The quest for greener shipping

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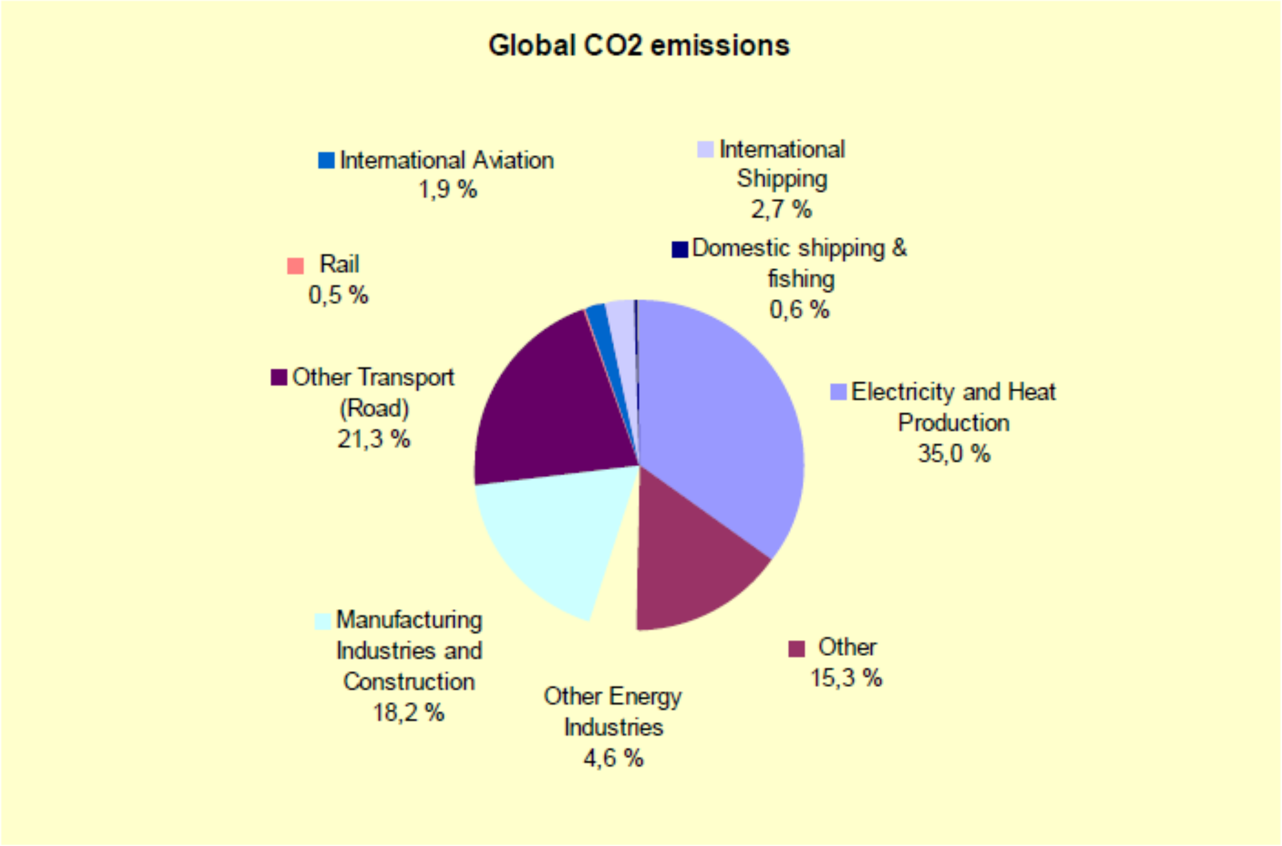
Outline

- Some basics
- Spectrum of measures
- Recent developments
- Prospects
- Discussion

Types of emissions

- Green House Gases-GHGs (mainly CO_2, but also CH_4 , N_2O and others)
- Non-GHG (mainly SO_2, but also NO_x and others)
- P.M., etc

Share of global CO_2 emissions



Emissions of CO_2 from shipping compared with global total emissions for 2007 (Source: Second IMO GHG Study 2009)

Comparison among modes

(source: IMO GHG study 2009)

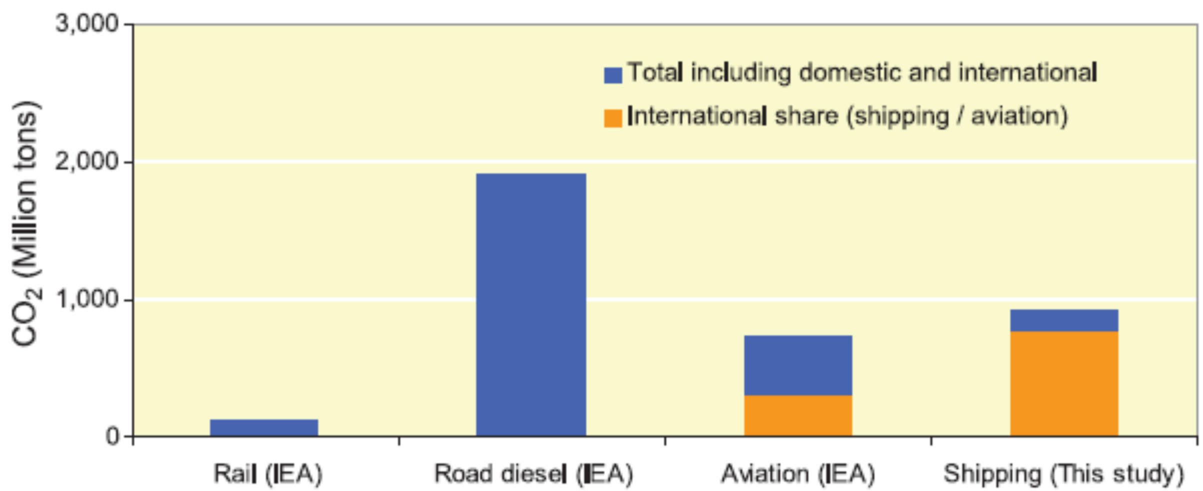


Figure 9.6 *Emissions of CO_2 in 2005 from shipping compared to other transport modes*

134 Second IMO GHG Study 2009

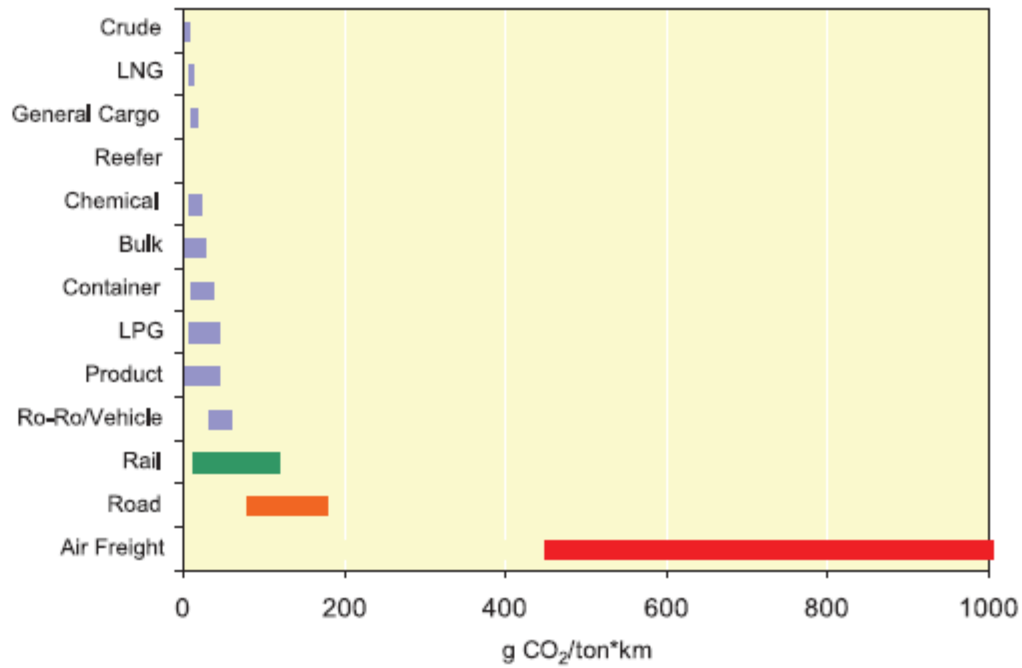


Figure 9.3 *Typical range of ship CO_2 efficiencies compared to rail, road and air freight*

Kyoto Protocol

- United Nations Framework Convention on Climate Change -UNFCCC (1997)
- COP-15 Copenhagen 2009 (a big failure)
- COP-16 Cancun 2010 (similarly)
- COP-17 Durban 2011 (similarly)
- Urgent measures to reduce CO_2 emissions are necessary to curb the projected growth of GHGs worldwide
- Shipping thus far escaped being included in the Kyoto global emissions reduction target for CO_2 and other GHGs
- Road: Fleet average reduction targets (CO_2/km)
- Aviation: EU ETS
- Shipping: until 2011 regulation only for SO_2, NOx

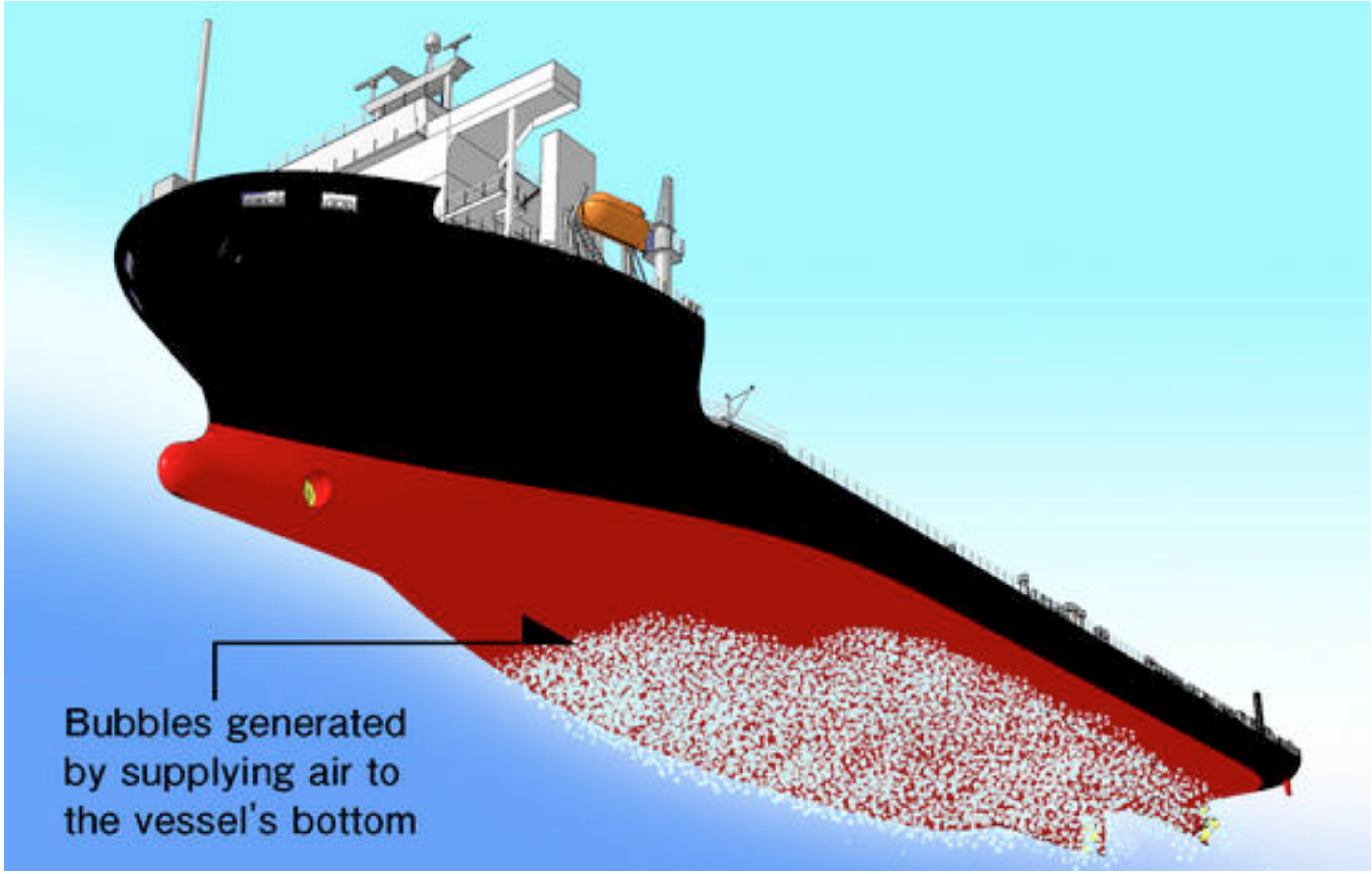
Era of GHG non-regulation in shipping:

- Officially ended July 2011 (adoption of EEDI)
- STILL: Measures to curb future CO_2 growth are being sought with a high sense of urgency.
- As CO_2 is the most prevalent of these GHGs, any set of measures to reduce the latter should primarily focus on CO_2.

