Decarbonization Efforts in International Shipping & Research @ CMS

SMI Forum 2023

Towards Maritime Net Zero

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Outline

- International Shipping Ambitions and Actions
- Maritime Decarbonization Research @ CMS
  - Modeling & analysis of historical & current status:
    - Emission and carbon intensity estimations
    - Understanding the drivers of emission and carbon intensity trends
  - Modeling & analysis of future scenarios:
    - Global and regional impact assessment of fuel, technology, policy pathways
  - Identifying opportunities and gaps

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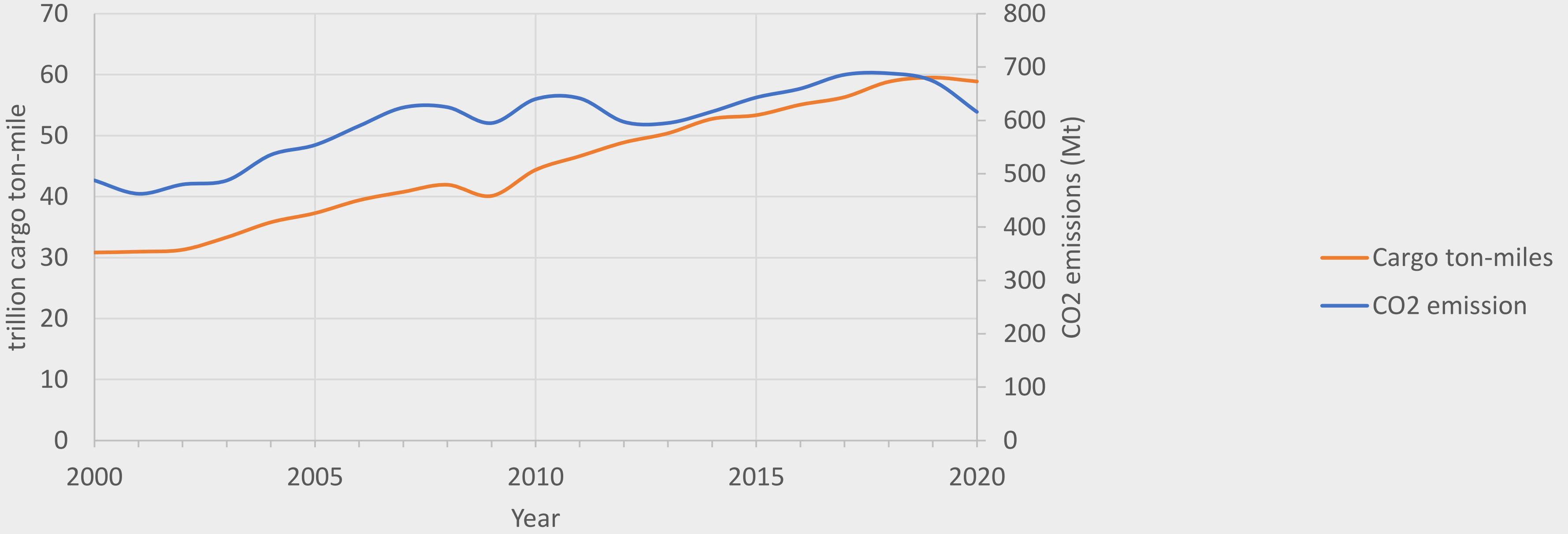
Emissions from International Shipping

- **Emissions** from international shipping has been increasing as international trade grows



Data sources: IEA World Energy Balances; UNCTAD Review of Maritime Transport series

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Global Reduction Targets & Decarbonization efforts

IMO GHG Reduction Targets

- **Reduce CO2 emission intensity** by at least **40% by 2030**, pursuing efforts towards 70% by 2050, compared to 2008.

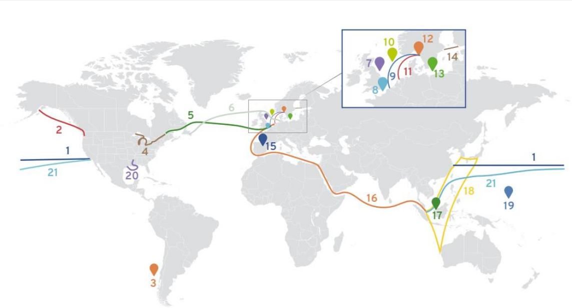
- To reach **net-zero GHG emissions** by or around **2050**

- Indicative checkpoints to reach net-zero:
  reduce total annual **GHG emissions** by **at least 20%,** striving for 30%, by **2030**;
  reduce by **at least 70%,** striving for 80% by **2040**
  (compared to 2008)

- uptake of **at least 5% zero or near-zero** GHG **emission fuels** and/or energy sources by **2030**

IMO Actions (regulations)

- **EEDI** Energy Efficiency Design Index
  - **mandatory design index** for *new* ships
- **SEEMP** Ship Energy Efficiency Management Plan
  - **mandatory** to have **energy efficiency management** plan for all ships
- **DCS** Data Collection System
  - **mandatory** requirement for all ships to record and **report their fuel consumption** since 2019 to calculate ship's operational carbon intensity
- **EEXI** Energy Efficiency Index for Existing Ship
  - **mandatory design energy efficiency index** for *all* ships
- **CII** Annual Carbon Intensity Indicator rating
  - **mandatory** to collect data for the reporting **annual operational CII**
  - **CII rating A, B, C, D or E** on a scale and mandatory to be recorded in the SEEMP



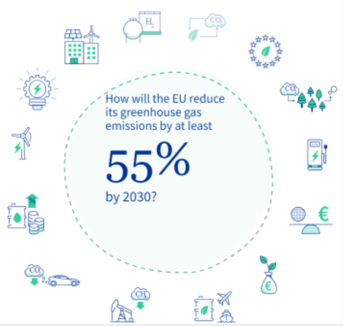
Regional Targets and Decarbonization Efforts

European Union

Targets: **reduce** GHG emissions by **at least 55% by 2030** compared to 1990 levels and achieve **climate neutrality** in **2050** (EU green deal)

Actions:

