leg (round voyage assumed). Calculations basis 67,000t cargo.

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