Measures contemplated

- Technological
  - More efficient (energy-saving) engines
  - More efficient ship designs
  - More efficient propellers
  - Cleaner fuels (low sulphur content, LNG)
  - Alternative fuels (fuel cells, biofuels, etc)
  - Devices to trap exhaust emissions (scrubbers, etc)
  - Energy recuperation devices
  - “Cold ironing” in ports
- Operational (logistics-based) measures
  - Speed reduction
  - Optimized routing
  - Several others
- Market-based
  - Emissions Trading Scheme (ETS)
  - Carbon Tax/Levy on Fuel
  - Several others


BELUGA PROJECTS
SkySails


Bubbles generated
by supplying air to
the vessel's bottom

Emissions 101

- Q: If we burn a ton of fossil fuel (heavy fuel oil, diesel, or other), how much CO2 is generated?

- A: Between 3.02 and 3.11 tons, depending on the fuel

Emissions 101b: how much CO_2 is produced by international shipping?

- No one knows for sure
- 2 basic methods to estimate
  - Top down (based on fuel sales)
  - Bottom up (activity based)

How much CO2 is produced by international shipping?

- Problem: Even estimates of past marine fuel sales are impossible to make
- Most global emissions estimates are based on **modeling** (even of past emissions)

GHG marine emissions estimates

- IMO latest update of GHG study (2009)

Table 1.1 *Summary of GHG emissions from shipping* during 2007*

	International shipping (million tonnes)	Total shipping: million tonnes	Total shipping: CO_2 equivalent
CO_2	870	1050	1050
CH_4	Not determined*	0.24	6
N_2O	0.02	0.03	9
HFC	Not determined*	0.0004	≤6

* A split into domestic and international emissions is not possible.

IMO GHG study 2009

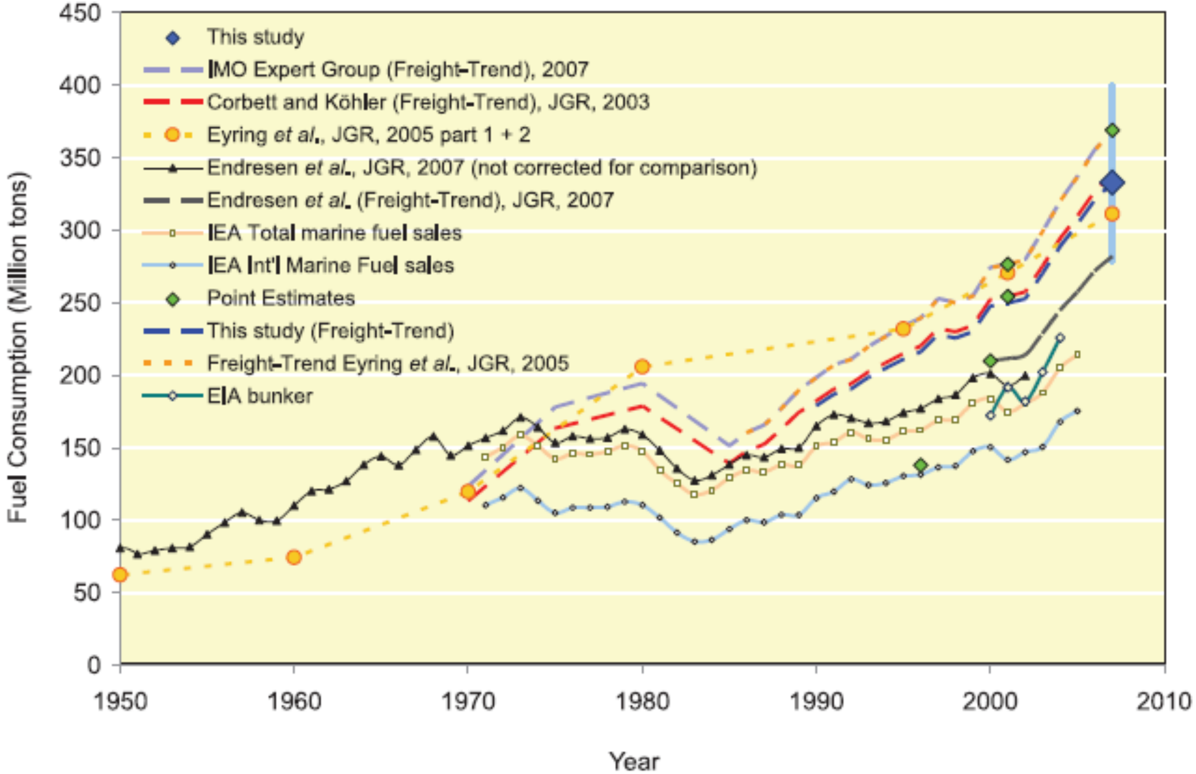


Figure A1.4 *World fleet fuel consumption (except naval vessels) from different activity-based estimates and statistics. Symbols indicate the original estimates for individual years and the solid lines show the original estimates of trend. Dashed lines show the backcast and forecast, calculated from the time evolution of freight tonne-miles with the point estimates. The blue square shows the activity-based estimate from this study and the blue range bar indicates the high and low bound estimates*

Future projections

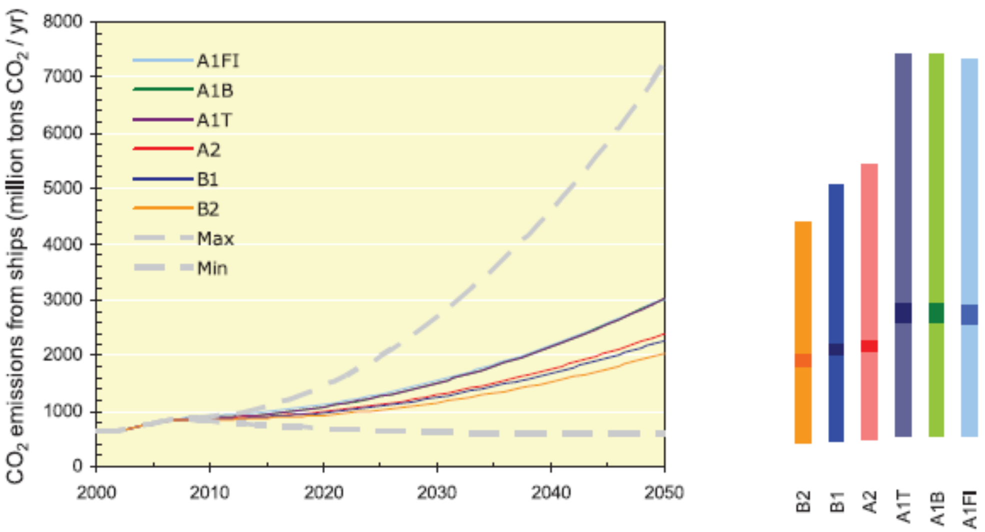


Figure 1.2 *Trajectories of the emissions from international shipping. Columns on the right-hand side indicate the range of results for the scenarios within individual families of scenario.*

- A scale of 10:1 between worst case and best case!

Emissions 101c: SO_2

- Produces acid rain
- 1 ton of fuel produces EXACTLY 0.02*S tons of SO_2, where S is the % of sulphur content in fuel
- IMO MARPOL ANNEX VI: progressive reduction in SO_2 emissions from ships, with the global sulphur cap reduced initially to 3.50%, effective 1 January 2012; then progressively to 0.50%, effective 1 January 2020.

Emissions 101d: NOx

- NO_x emissions depend on **engine type**. The ratio of NO_x emissions to fuel consumed ranges from 0.087 for slow speed engines to 0.057 for medium speed engines.

Some "parallel" tracks

- Track 1: The SOx / NOx track
  - Track 1A: SOx
  - Track 1B: NOx
- Track 2: The GHG track
  - Track 2A: EEDI
  - Track 2B: MBMs

The SOx/NOx track (track 1)

MEASURES

- Low-S fuels (SOx)
- Tier II/III engines (NOx)
- Emissions control areas or ECAs (Baltic, North Sea, Channel, North America)

SIDE-EFFECTS

- Loss of ‘cooling effect’ of SOx → More CO_2
- More CO_2 if less NOx
- More CO_2 by low-S fuel production
- Possible shifts to land-based modes (main example: Baltic)

→ More CO_2

- (hello track 2!)

The GHG track (track 2)

- Track 2A: EEDI
- Track 2B: MBMs

- Thus far, the two have been discussed at the IMO in parallel
- Q: are tracks 2A, 2B really parallel?
- No!

Biggest development

- IMO's adoption of EEDI last July
- Adopted as an amendment to MARPOL's Annex VI
- Fierce resistance by China, India, Brazil, Saudi Arabia and other developing countries
- Matter highly political

Energy Efficiency Design Index (EEDI)

- Defined as

$$\frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE}*\right) + \left(\left(\prod_{j=1}^{M} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}\right)}{f_i \cdot Capacity \cdot V_{ref} \cdot f_w}$$

- Ratio of installed power divided by (capacity* speed) [gr CO2/ton-mile]

EEDI contd

- Mandatory for newbuildings
- All will have to have: EEDI ≤ EEDI ref. line
- Ref. line = f(ship type, DWT) = $a(DWT)^{-c}$
- Ref. line more stringent in future years