- FuelEU maritime initiative to increase the demand for and consistent use of renewable and low-carbon fuels and reduce the greenhouse gas emissions from the shipping sector.
  - GHG intensity of fuels used by shipping sector will gradually decrease over time to 80% by 2050
- EU-ETS (pricing mechanism on GHG emissions)



Route based / Green Corridor Initiatives

Zero-emission fuels and technologies along trade routes between two (or more) ports can help accelerate adoption of alternatives to conventional fuels in the maritime industry for GHG emissions reduction

Singapore-Rotterdam Green Corridor

- **20% reduction** in GHG emissions (striving for 30%) by **2030**, compared to 2022

West Australia-East Asia Iron Ore Green Corridor

- Ships on **clean** ammonia to be deployed by 2028 and reach **5% adoption by 2030**

LA-Long Beach-Singapore Green and Digital Corridor

SILK Alliance

MARITIME DECARBONIZATION PROGRAM @ CMS

To develop analytical models and tools to study decarbonization pathways and its impacts, to further inform policy development and responses, and business decisions on both the local and international stages

- **Current projects / activities**
  - An Integrated Model for Maritime Emission Reduction (**AIMMER**)
  - Modeling and design of green & digital shipping corridors

- *Some past projects*
  - Impacts of IMO Technical and Operational Energy Efficiency Measures
  - Greenhouse Gas Emissions Estimations from International Shipping
  - Analysis of Carbon Intensity Indicators for International Shipping

Some track record of team:
- Expert reviewer of 4th IMO GHG Study report
- Invited expert on several IMO ad-hoc committees
- Invited speaker / participant at IMO Expert workshop on Impact assessments
- Active attendance at IMO MEPC and ISWG-GHG meetings

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Research on Maritime Decarbonization

Towards maritime net zero

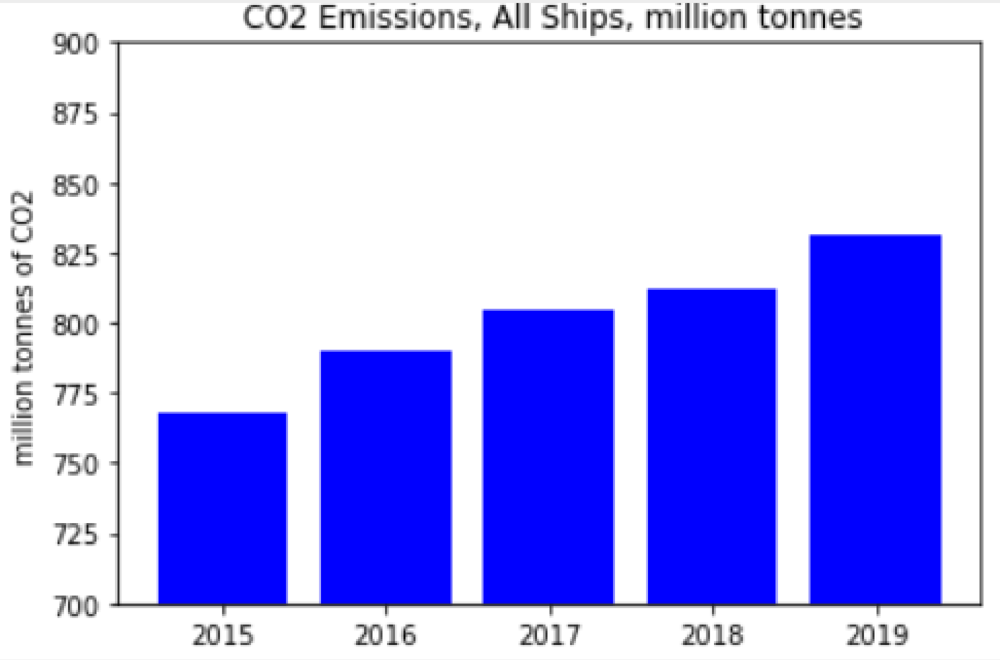
Current Status	Future Scenarios
Emissions and Intensity modeling & estimations	Projecting future emissions under different scenarios
↓	↓
Understanding the drivers of observed trends	Understanding economic and environmental impacts

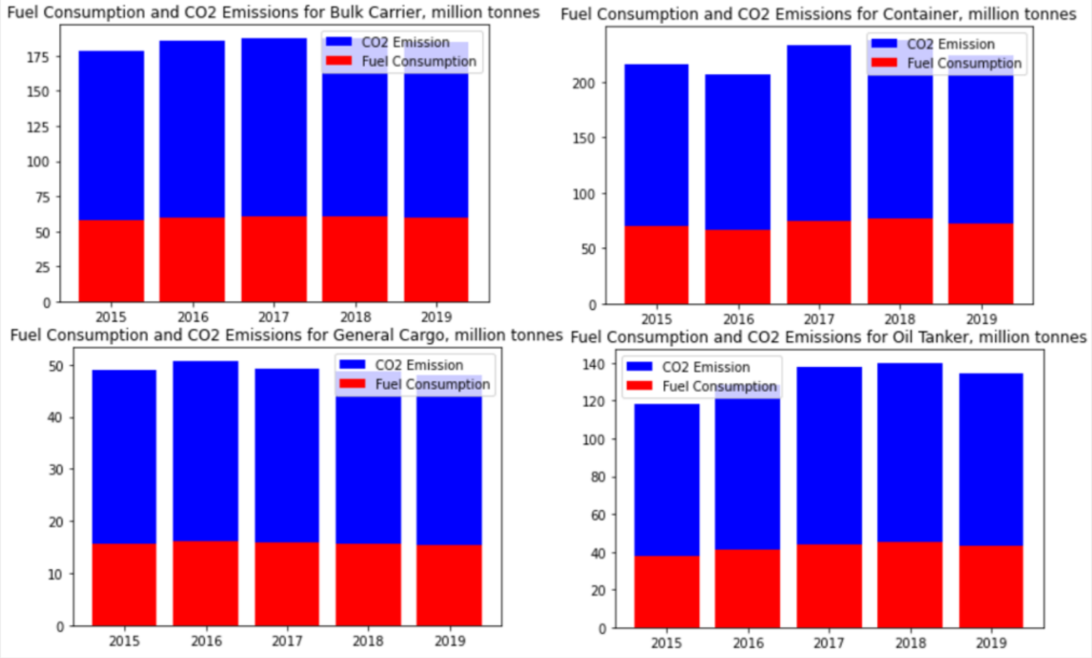
Towards maritime net zero

Current & historical emission and intensity trends and understanding the drivers of these trends

Emission Inventory Estimation

- Using AIS data and ship technical data, the team has developed models to estimate total emissions from international shipping.
  - annual fuel consumption and emissions by ship type and ship size.
  - emissions on particular routes can be further zoomed in and analyzed accordingly.

