Panel 1

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EMERGING TECHNOLOGIES TO REDUCE GREENHOUSE GAS EMISSIONS

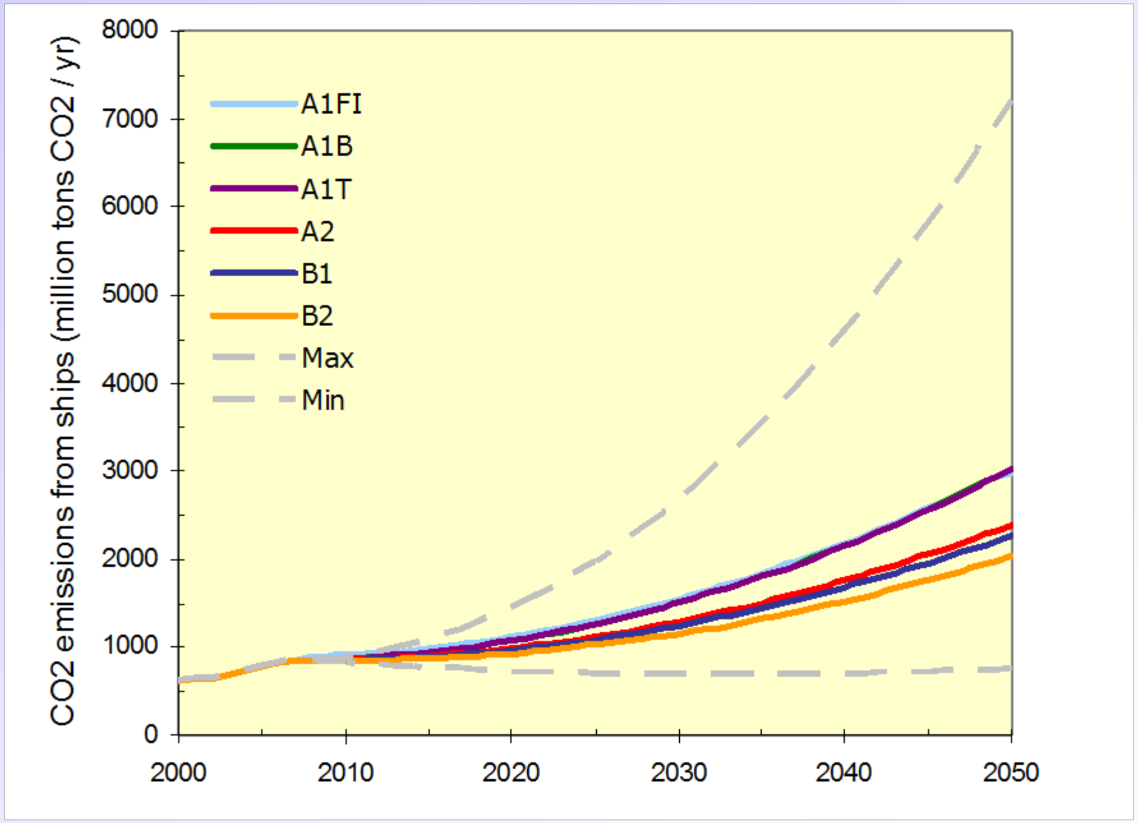
Climate Change and Shipping Challenges

- CO_2 is main GHG of concern. Shipping currently responsible for ~2.7% of human CO_2 emitted

- Maritime nations speically vulnerable to Climate Change

- United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol assign IMO responsibility for reducing GHG emissions from international shipping.

- IMO GHG reduction workplan based upon IMO studies of a range of technical, operation and market-based reduction