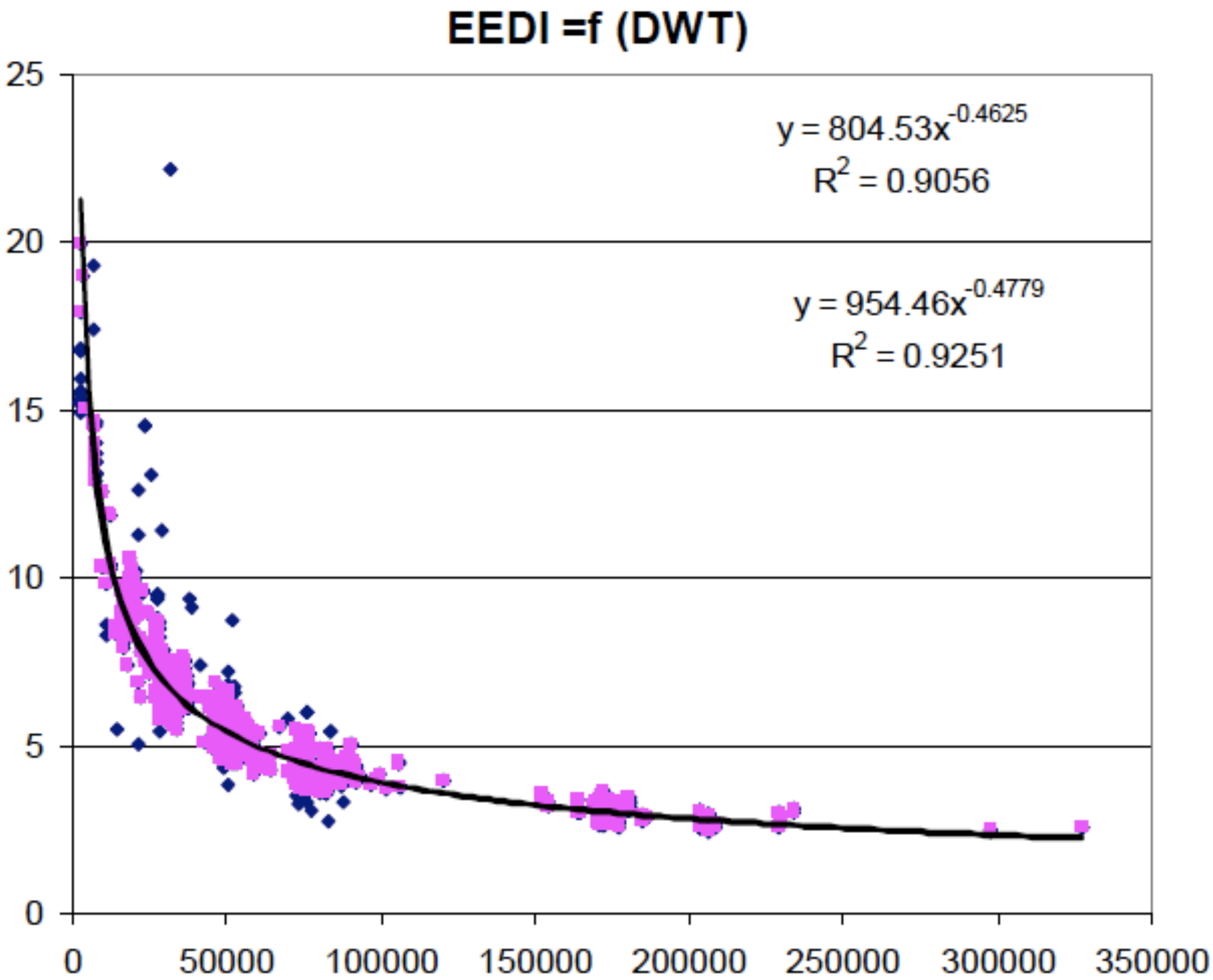


Figure 1: Dry bulk carriers
All data: 2,259 ships. Without outliers (shown in blue ◆): 2,218 ships

Concerns

- To reach required EEDI, **the correct solution** would be to **optimize hull, engine and propeller**
- **The easy solution** would be to **reduce design speed**
- This could lead to **underpowered ships**
- More CO2 to maintain speed in bad weather
- It could also lead to **modal shifts**

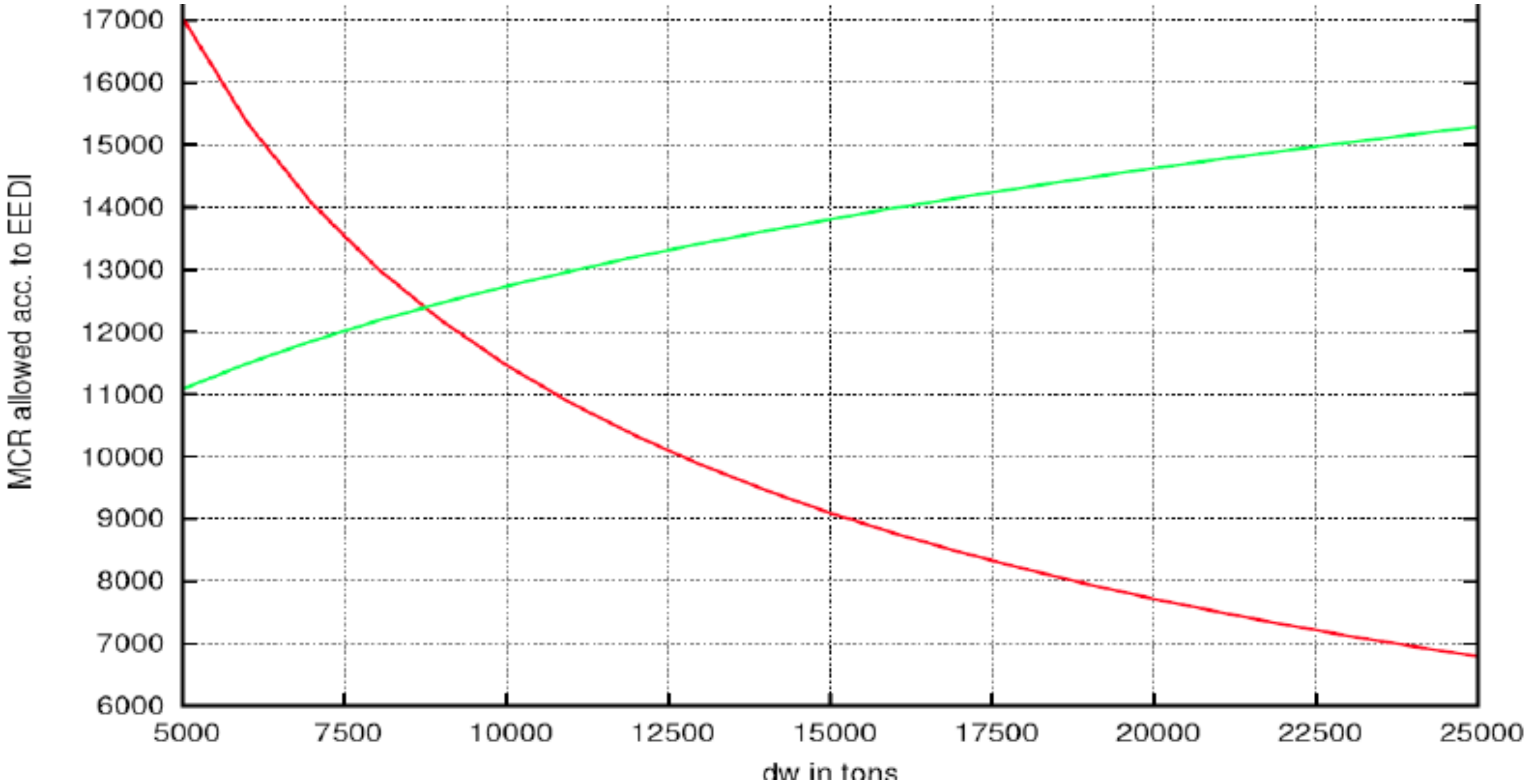
Compromise on safety?

- A ship needs to have adequate power to maintain speed in bad weather, manoeuvering, etc
- IACS et al submission at MEPC 62 (minimum power requirements)
- ICS submission at MEPC 62 (minimum safe speed of 14 knots)

Prof. Krüger's analysis

- Max allowable power to be EEDI-compliant GOES DOWN as ship size goes up
- Among all ship types, only containerships do not have this problem!
- Problem particularly acute for Ro/ro's.

Ro/ro breakdown



Other ‘parallel’ tracks

- Q: are the tracks below really parallel?
  - Technical measures
  - Operational measures
  - Market based measures

A: not really

How does an MBM work?

- It induces ship owners to adopt measures that will reduce CO_2 emissions

- These measures can be
  - **operational** (short run) or
  - **technical** (long run)

‘Operational’ example

- Impose a Levy on bunkers
- Induces ships to slow steam
- CO_2 is a non-linear function of speed
- Slow steaming will reduce CO_2 emissions

‘Technical’ example

- MBM may induce shipowners to purchase ships that are more energy-efficient (better engines, propellers, hulls, etc)
- They might invest in these technologies that would save CO2, rather than pay for the MBM

(equivalent: buying a hybrid car)

What else can an MBM do

- May also collect money to be used to reduce CO_2 emissions outside the marine sector ('offsetting')
- May use part of the money to support LDCs and R&D

Market Based Measures

- 11 MBM proposals at MEPC 60 (March 2010)
- Expert Group formed by IMO Sec. General
- Feasibility study
- Work: May- August 2010
- Various discussions in 2010, 2011, 2012
- **NO CONCLUSION YET**

9 Criteria for evaluation

.1 Environmental effectiveness

.2 Cost-effectiveness and potential impact on trade and sustainable development

.3 The potential to provide incentives to technological change and innovation

.4 Practical feasibility of implementing MBM

.5 The need for technology transfer to and capacity building within developing countries, in particular the least developed countries (LDCs) and the small island development states (SIDS)

9 criteria cont'd

.6 The relation with other relevant conventions (UNFCCC, Kyoto Protocol and WTO) and the compatibility with customary international law

.7 The potential additional administrative burden and the legal aspects for National Administrations to implement and enforce MBM

.8 The potential additional workload, economic burden and operational impact for individual ships, the shipping industry and the maritime sector as a whole, of implementing MBM

.9 The compatibility with the existing enforcement and control provisions under the IMO legal framework.

MBM proposal groups

- International GHG Fund (Denmark et al) (LEVY)
- Emissions Trading Schemes (Norway, UK, France, Germany)
- Various hybrids, based on EEDI (USA, Japan, WSC)
- Port-based (Jamaica)
- Rebate mechanism (IUCN)
- Bahamas proposal

In-sector vs out-of-sector

- All proposals describe programs that would target GHG reductions through:
  - **In-sector** emissions reductions from shipping; or
  - **Out-of-sector** reductions through the collection of funds to be used for mitigation activities in other sectors that would contribute towards global reduction of GHG emissions

- Example: collect money to invest in wind farms in New Zealand

Bahamas’ original proposal

- (basically) do nothing
- Q: will do-nothing reduce emissions?
- A: YES!