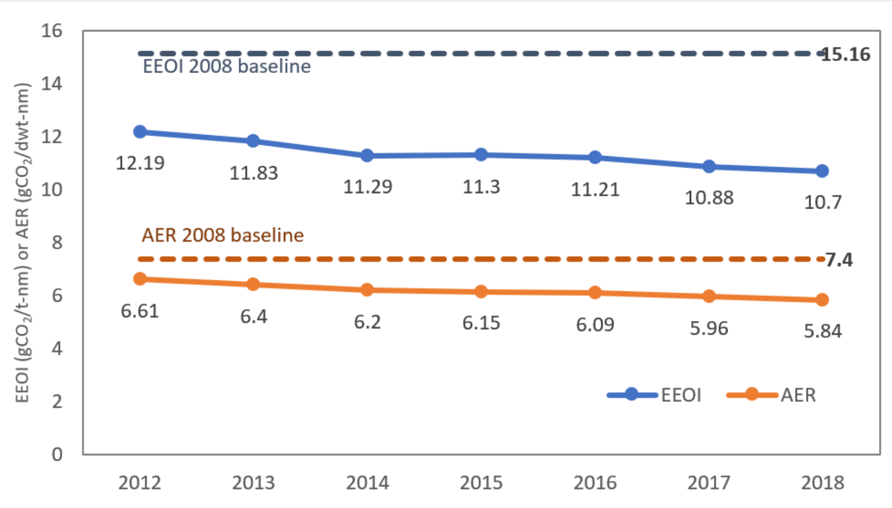




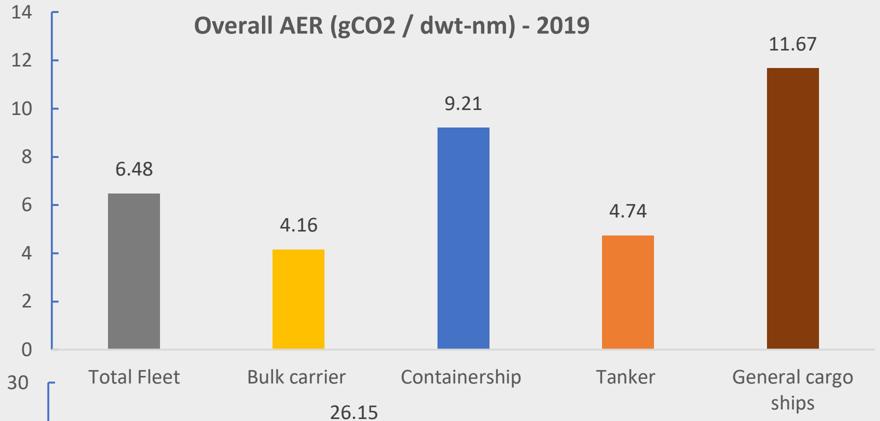
Carbon Intensity of Shipping

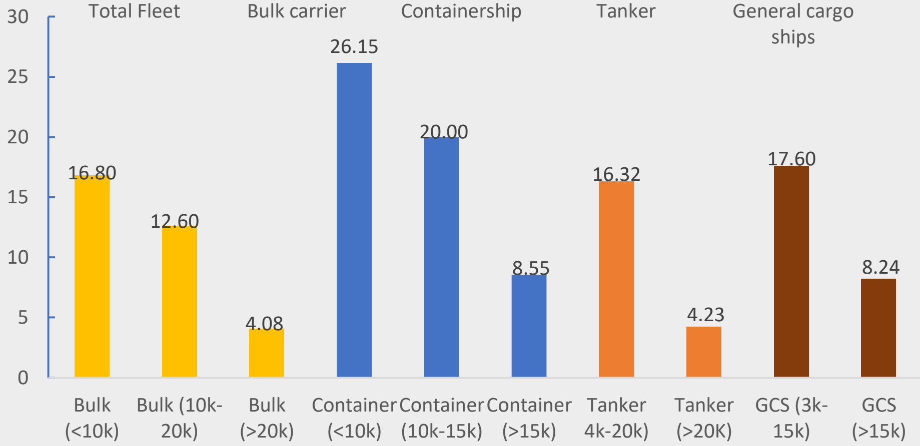
- **Enhancing energy / carbon efficiency** of ships is one of the approaches to reduce GHG emissions.
- IMO targets include reducing the carbon intensity (GHG emissions per transport work done) of international shipping by at least 40% by 2030.
- Operational Indicators:

$$EEOI = \frac{\sum_i (fuel\ consumption_i) C_i}{\boldsymbol{m}_{cargo} \times distance} \qquad AER = \frac{\sum_i (fuel\ consumption_i) C_i}{DWT \times distance}$$