Buhaug et al, Second IMO GHG Study 2009

Today we discuss potential for Technology to fill the wedge

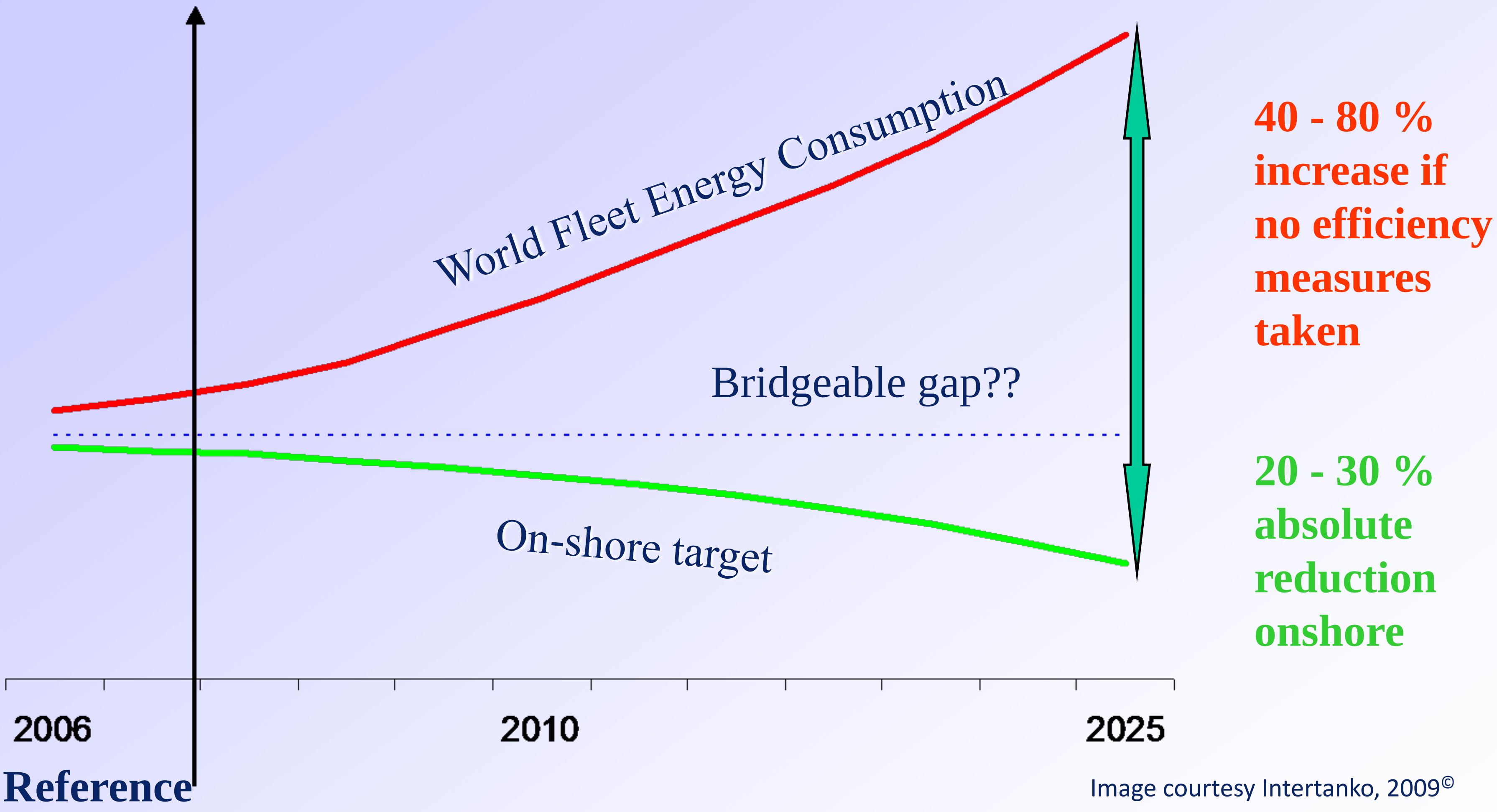


Image courtesy Intertanko, 2009©

Emerging Technologies Overview

Example Technologies *(not exhaustive)*

- **New designs for new ships**
  - Hulls, propellers, engines, auxiliaries, other
- **Retrofit designs for existing ships**
- **Enabling technologies for operational changes**
  - Kites, combustion, exhaust treatments
- **Innovation "technologies" affecting service**
  - "Soft Technologies": e.g., re-scheduling for slower speeds, coordinated arrival time, economies of scale, port network changes

Topics from Program

Designing a perfect GHG efficient ship. Improvements in hull & propeller design Changes in material, propulsion systems, alternative fuels (fuel cells, natural gas, etc).

Emerging GHG Equipment and Systems. CO_2 exhaust treatment systems; fuel cells; natural gas.

Transportation interface (ship/shore/land). How it can contribute to the reduction of CO_2 emissions.

These raise common issues with diverse perspectives across industry and agencies

Emerging Technologies Panel
Overview of Issues to Discuss

Issue 1: Ways to achieve robust designs for new ships to meet GHG reduction targets.