Critical parameter: fuel price

- Much of the CO_2 reduction will come because of measures that become cost-effective as fuel prices go up
- It is very likely that fuel prices will be much higher in the future
- Ship owners would implement these measures without being forced to do so

Marginal Abatement Cost (MAC): dollars per ton of CO_2 averted

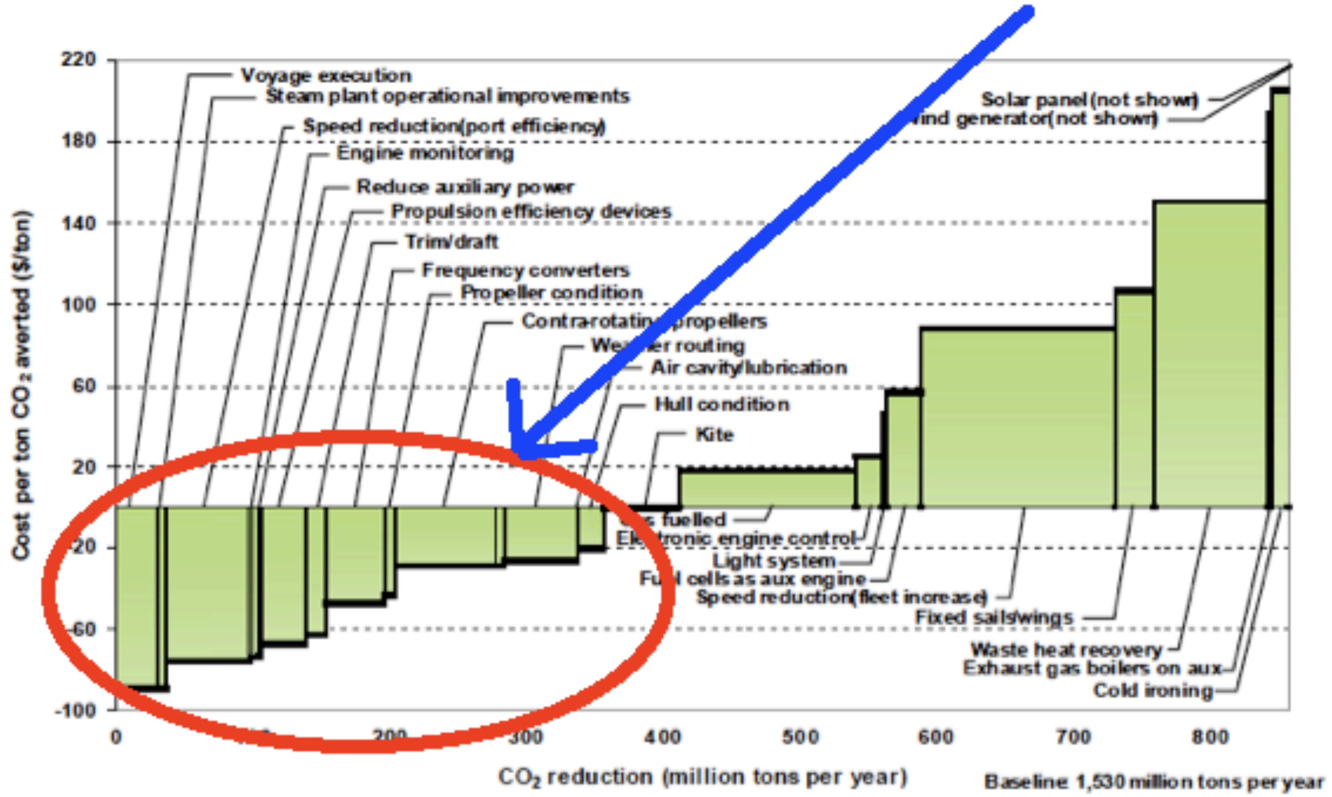
Let A be a CO_2 abatement measure

- MAC(A) = ΔNCOST(A)/ΔCO2(A), where
  - ΔNCOST(A) = Net cost differential in implementing A
  - ΔCO2(A) = tons of CO_2 averted by A
- ΔNCOST(A) = ΔGCOST(A)- ΔFUEL(A)*PFUEL, where
  - ΔGCOST(A) = Gross cost differential in implementing A
  - ΔFUEL(A) = Fuel consumption averted by implementing A
  - PFUEL = fuel price
- **MAC(A) = ΔGCOST(A)/ΔCO2(A) – PFUEL/F**
  - F = CO_2 coef (between 3.02 and 3.11)

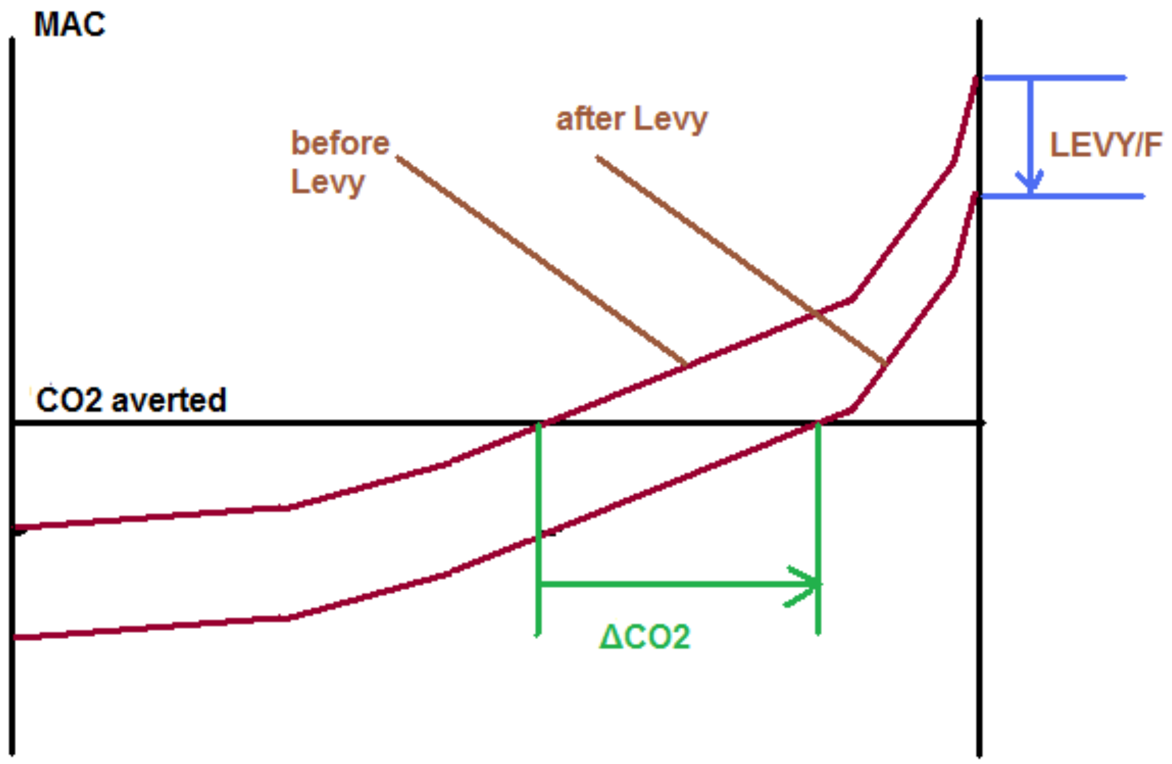
DNV's MAC curves

- MAC<0

Figure 1 – Average abatement curves for world shipping fleet 2030



Effect of Levy using MAC curves



MEPC 63: last Feb-March

MEPC 63 cont'd

- EEDI
- Continued discussion on how to best implement it
- Adoption of guidelines

Guidelines adopted

- 2012 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships;
- 2012 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP);
- 2012 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI); and
- Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI).

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MEPC 63: Greece's proposal

- Keep on table only Levy and ETS proposals
- Put on hold hybrid MBMs (US, Jap., WSC)
- Discard all others (Bahamas, Jamaica, IUCN)

MEPC 63: Greece's proposal

- Keep on table only Levy and ETS proposals
- Put on hold hyb… (US, Jap., WSC)
- Discard all …rs (Baha… Jamaica, IUCN)
- **KEEP ALL ON THE TABLE**

MEPC 63

- Draft Resolution on Technical Co-operation and Transfer of Technology
- Brought forward by developing countries (China, India, Brazil, etc)

MEPC 63

- Draft Resolution on Technical Co-operation and Transfer of Technology

- Brought forwar[illegible]loping countries (China, Ind[illegible]azil, et[illegible])

- **NO CONSENSUS**

Opposition

MEPC 63

- Proposal for an Impact Assessment Study on MBMs
- Brought forward by the Chairman of MEPC
- Supported by developed countries

MEPC 63

- Proposal for an Impact Assessment Study on MBMs
- Brought for by the man of MEPC
- Supported evelope ntries

- **NO CONSENSUS**

Opposition

Enter European Commission!

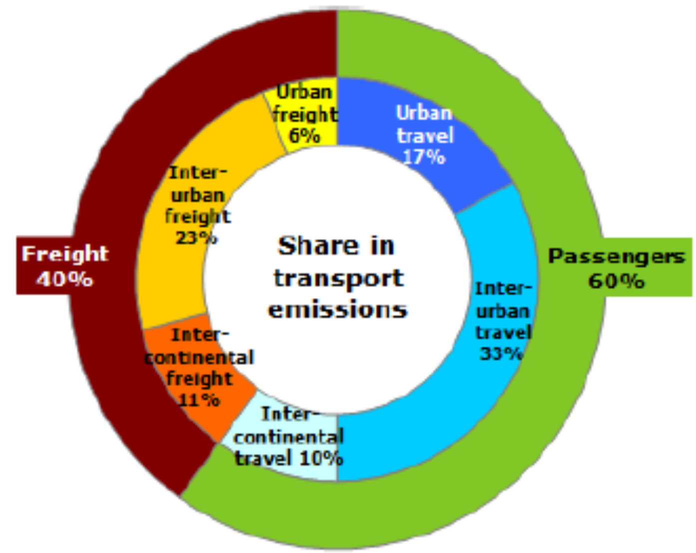
- Has supported IMO process, BUT:
- Has stated very clearly that if IMO drags its feet, EU will proceed on its own
- Specifically, if no decision by EU-27 by Dec. 31, 2011, Commission will develop its own proposals
- IMO decision on EEDI: not enough

What will the EU propose?

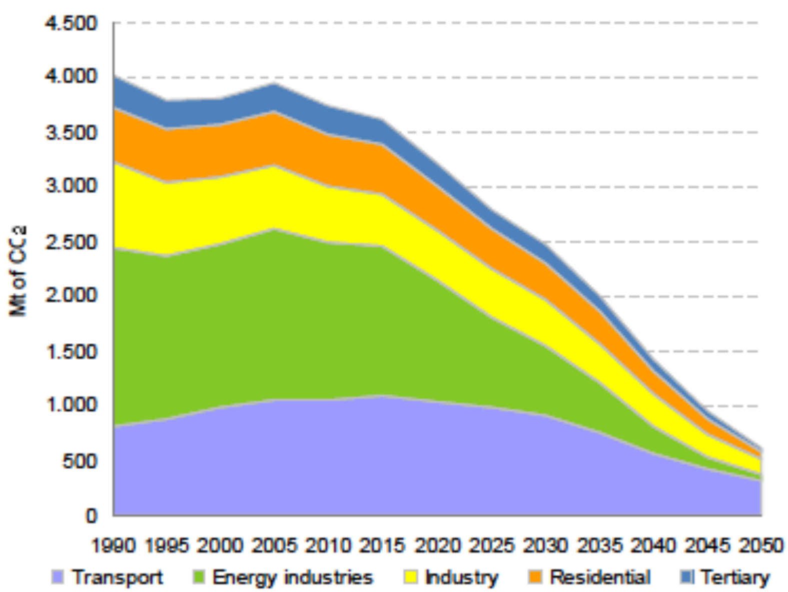
- Rumor: ETS (like in airlines)
- Officially: all options open
- Several studies under way
- Some stakeholders are against **regional** measures

A tight carbon budget for the transport sector

- In October 2009, the European Council showed support for the objective of reducing GHG emissions in the EU by 80 to 95% by 2050 compared to 1990 levels