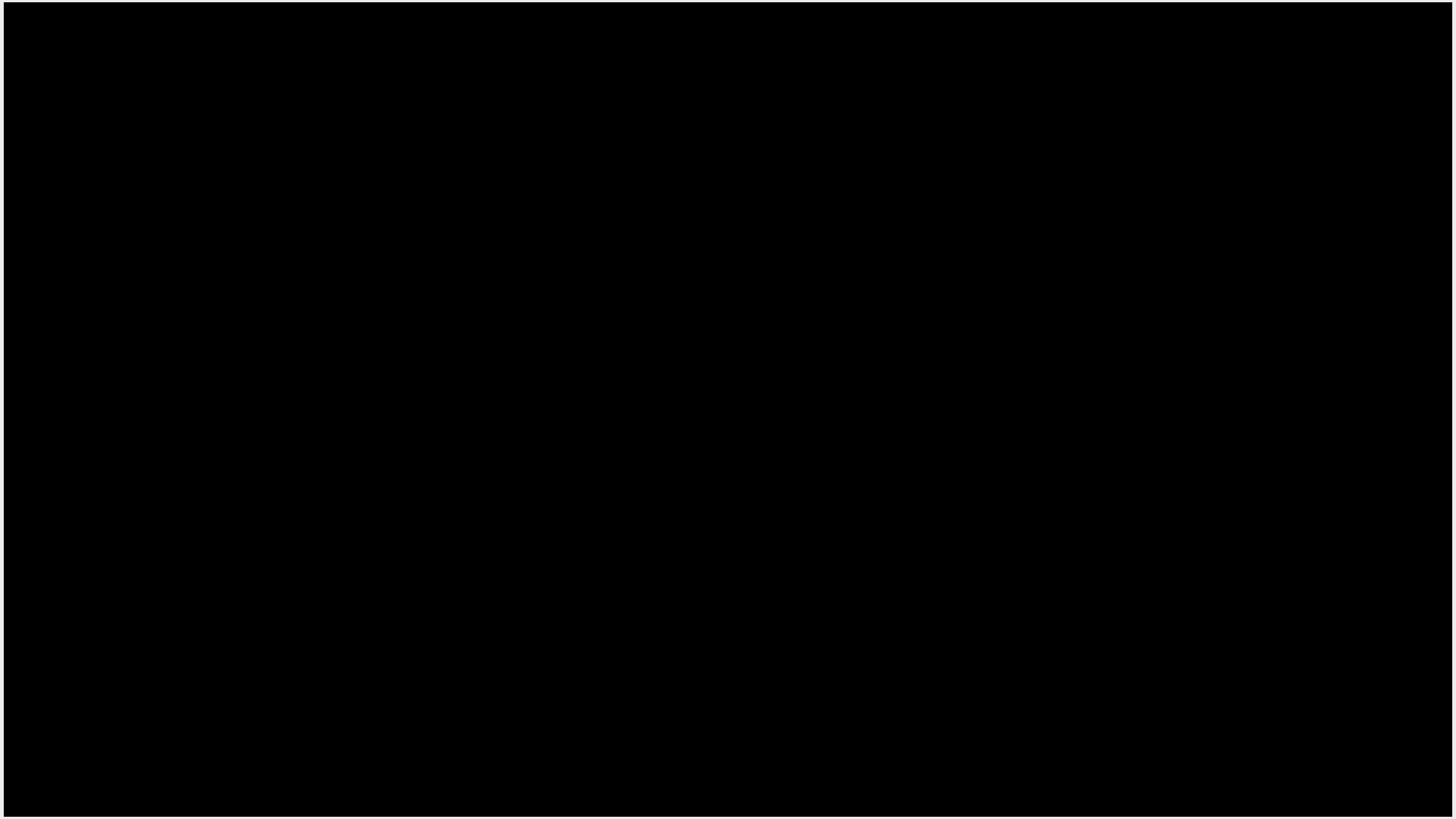


decreasing trends in both the EEOI and AER over the decade





Visualization of Emissions and Intensity

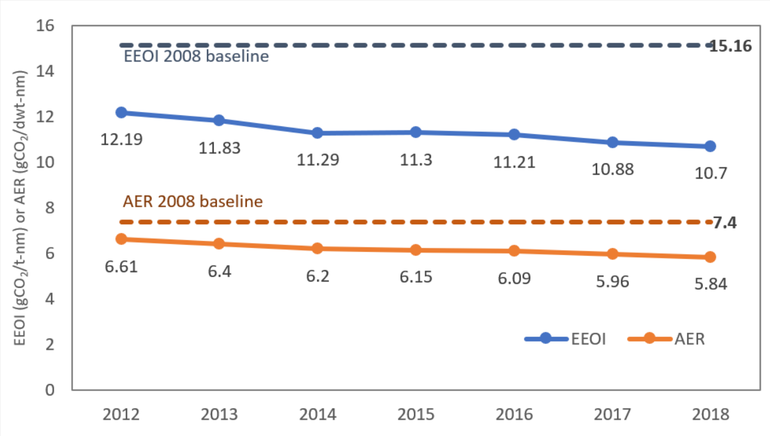


Understanding energy efficiency measures

Decomposition identity:

$$V_{EEOI} = \sum_i \frac{CTM_i}{CTM}\frac{DTM_i}{CTM_i}\frac{F_i}{DTM_i}\frac{C_i}{F_i}$$

$$V_{AER} = \sum_i \frac{DTM_i}{DTM}\frac{F_i}{DTM_i}\frac{C_i}{F_i}$$



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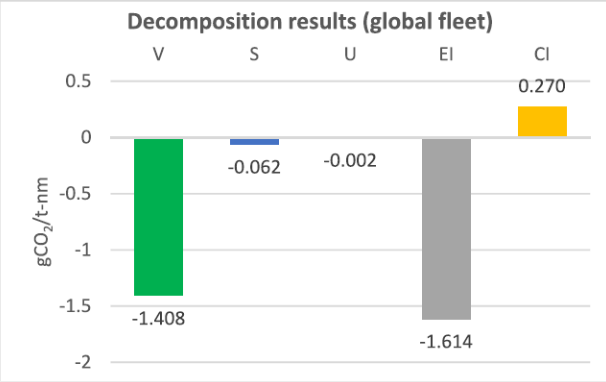
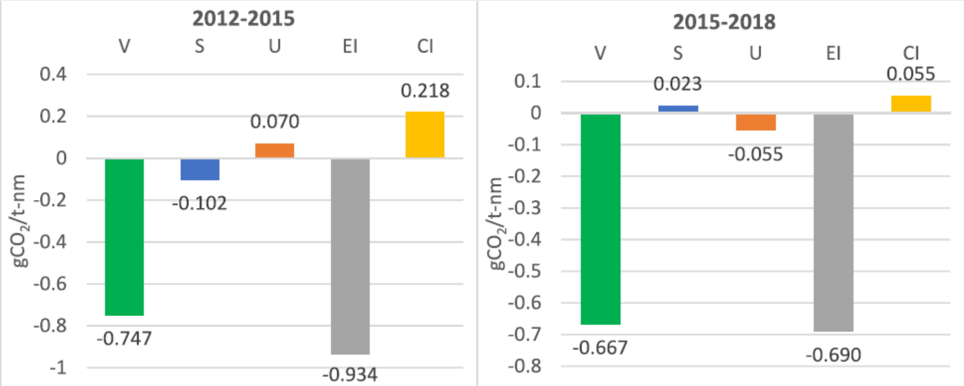