Issue 2: Adopting promising technologies across the fleet, current and future.

Issue 3: Operational/logistics innovations involving "soft" and hard" technologies.

Issue 4: Technology drivers, potential barriers

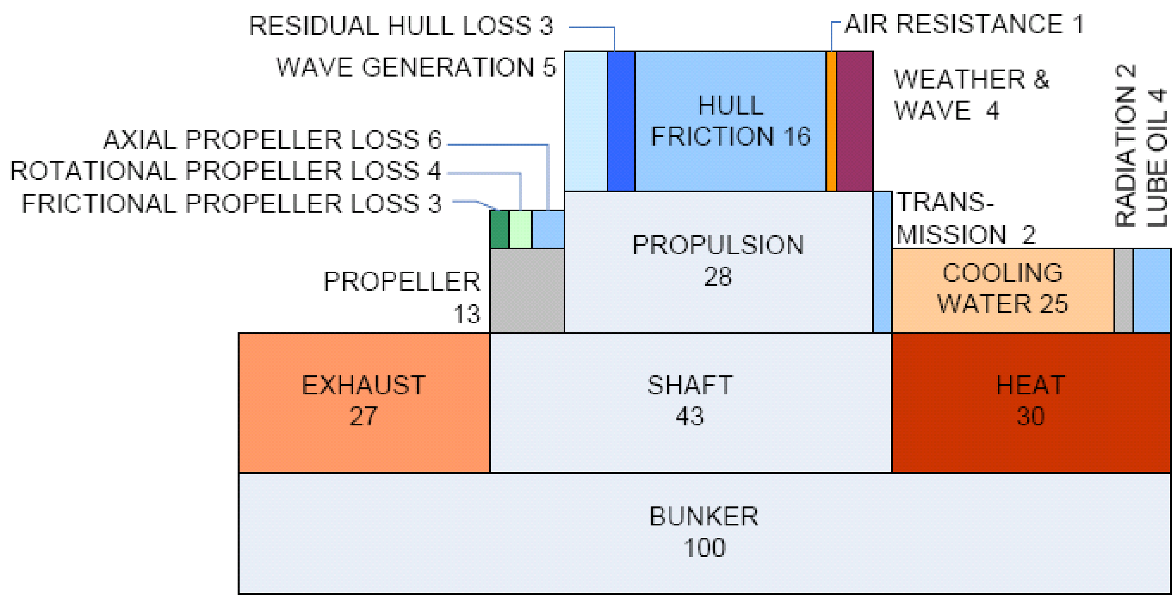
Issue 1: Robust New Ship Designs

$$\text{Index (gm } CO_2\text{/tonne - nm)} = \frac{\text{Energy Consumed x Carbon Factor (enviro-cost)}}{\text{Transport Work Done (public benefit)}}$$

- **New designs are promising, but fleet turnover rates present a key challenge for commercial sector with global-scale GHGs and high growth**

- Design Index Parameters: Theoretical energy consumption, efficiency improvements such as waste heat recovery; correction factors for weather, ice strengthening, special built ships (e.g. North Sea shuttle tankers), etc,; design speed; design cargo capacity

- Optimization of ship design will reflect new operational constraints that include energy savings through utilization and



Buhaug et al, Second IMO GHG Study 2009

Assessment of Emissions Reduction Potential

Recent work on behalf of the IMO evaluated a wide range of potential CO_2 savings per tonne-mile using known technologies.

Ranges vary greatly due to diverse fleet designs, ages, and technology utilization.

DESIGN (New ships)	Saving of CO_2/tonne-mile	Combined
Concept, speed & capability	2% to 50%	10% to 50%
Hull and superstructure	2% to 20%	
Power and propulsion systems	5% to 15%	
Low-carbon fuels	5% to 15%	
Renewable energy	1% to 10%	
Exhaust gas CO_2 reduction	0%	

Buhaug et al, Second IMO GHG Study 2009

Second IMO GHG Study 2009 available at:
http://www.imo.org/includes/blastDataOnly.asp/data_id%3D26047/INF-10.pdf

Issue 2: Promising Fleet Technologies

- **GHG targets may not wait for new-build fleet turnover; some low-GHG technology may serve current fleet. How to choose the next options?**

- Operational Indicator Parameters: Actual fuel consumed, distance traveled, cargo carried over a series of voyages.