Source: PRIMES-TREMOVE and TREMOVE



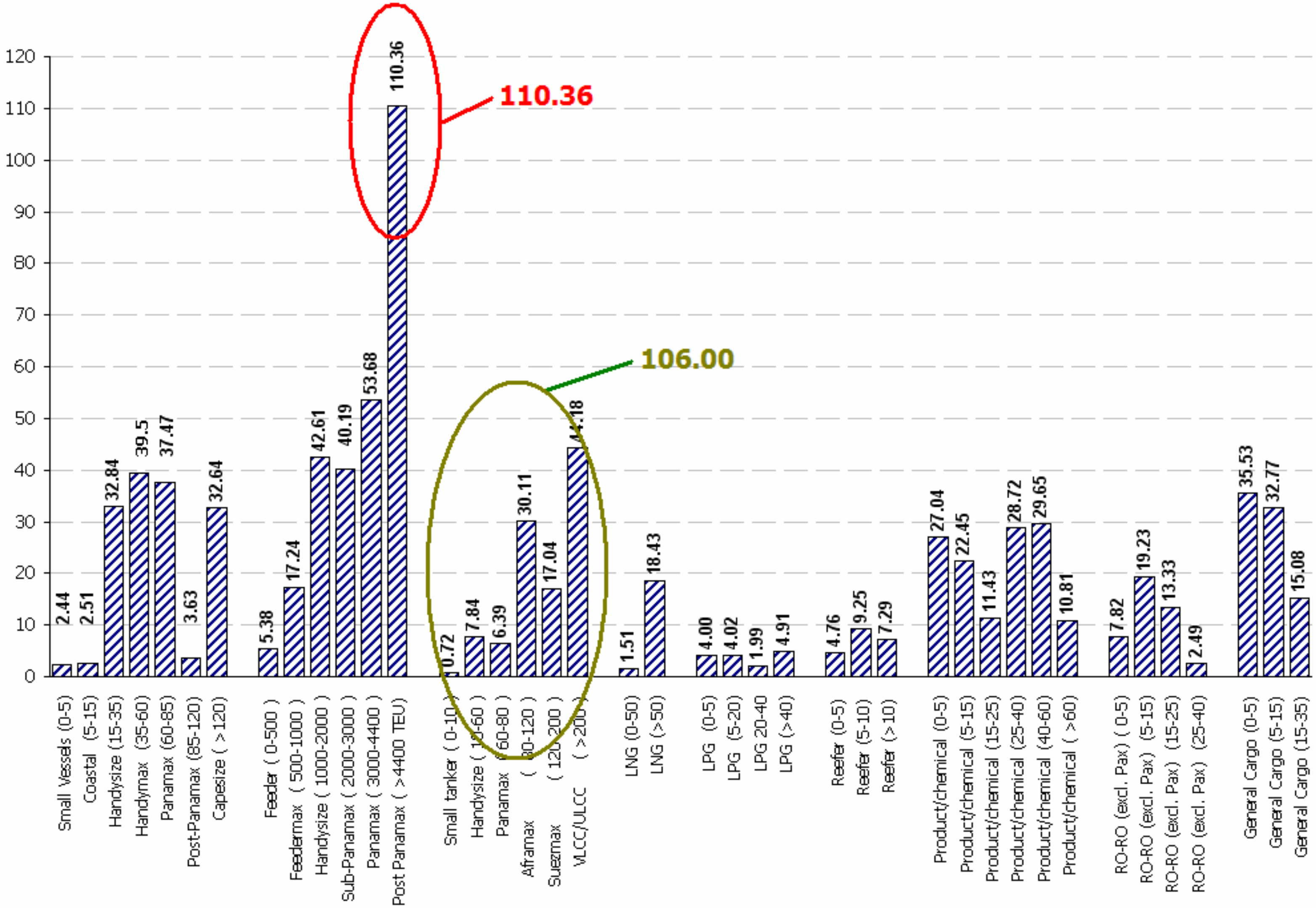
Source: PRIMES, NTUA (E3MLab)

- Transport accounts for about one fourth of GHG emissions: 60% comes from passenger transport, one quarter is urban, less than one quarter is inter-continental and over half is medium-distance

2011 Transport White Paper

- Sets a goal of reducing GHG emissions from transport (all modes) by 60% by 2050
- IMO has equally ambitious goals to reduce EEDI by 30% by 2030
- Main challenge: how can international shipping grow and be profitable in the face of such ambitious environmental goals

CO2 emissions per vessel category (million tonnes)



*Psaraftis, H.N. and C.A. Kontovas (2009), "CO2 Emissions Statistics for the World Commercial Fleet", WMU Journal of Maritime Affairs, 8:1, pp. 1-25.

Speed reduction

- An obvious way to reduce emissions

- Killing 3 birds with one stone?

- Pay less for fuel
- Reduce CO_2 (and other) emissions
- Help sustain a volatile market

Dual targetting

- OPERATIONAL
- Operate existing ships at reduced speed (derate engines)
- Slow steaming kits

- STRATEGIC (DESIGN)
- Design new ships that cannot go very fast (have smaller engines)

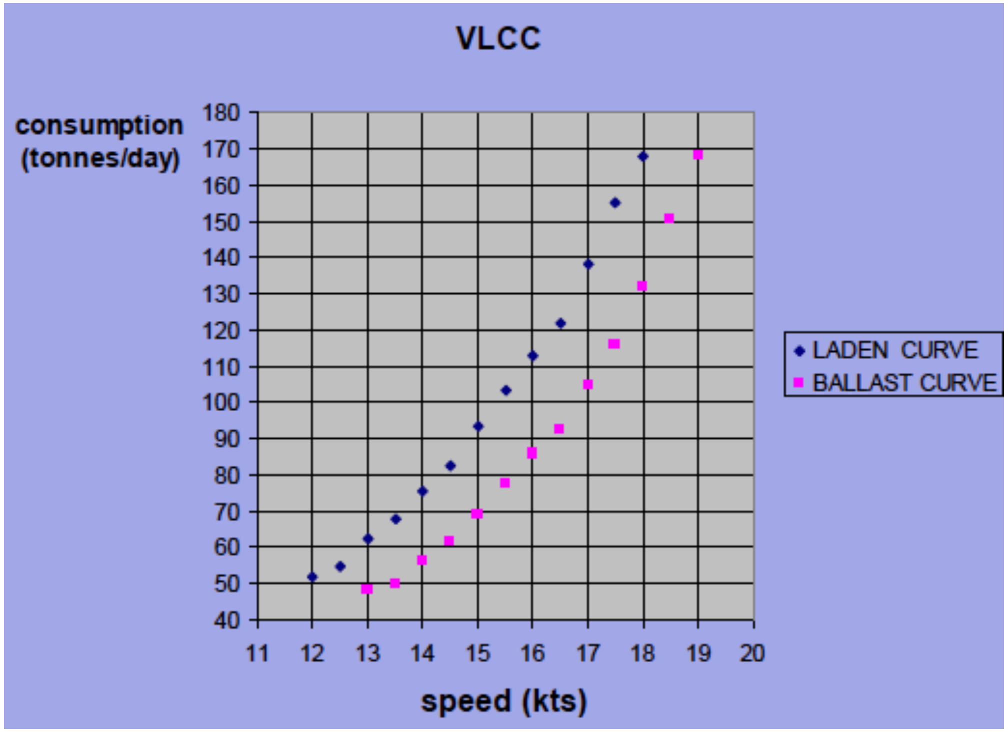
How much slower?

- From 20-25 knots, go down to 14-18
- New Maersk 18,000 TEU ships: 19 knots
- Project ULYSSES:

  Go 5-6 knots!

Fuel consumption vs speed

- $FC = kV^n$ ($n \geq 3$)
- $FC = (A+BV^n)\Delta^{2/3}$
- $FC = f(V,\Delta)$



Is ship speed fixed?

- NO!
- Ships do NOT trade at predetermined speeds.
- Those who pay for the fuel, that is, the ship owner if the ship is in the spot market on voyage charter, or the charterer if the ship is on time or bareboat charter, will **choose an optimal speed** as a function of
  - (a) bunker price, and
  - (b) the state of the market and specifically the spot rate