Decomposition results (EEOI) for global fleet (2012-2018)



Decomposition results (EEOI) for global fleet (2012-2015); (2015-2018)

<u>Results and Insights</u>:

- Analyses of EEOI and AER share similar trends.
- **Energy intensity** was the **most significant contributor** to reductions in carbon intensity globally, and also across all ship types, while *capacity utilization had minimal role*.
- Indicates that **energy intensity is a significant long-term driver** and policies and actions taken by the industry have had an impact (e.g. EEDI, SEEMP, speed reduction), while **changes in structural and capacity utilization are driven by exogeneous market forces** that can cancel out or *reverse the effects* over long periods or on other drivers
- Further tightening of measures and enhancement of coverage of the energy efficiency requirements to existing ships are likely to bring about further improvements to energy efficiency. However, comparing 2012-2015 and 2015-2018, we see that there are *limitations to improvements in energy efficiency* (technical and operational measures reach their practical limits). Focus on **transformation of energy mix** required **to further improve**.

<u>Additional results</u>: Detailed decomposition by different ship types and joint analyses of EEOI & AER; further work on understanding transport structures and trade patterns on energy consumption

Sou WS, Goh T, Lee XN, Ng SH, Chai KH (2022), Reducing the carbon intensity of international shipping – The impact of energy efficiency measures, *Energy Policy*, 170, 113239

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Future scenarios, pathways and impact

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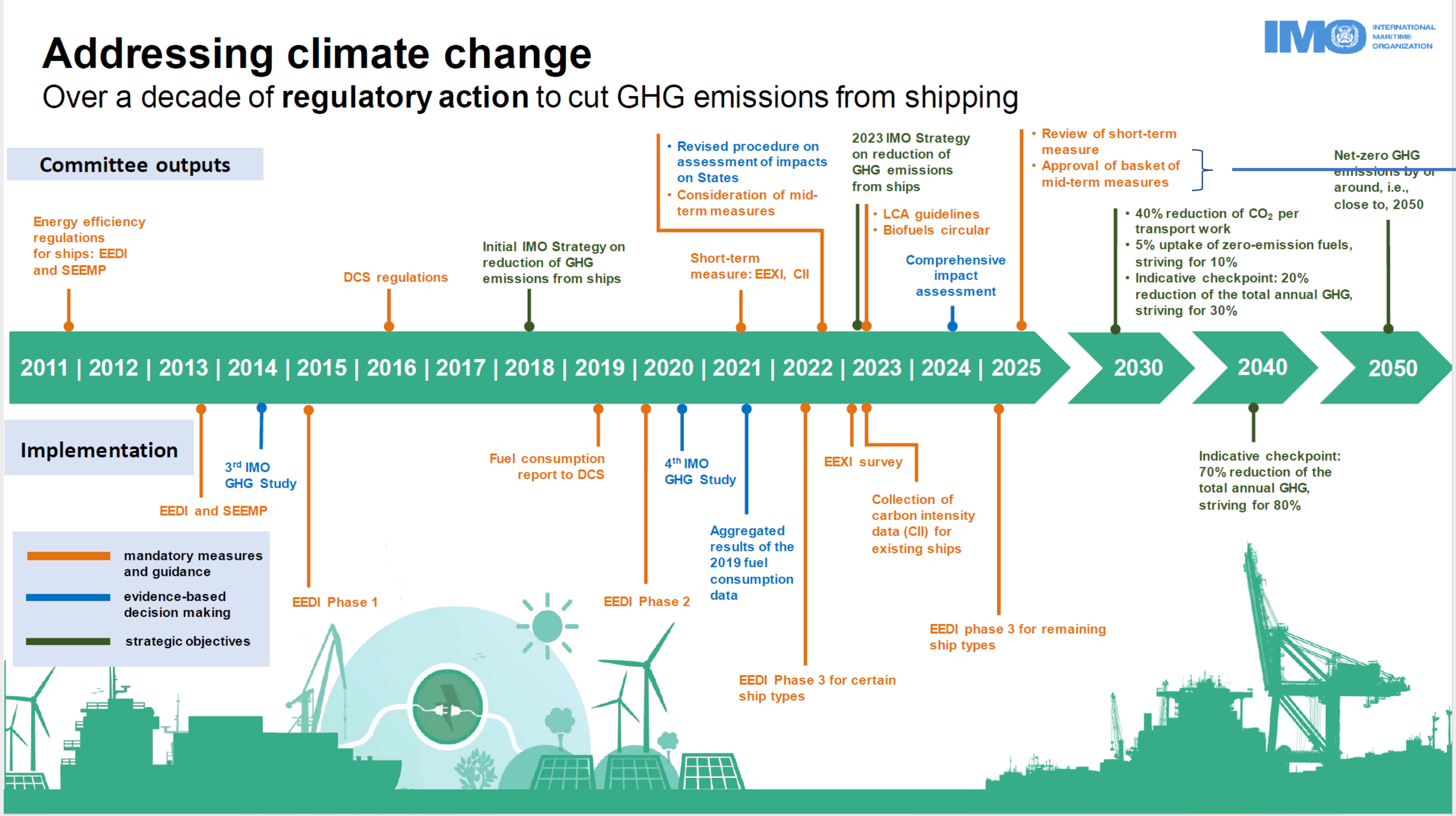
Further regulatory actions



1. **Technical measure: marine fuel standard**
2. **Economic measure: GHG pricing mechanism**

Impact Assessment: Global and Regional

- There is increasing pressure to produce actions, and hence a need for greater granularity to answer questions such as:

TARGETS (or LEVELS OF AMBITIONS)

- Are we **on track** to meet 2030 & 2050 revised targets? If not, what's **the gap**?
- How should international shipping **achieve the targets**?