- Marginal Abatement Cost (MAC): The cost of additional inputs needed to produce the output. More formally, the marginal cost is the derivative of total production costs with respect to the level of output.

- IMO: The MACC (Marginal Abatement Cost Curve) considers the cost of reducing the emissions by the next ton of CO2, given the reduction that has been achieved by the options that have already been implemented (IMO, 2009)

Table A4-1 – Approximate cost efficiency and maximum abatement potential for the different groups of measures* (2020, fuel price is US$500/tonne, interest rate is 4%)

	Cost efficiency (US$/tonne of CO_2)	Maximum abatement potential (Mt)
	Central estimate (low bound estimate / high bound estimate)	
Retrofit hull measures	−155 (−140 / −160)	30 (10 / 55)
Voyage and operational options	−150 (−140 / −160)	25 (5 / 45)
Air lubrication	−130 (−90 / −150)	20 (10 / 25)
Propeller/propulsion upgrades	−115 (−70 / −155)	50 (45 / 60)
Other retrofit options	−110 (−75 / −135)	70 (40 / 100)
Hull coating and maintenance	−105 (−65 / −140)	40 (15 / 65)
Propeller maintenance	−75 (−65 / −120)	45 (25 / 65)
Auxiliary systems	80 (250 / −90)	5 (2 / 10)
Speed reduction	110 (80 / 135)	100 (90 / 110)
Main engine improvements	175 (470 / −120)	5 (1 / 10)

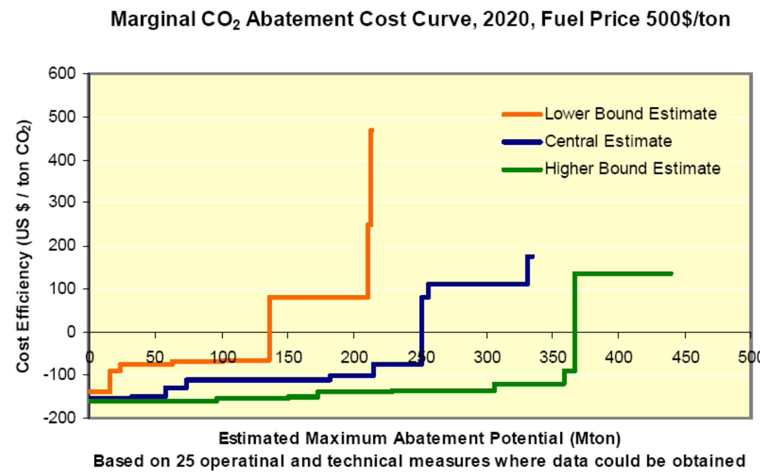


Figure 5-2 – Indicative marginal CO_2 abatement costs for 2020

Buhaug et al, Second IMO GHG Study 2009

Criteria for Evaluating Technology

Direct costs from a business/industry context

- Capital costs (or net-present capital costs)
- Operating costs (often fuel efficiency gains)
- Service effect costs (lost revenues)
- Opportunity costs (alternate investment value)
- Can be combined to assess life-cycle costs

Cost-effectiveness to achieve target

- Marginal abatement cost
- Industry cost per ton CO_2 avoided

Benefit-cost including externalities for setting targets

- Attempts to include climate-scale or regional mitigation effects
- Benefit:Cost ratios > 1 (or threshold) qualify for targets
- Social net benefit per ton CO_2 avoided

Strengths "Pros"	Weaknesses "Cons"