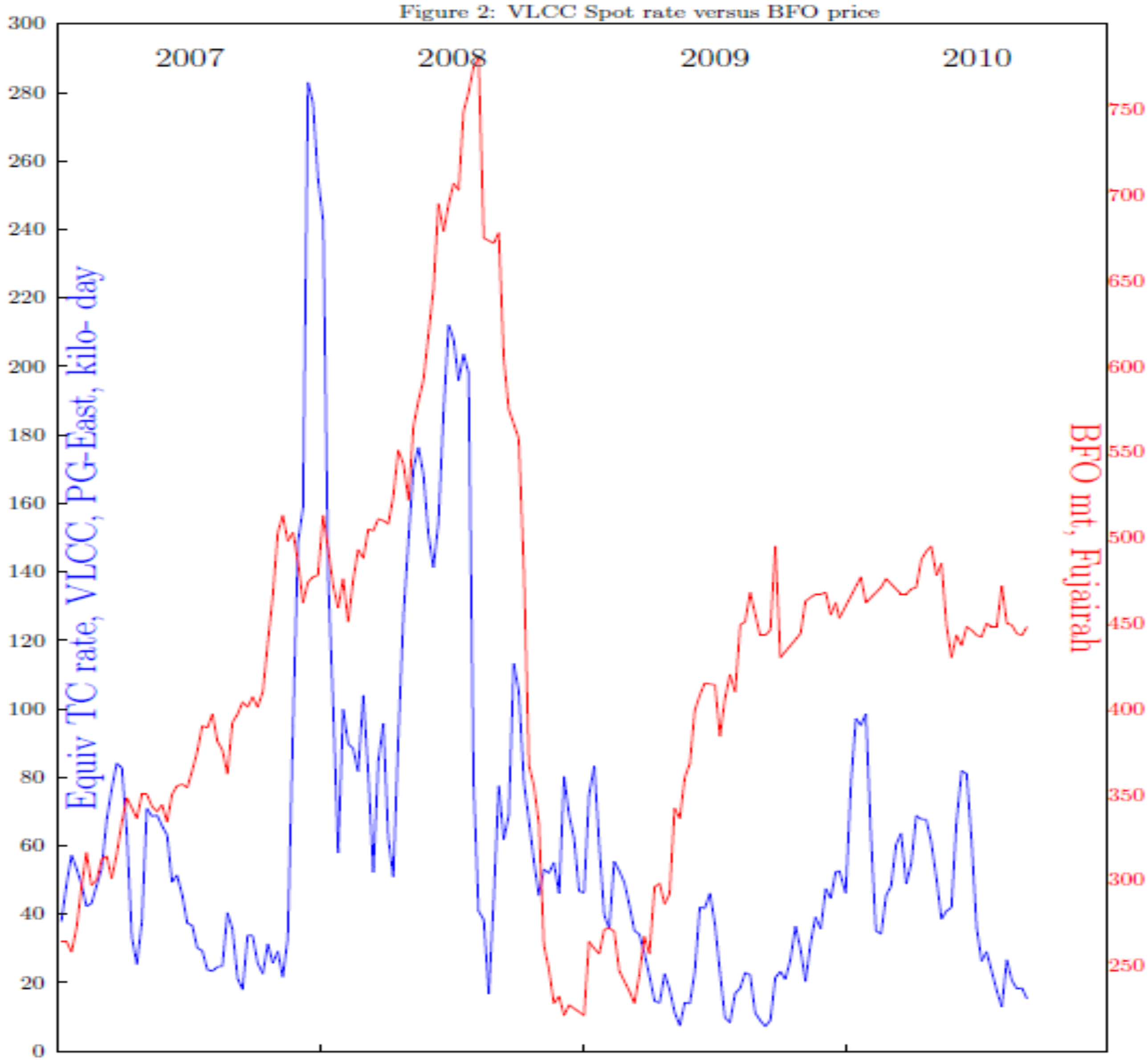


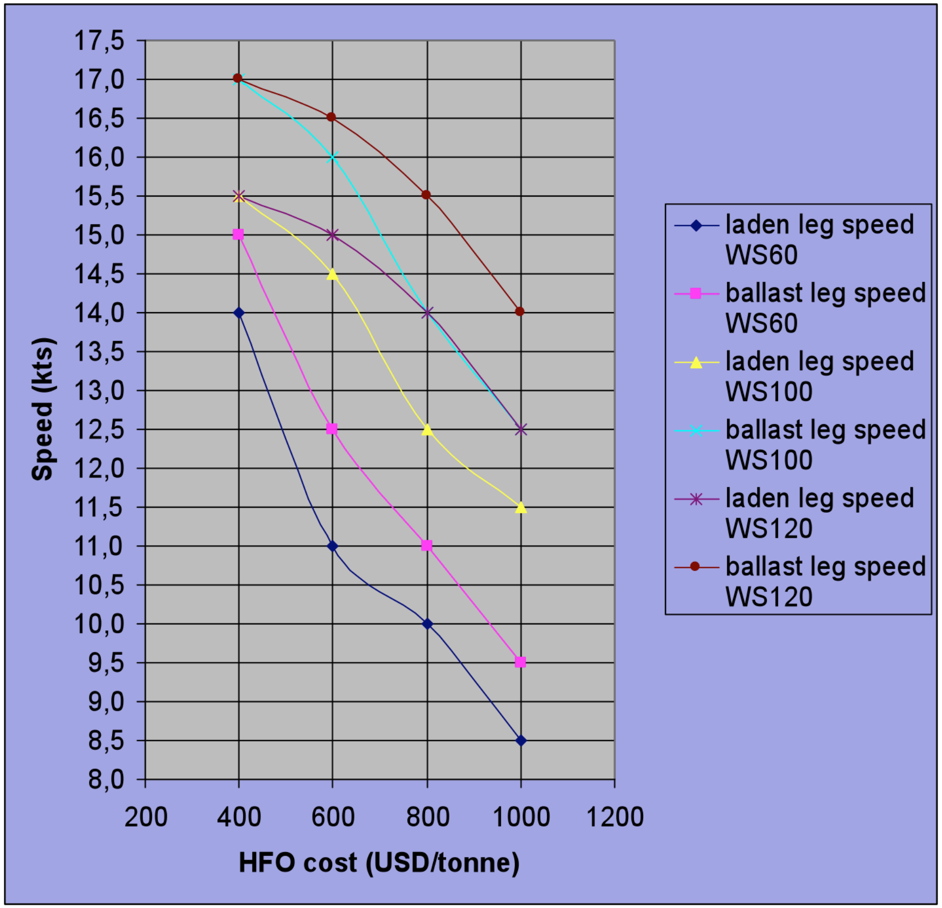
Figure 2: VLCC Spot rate versus BFO price
2007
2008
2009
2010
Equiv TC rate, VLCC, PG-East, kilo- day
BFO mt, Fujairah
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
750
700
650
600
550
500
450
400
350
300
250

Speed basics

- Even though the owner's and time charterer's speed optimization problems may seem at first glance different, for a given ship the optimal speed (and hence fuel consumption) is in both cases the same.
- In that sense, from an emissions standpoint, it makes no difference who is paying for the fuel, the owner, the time charterer, or the bareboat charterer.

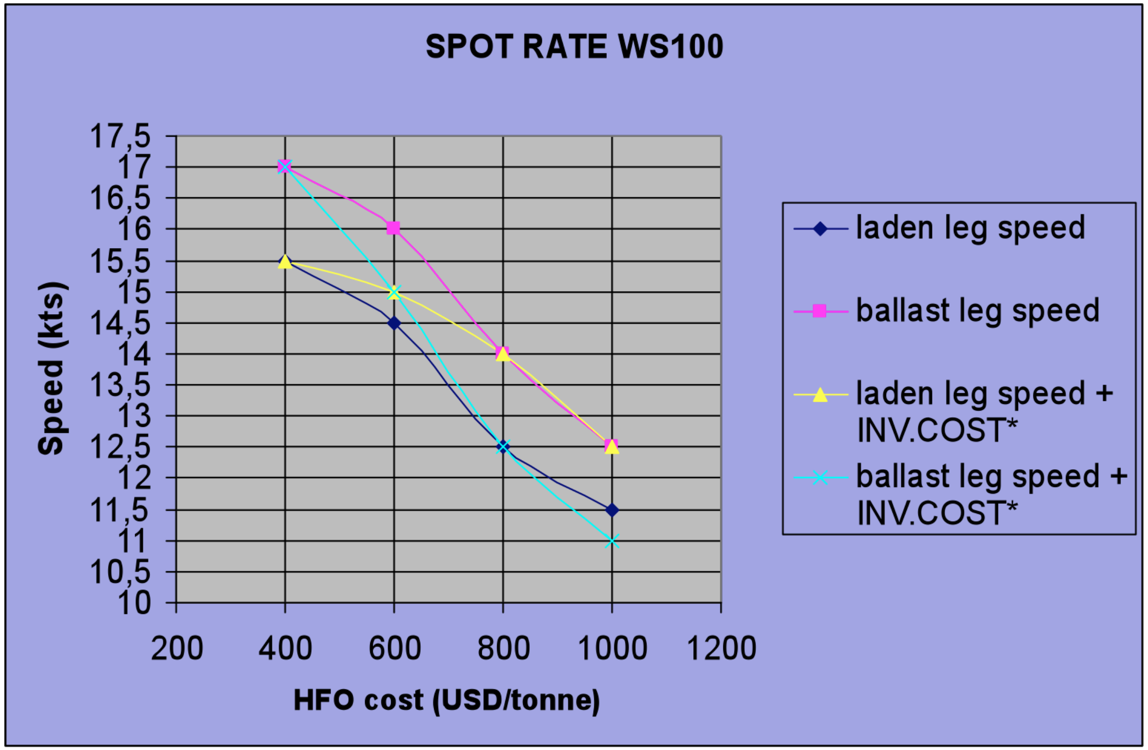
VLCC results

- Route: Gulf-Japan
- Optimize both laden and ballast speeds

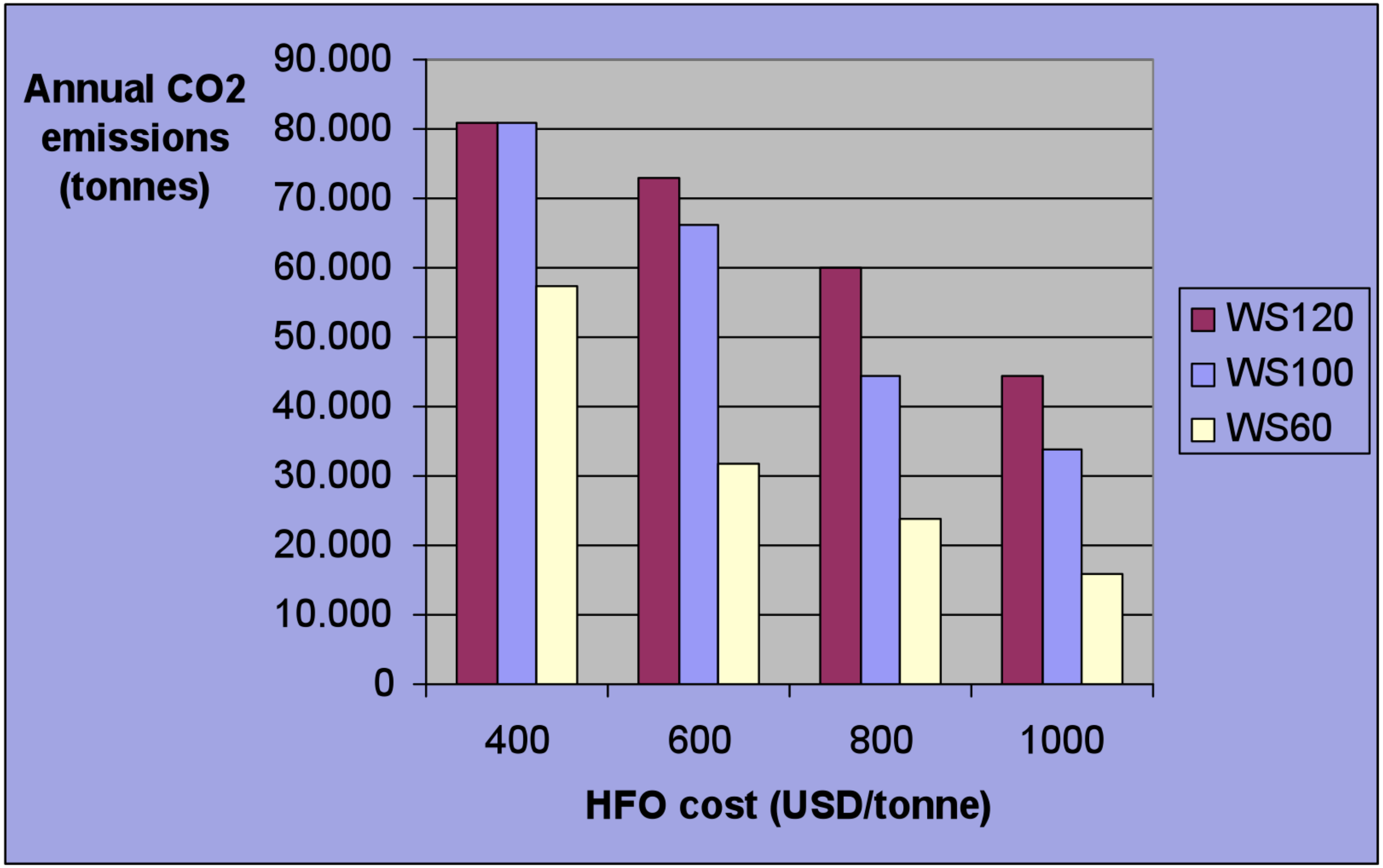


VLCC cont’d

- Include cargo inventory costs



Effect of fuel price on emissions

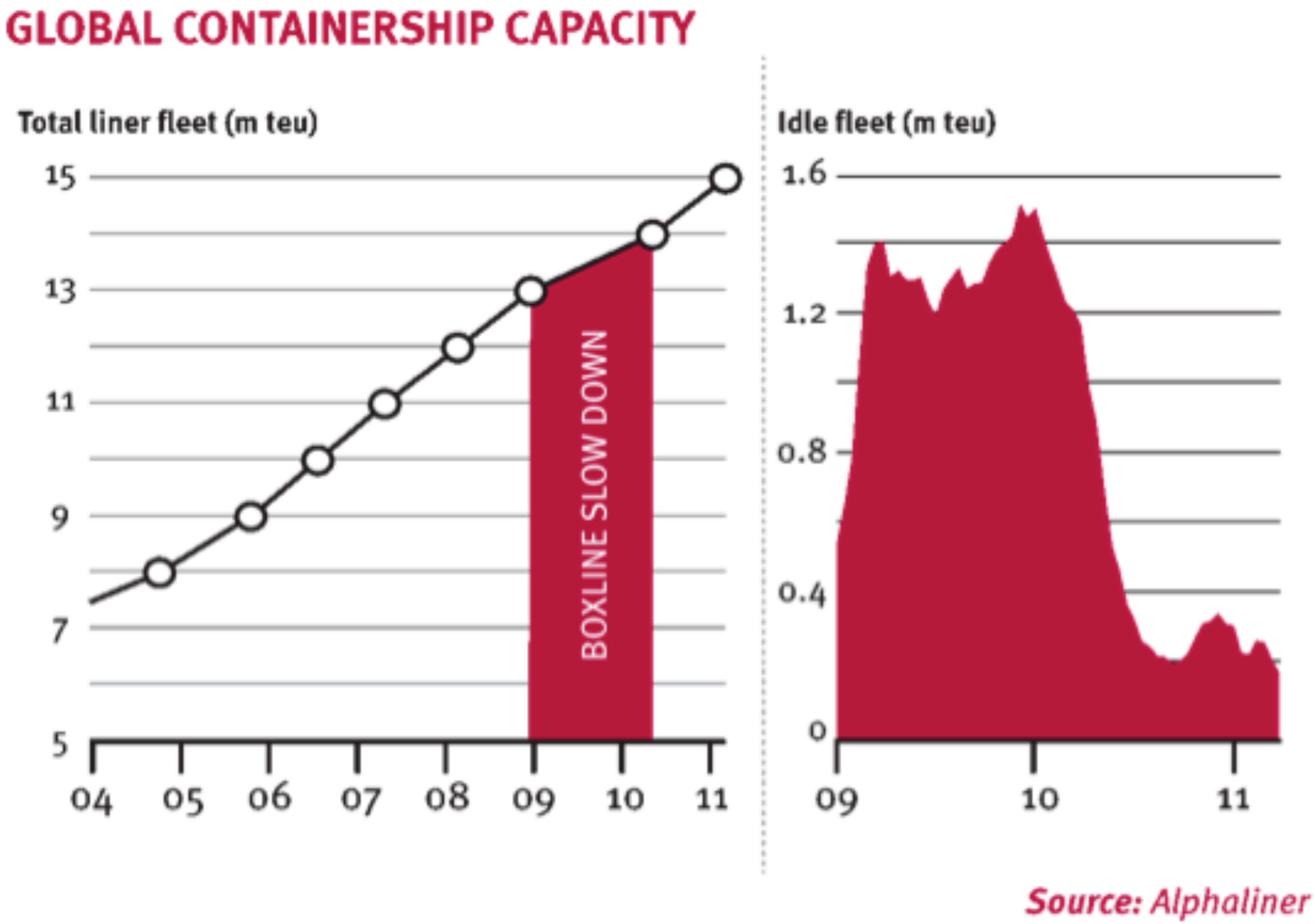


Is slow steaming being practised today?