MEASURES & PATHWAYS

- What **other technologies / measures** need to come in place to fill the gap?
- How would the proposed **mid- & long-term energy measures** contribute to emission reduction?

IMPACT ANALYSIS

- What will be **the economic & environmental impacts** of potential global (IMO) and regional measures and policies on **international shipping** and **states**?
- If the **Strategy** is tightened, how would it potentially impact international shipping **globally / regionally**?
- How should countries **prepare** for the global shift to decarbonize (as bunkering hub, transshipment hub, etc.)?

AIMMER

An integrated model developed to

– Evaluate the global maritime transition pathways (policy, regulation & technology) through a series of scenario analysis

– Identify opportunities and gaps in decarbonization capabilities in the global shipping community

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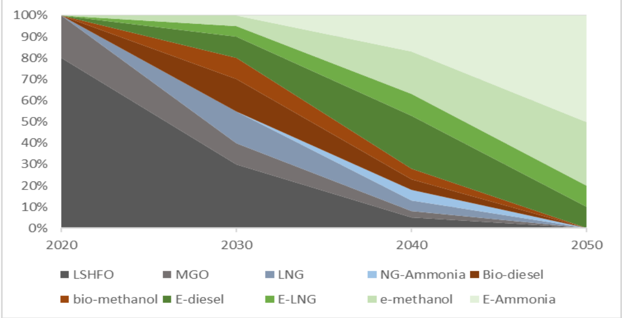
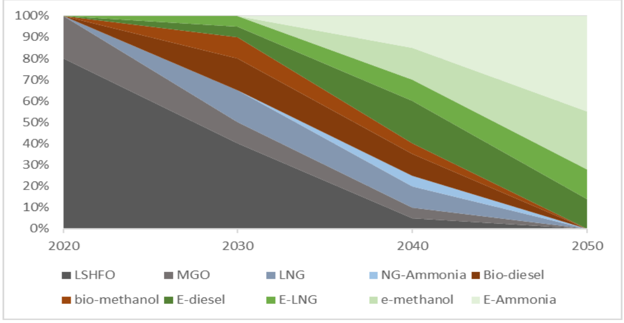
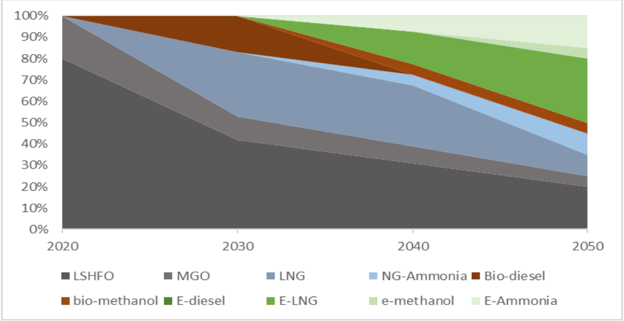
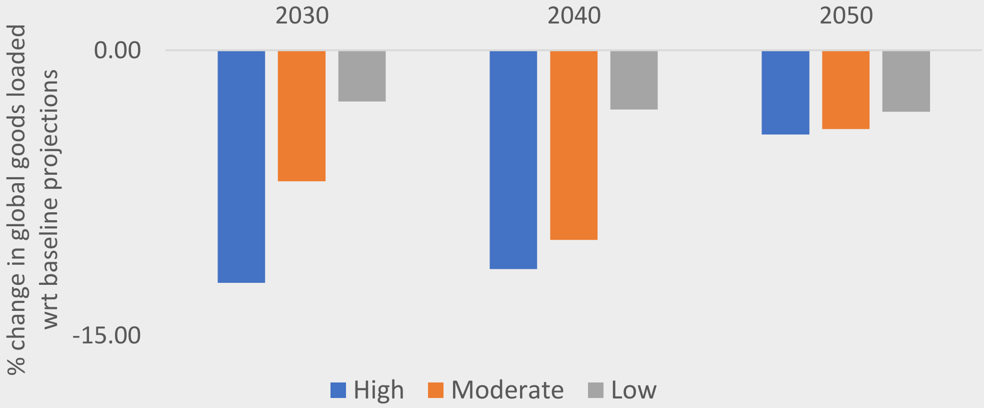
<u>Example</u>: some scenarios and impact on global exports

	Scenario 1: High Ambition	Scenario 2: Moderate Ambition	Scenario 3: Low Ambition
	• **IMO Revised Strategy –** <u>Net-zero emissions by 2050</u> – 10% green fuel uptake and 30% emission reduction w.r.t. 2008 level by 2030; 80% emission reduction w.r.t. 2008 level by 2040 • **Carbon price** - high	• **IMO Revised Strategy –** <u>Net-zero emissions by 2050</u> – 5% green fuel uptake and 20% emission reduction w.r.t 2008 level by 2030; 70% emission reduction w.r.t. 2008 level by 2040 • **Carbon price** - moderate	• **IMO Initial Strategy –** <u>50% emission reduction by 2050,</u> w.r.t. 2008 level • **Carbon price** - low
Base climate scenarios	**RCP1.9-SSP1**	**RCP1.9-SSP1**	**RCP2.6-SSP4**
Fuel pathways derived from UMAS(2021), DNV(2022), IEA(2021), IRENA(2021)			
Fuel Standard ISWG-GHG 12-3-3 (Austria et al.)	**High requirement**	**Min requirement to meet IMO Target**	**Min requirement to meet IMO Target**
Carbon prices ISWG-GHG 12-3-14 (Norway); MEPC 77-7-17 (CSC)	**2030: 210 USD/t-CO2** **2040: 255 USD/t-CO2** **2050: 300 USD/t-CO2**	**2030: 140 USD/t-CO2** **2040: 200 USD/t-CO2** **2050: 250 USD/t-CO2**	**2030: 75 USD/t-CO2** **2040: 150 USD/t-CO2** **2050: 200 USD/t-CO2**