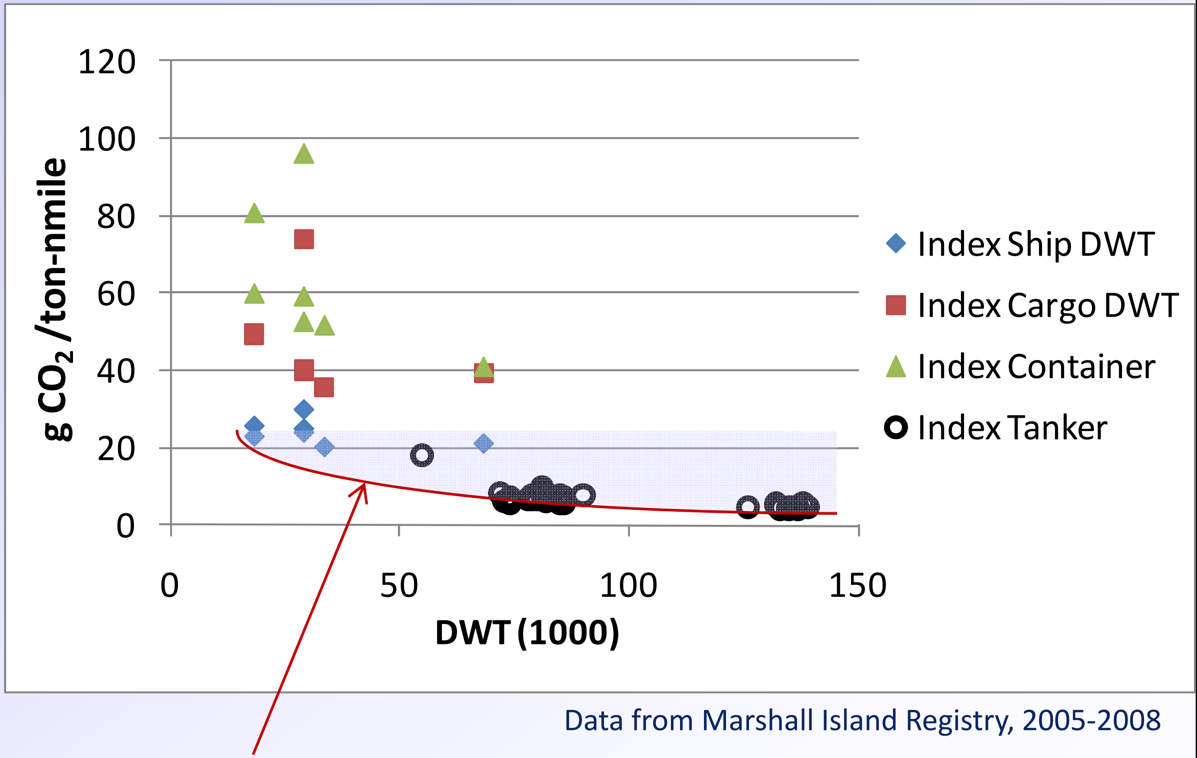
Strengths and weaknesses could partly depend upon whose perspective is being considered: e.g.,

Industry
Policy makers
UNFCCC negotiators
Advocates

Issue 3: Innovative Technologies for Fleet Performance

$$\text{Index (gm } CO_2\text{/tonne - nm)} = \frac{\text{Energy Consumed x Carbon Factor (enviro-cost)}}{\text{Transport Work Done (public benefit)}}$$

- System context needed for GHG technology to serve industry goals: operations, business contracting, etc.
- ***Metrics matter and verification technologies are needed to inform decisions.*** **"We control what we measure and report."**
- **Ballast voyages and utilization constraints may be operational technology barriers to achieving targets.**
- **Spot market trades and liner trades may respond differently to common incentives for technology.**



Data from Marshall Island Registry, 2005-2008

What is the potential for co-optimization of ship designs and operations?

Technologically & operationally diverse, various innovations achieve fleetwide targets

World Maritime Day Parallel Event 2009

EPA United States Environmental Protection Agency

IMO

Assessment of Emissions Reduction Potential

Recent work on behalf of the IMO evaluated a wide range of potential CO_2 savings per tonne-mile using known operations.

Ranges vary greatly due to diverse fleet designs, ages, and technology utilization.

IMO report noted that non-financial barriers may currently limit adoption of certain measures

OPERATION (All ships)	**Saving of CO_2/tonne-mile**	**Combined**
Fleet management, logistics & incentives	5% to 50%	10% to 50%
Voyage optimization	1% to 10%	
Energy management	1% to 10%	