OF COURSE!

- Practically 0 tanker and bulk carrier lay up
- 0.2 mm tons of bulkers laid up out of 564.1 mm afloat*
- 2.6 mm tons of tankers out of 440.1 mm tons afloat*

*Clarksons Shipping Intelligence Weekly, 2011-06-03,


GLOBAL CONTAINERSHIP CAPACITY
Total liner fleet (m teu)
15
13
11
9
7
5
04
05
06
07
08
09
10
11
BOXLINE SLOW DOWN
Idle fleet (m teu)
1.6
1.2
0.8
0.4
0
09
10
11
Source: Alphaliner

Container sector

- "For Maersk Line slow steaming is here to stay because it remains a win-win-win situation. It is better for our customers, better for the environment, and better for our business."

Eivind Kolding, Maersk Line CEO

MAERSK

Enter the 'speed regulators' !

- 2 ways to regulate speed:

- (A) Indirect way: Via EEDI
- (B) Direct way: Mandate it (set a speed limit)

(B) Setting a speed limit

- If speed limit is ABOVE optimal slow steaming speed, superfluous
- If speed limit is BELOW optimal slow steaming speed, distortions may occur

- SHORT TERM: higher freight rates
- LONG TERM: build more ships than you need

Parenthesis:
direct speed limits at IMO

- Proposal by Clean Ship Coalition at MEPC 61: *"Speed reduction should be pursued as a regulatory option in its own right and not only as possible consequences of market-based instruments or the EEDI."*

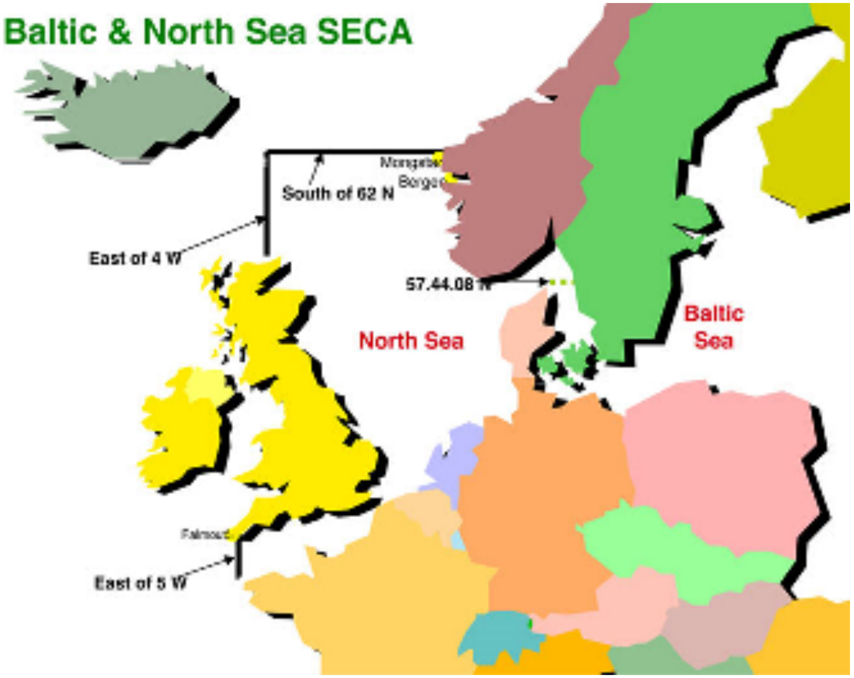
- The proposal was NOT supported: *"The Committee agreed that speed considerations would be addressed indirectly through the EEDI, the SEEMP and by a possible market-based mechanism and, therefore, decided that no further investigation of speed reductions as a separate regulatory path was needed."*

Speed limits distortions

- Building more ships to match demand throughput
- Increasing cargo inventory costs due to delayed delivery
- Increasing freight rates due to a reduction in ton-mile capacity
- Inducing reverse modal shifts to land-based modes (mainly road)
- Implications on **SAFETY**.

Sulphur Emissions Control Areas: SECAs

- SO2 reduction: high on IMO agenda
- Regional policies
- Big question: how to limit SO2 emissions
- Various measures (cleaner fuel, scrubbers)



Use cleaner fuels in SECAs

- If a ship is forced to use low sulphur fuel at a SECA, to reduce SO_2 emissions.
- This fuel is more expensive than high sulphur fuel. Hence freight rates go up.
- This may induce shippers to use land transport alternatives (trucking), which will increase CO_2 emissions thru the logistics chain!

From green ships to green logistics

- Green logistics: An attempt to attain an acceptable environmental performance of the intermodal supply chain, while at the same time respecting traditional economic performance criteria.
- The concept of “Green Corridors” is being analyzed in many circles, notably in Europe, as flows of cargoes that achieve a desirable environmental performance, while at the same time being efficient logistics-wise.

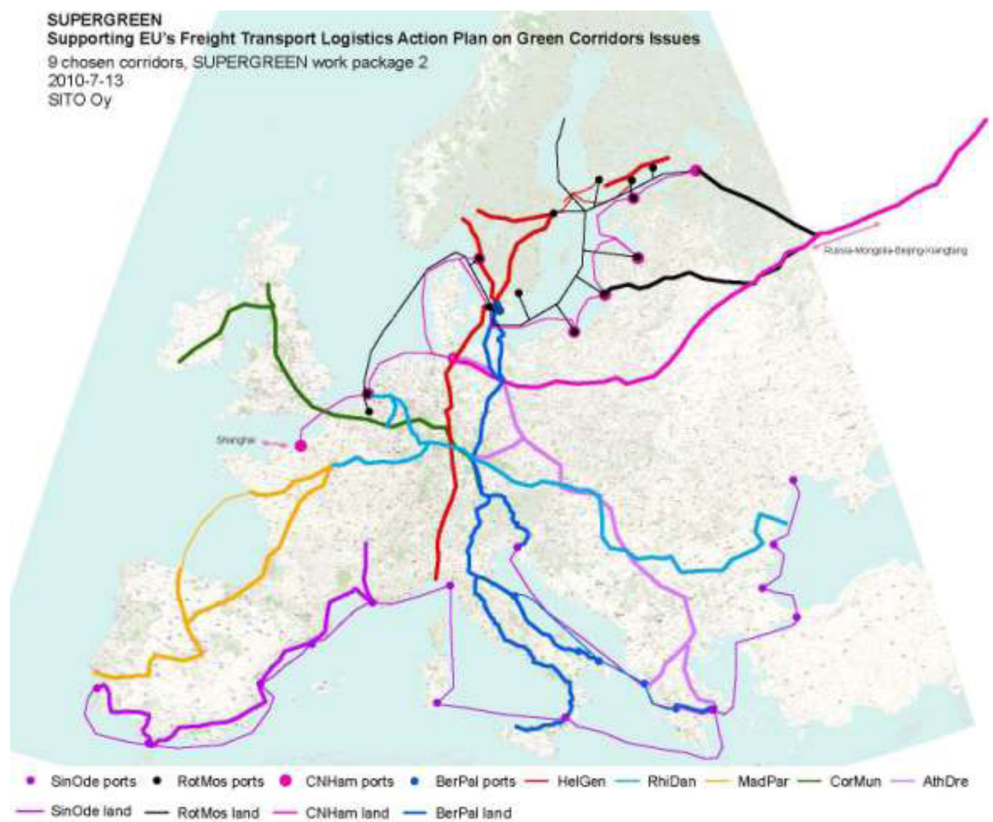
What is a green corridor?

EU Commission:

- Green Corridors are a European concept denoting long-distance freight transport corridors where advanced technology and co-modality are used to achieve energy efficiency and reduce environmental impact.

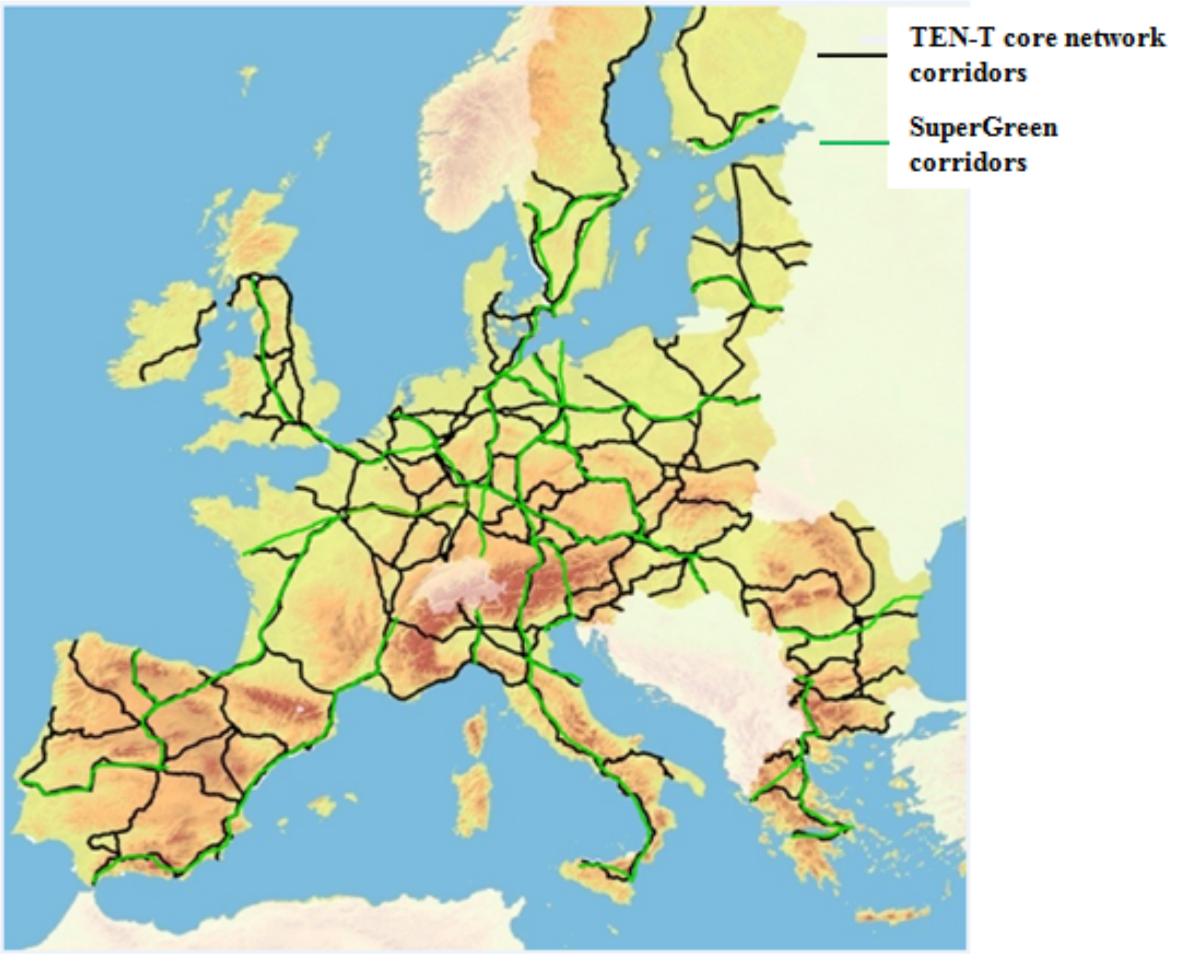
SuperGreen: an EU project coordinated by NTUA