Note:
- Low ambition scenario is observed to have smaller adverse impact to global total goods loaded (from BAU)
- High and moderate ambition may appear to have more impact to global total goods loaded, but these two scenarios ensure that international shipping decarbonizes according to the IMO Revised Strategy

Impacts on global shipping goods loaded by scenario

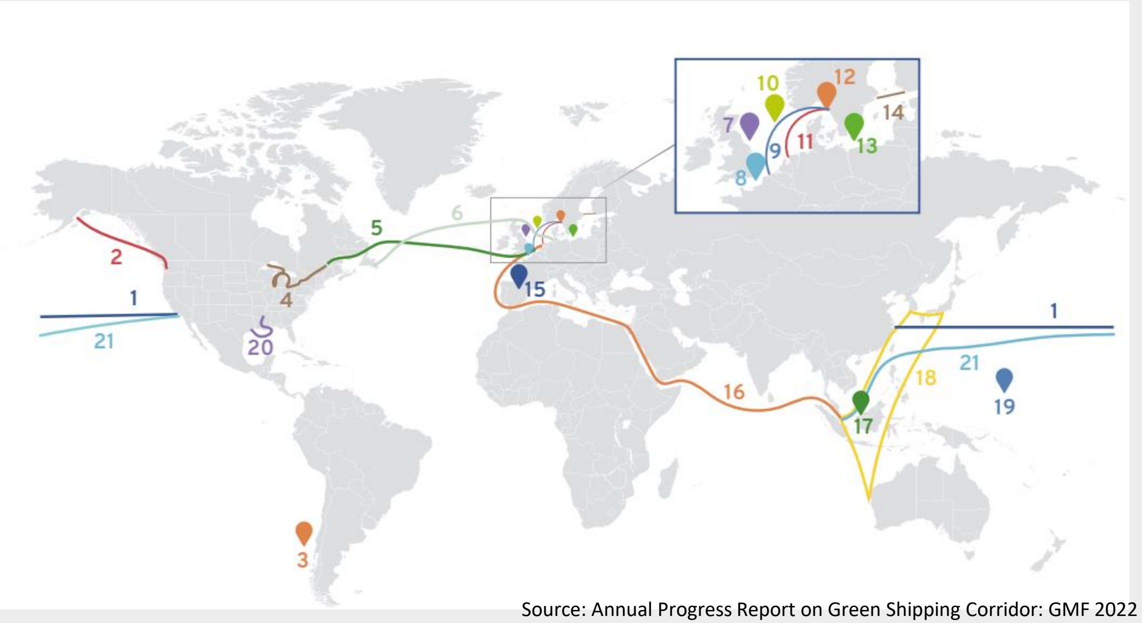


Regional - Green & Digital Shipping Corridors

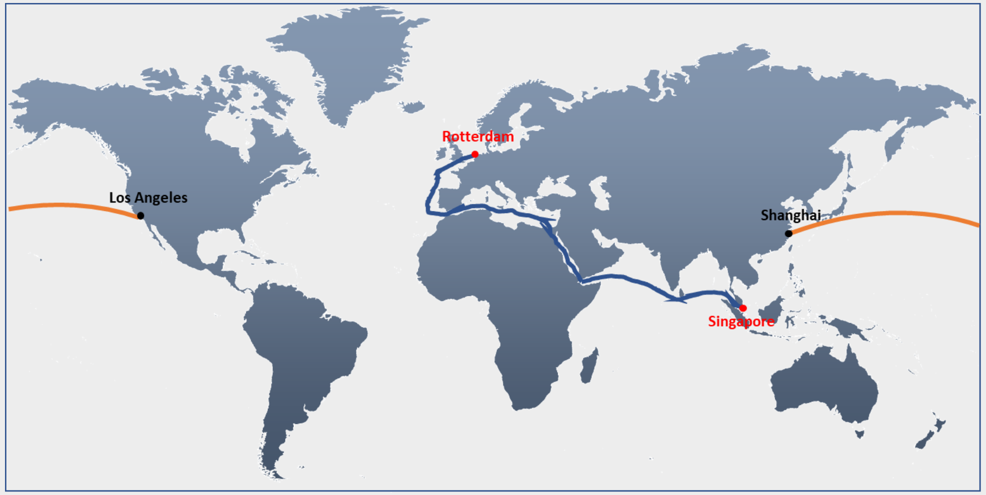
- Arena where value chain stakeholders come together and deploy new technologies and business models (help a diverse and disaggregated industry align and diversify collective risks)
- Increasingly viewed as essential tool to kick-start shipping's transition to zero emissions

Planning and development of ***green*** *and* ***digital shipping corridors*** *to enable low and zero carbon shipping*