Buhaug et al, Second IMO GHG Study 2009

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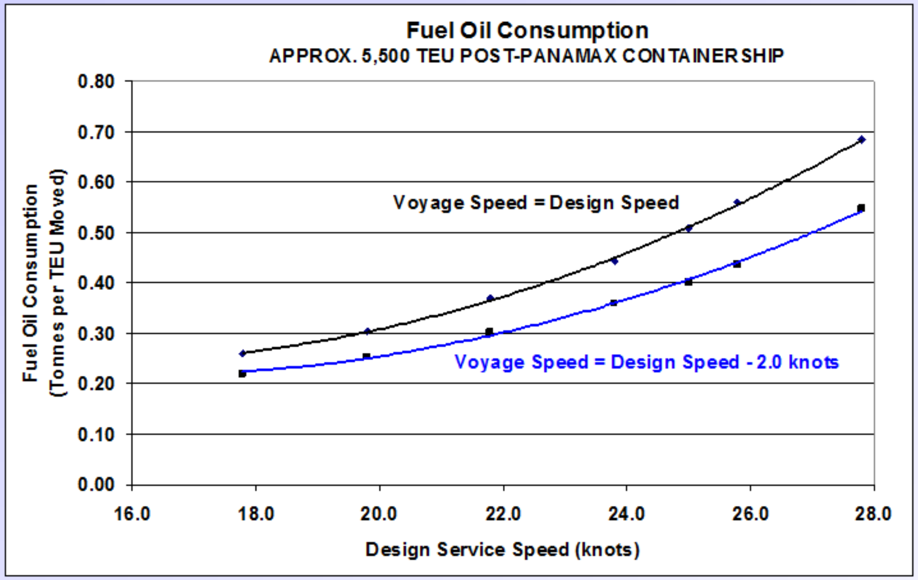
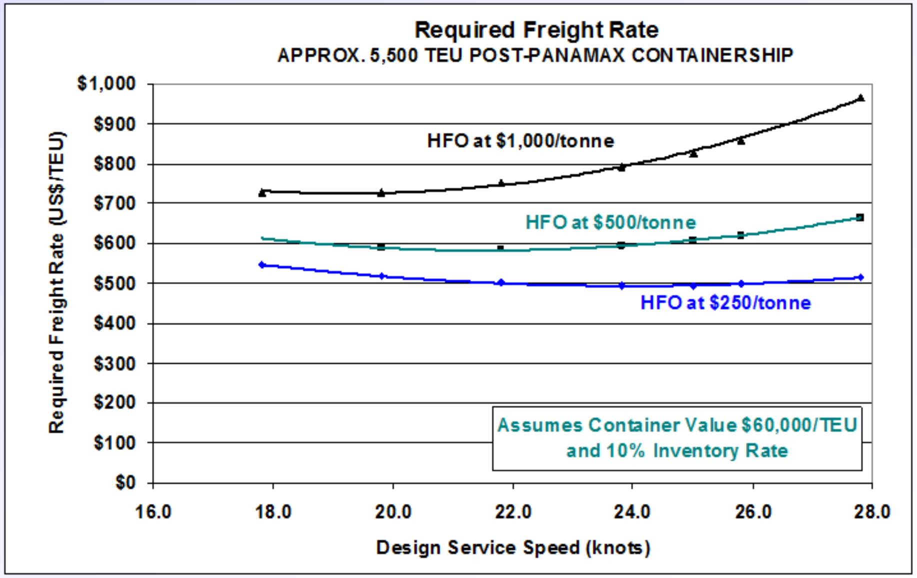
Containership Speed Optimization

A 50% reduction in fuel consumption and CO_2 emissions is realized by reducing design speed on a Post-Panamax containership from 25 knots to 18 knots. Increases in fuel oil price encourages reductions in speed.





Issue 4: Consider Technology Drivers, Avoid Barriers

➢**Need to incentivize technology innovation, adoption, diffusion**

➢ **Given: All parties favor better technology to Modernize, Maximize, Optimize. But some of the new guidelines do not support opportunities for optimization (e.g., ballast voyages).**

➢***Existing*, *Emerging*, *Evolving* may respond to different drivers or common drivers. Which work best?**

➢**Panels 2 and 3 may consider practices and regulations in which emerging technologies win or lose.**

One key issue is the legacy of shipping design and operations, and the pace of change needed for fleet GHG targets

- **Questions revolve around technology pathways**
  - Self-regulation or voluntary regulation
    - Are meaningful GHG targets possible?
  - Mandate designs or require operational changes
  - Incentivize through fees or levies
    - Certain pricing, uncertain target?
  - Incentivize through market mechanisms
    - Uncertain pricing, more certain performance?

Technology alone may not satisfy all targets, but can offer win-win alternatives

Panel 1

THANK YOU

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