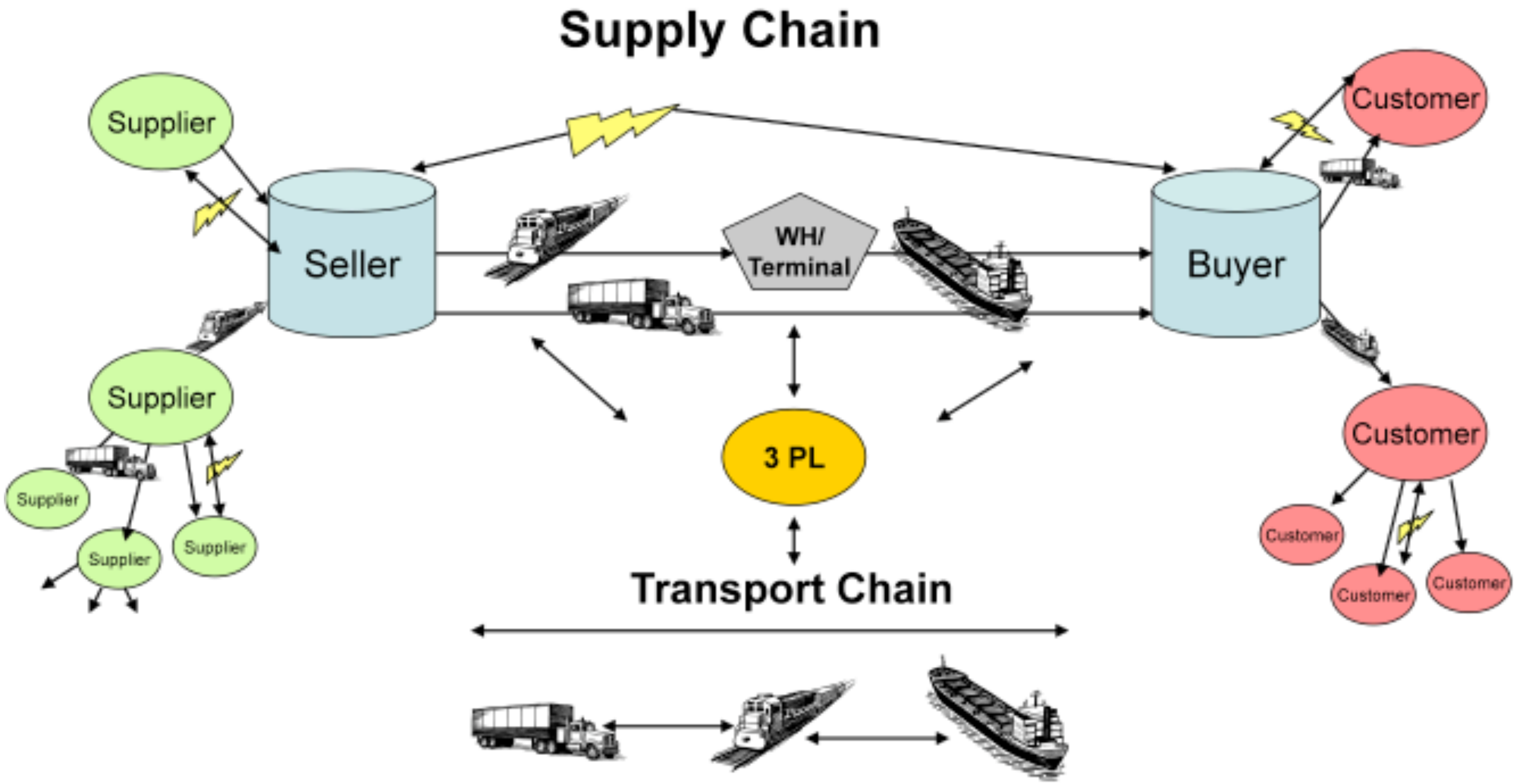
supergreen



www.supergreenproject.eu

Green corridors
vs TEN-Ts

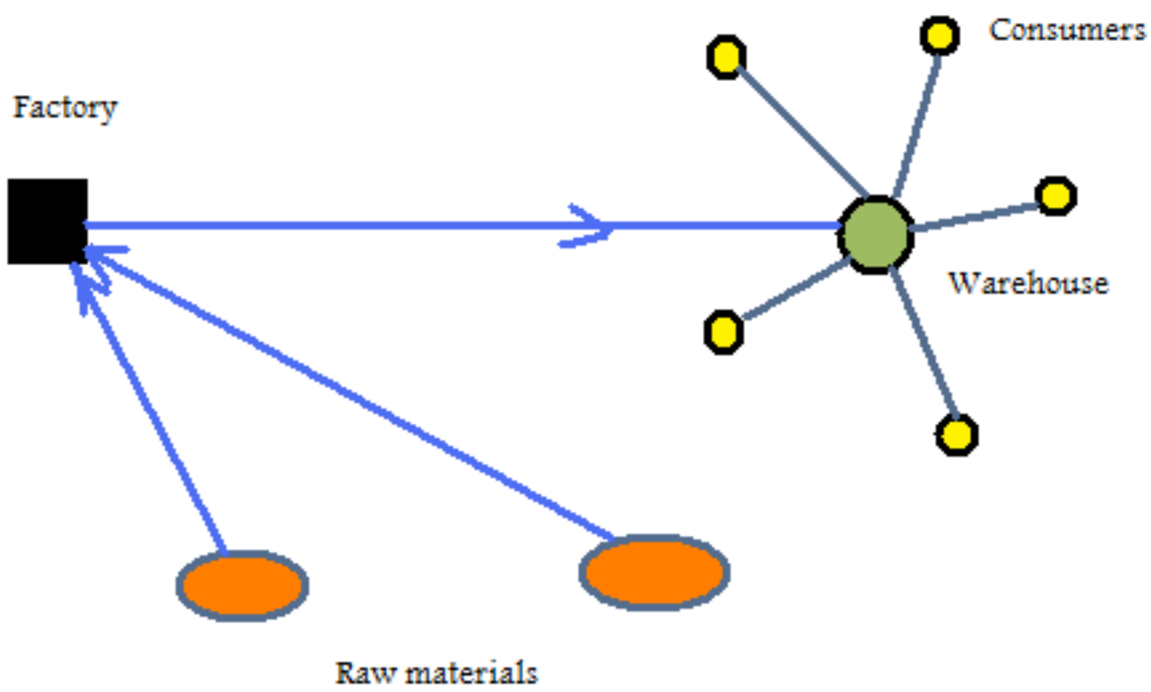




Part loads/Groupage: Line traffic - > terminals, consolidation, 3PL

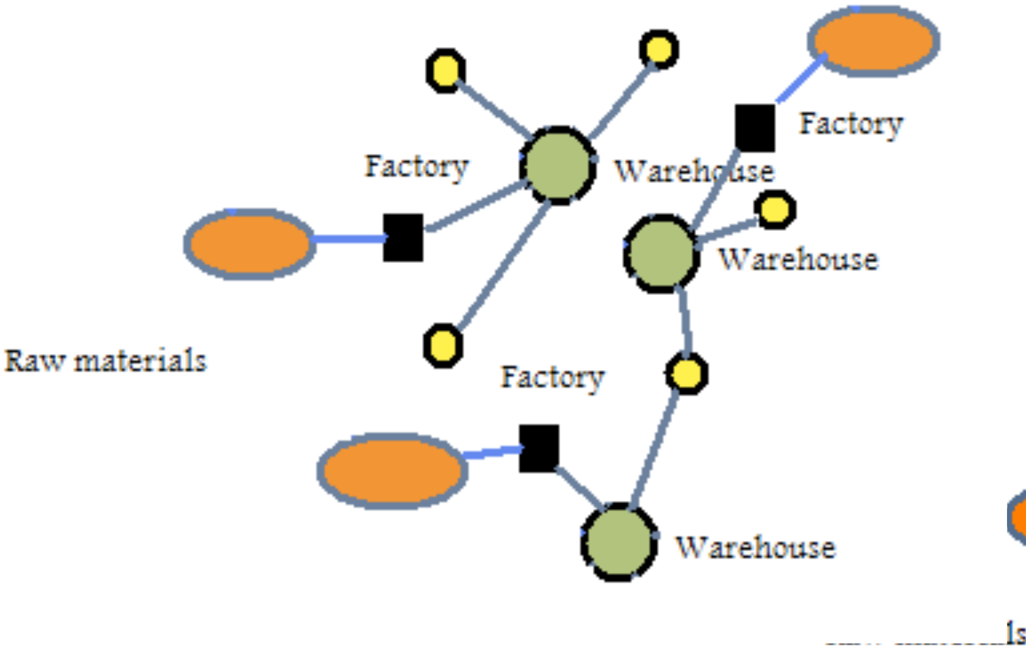
Full loads/ FTL,FCL: Bulk, Tramp Traffic, Contracted containers/tankers/rail cars

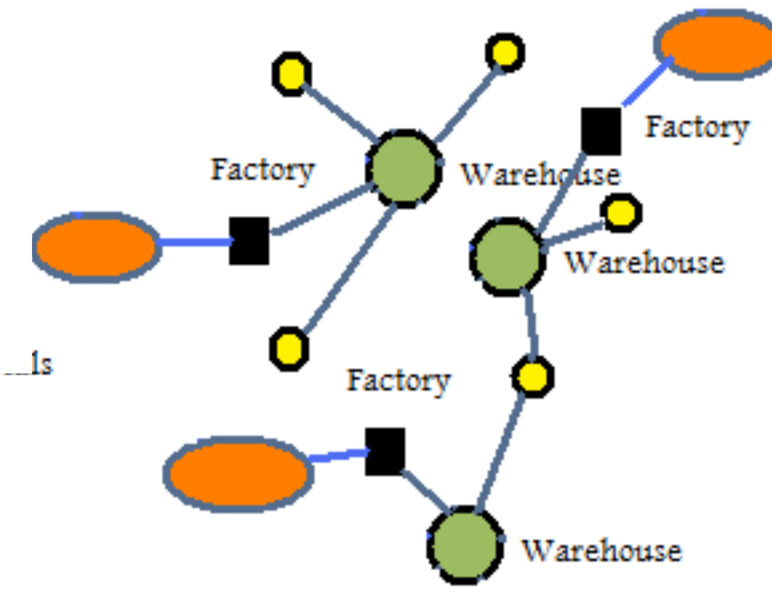
Which model?



- Long haul

Short haul (if price of emissions is high enough)





Is this green enough?

- Globally, ruminant livestock produce about 80 million metric tons of CH_4 annually, accounting for about 28% of global CH_4 emissions from human-related activities

  (source: US EPA)

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- Work at EU/DG-Clima
- Work at United Nations Commission for Europe (UNECE)

Thank you very much!

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