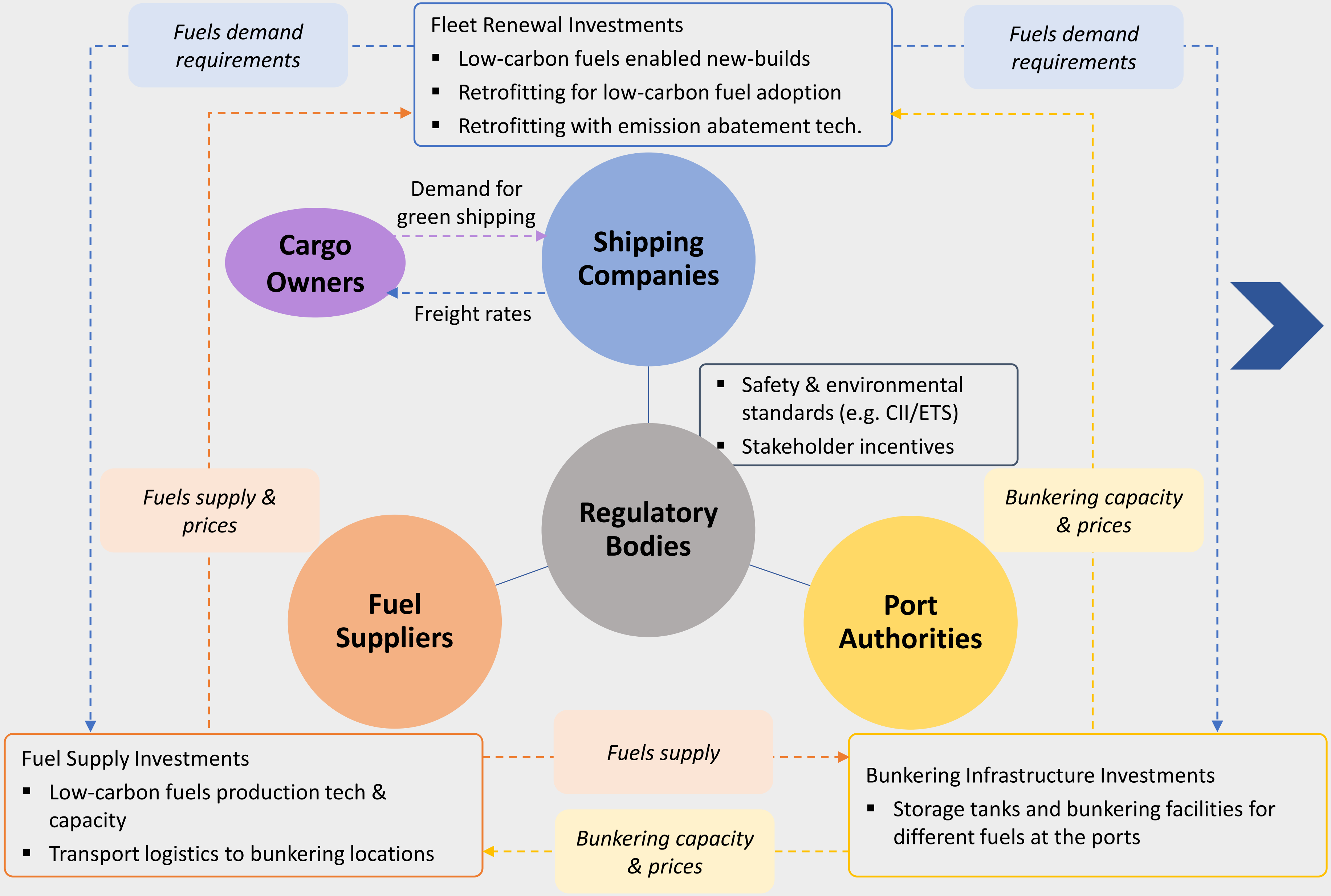
- identify feasible technological (fuel and infrastructure) pathways, cost gaps and policy and instruments (public and private) needed to achieve reduction targets (goals) on major shipping routes.



Source: Annual Progress Report on Green Shipping Corridor: GMF 2022



Green Corridor: Multi-Stakeholder Collaboration



Corridor Green Objectives:

- ✓ Reduction in carbon intensity and GHG emissions
- ✓ Adoption of near-zero & zero emission fuels adoption

Cost Gap for Green Shipping

Cost Gap: "**Additional cost that is incurred to achieve the green shipping targets of the corridor**"

Additional Capex & Opex (vessels, fuels, infrastructure) that corridor stakeholders must invest to meet the green shipping targets in the long-term (2025-35)

Δ Cost = Cummmulative estimated cost under green corridor shipping (GCS) case − Cummmulative estimated cost under business−as−usual (BAU) case

BAU Case: Stakeholders operating under existing maritime decarbonization guidelines *(CII, regional ETS)*

GCS Case: BAU guidelines + green shipping targets *(emissions/carbon intensity reduction and low-carbon fuels adoption)*

Cost Gap for Green Shipping

Vessel/Voyage-related investments

- New-build acquisitions (alternative-fuels enabled)
- Existing vessel retrofitting (energy efficiency & alt-fuel conversions)
- Fleet deployment operations utilizing alternative-fuels

Fuel demand

Fuel supply & prices

Fuel-related investments

- Alternative-fuels production: technologies, capacity
- Fuel storage and distribution logistics infrastructure

Cost Gap for Shipping Companies

Financial Incentives & Policy Design
Green loans, CFDs, tax rebates, subsidies,..

Cost Gap for Fuel Suppliers

Case Study Insights: gaps and driving factors

Output		Insights / Key Driving Factors
Cost Gap GCS case - BAU case	Cumulative cost gap Annual Cost Gap per TEU	• Absolute WtW CO2-eq emissions reduction targets • Fuel Opex major contributor to cost gap between GCS and BAU cases • Lower (Capex) investments in early periods • Higher (Opex) investments in later periods
Fuel Energy Share		• Relative emissions MAC curves of fuels (prices & emissions factors) along with the supply availability drives the adoption choice alt-fuel mix
Fleet Composition		• In all fuel (price & supply) scenarios, a mix of dual fuel (alt. fuel) ships come into operation. • No significant variation in fleet composition in different scenarios
Binding Targets	BAU case	• Vessel CII requirements
	GCS case	• Depending on corridor targets. Needs to be more stringent than current CII (e.g. absolute targets, alt-fuel adoption targets)

Insights: closing the gap

Output		**Value Range**
Cost Gap GCS case - BAU case	Cumulative cost gap	**X - Y $**
	Annual Cost Gap per TEU	**xx - yy $/TEU**

close the gap

- % - cargo owners (e.g. buyers alliance)
- % - financial instruments (private / public); CfD
- ⋮
- % - rebates / subsidies

Summary

- Maritime Decarbonization is a large and challenging problem but shipping must do its part to help mitigate climate change.
- Various international and regional targets have been set to achieve net-zero emissions by 2050.
- Net-zero emissions require aggressive adoption of emission mitigation measures including green fuels, new technologies, regulatory policies and co-operative efforts across states and regions.
- Actions are rapidly evolving to facilitate the transition.
- At CMS, we focus on the *modeling* and *analytics* to understand the complexities of current state and *future* possibilities / *scenarios*; and importantly the economic and environmental impact of various future pathways and regulations.
  - states / regions will likely experience different impacts from maritime decarbonization actions


Thank You
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