COLUMBIA UNIVERSITY SCHOOL OF INTERNATIONAL AND PUBLIC AFFAIRS

NY Energy Forum on Aviation Fuels

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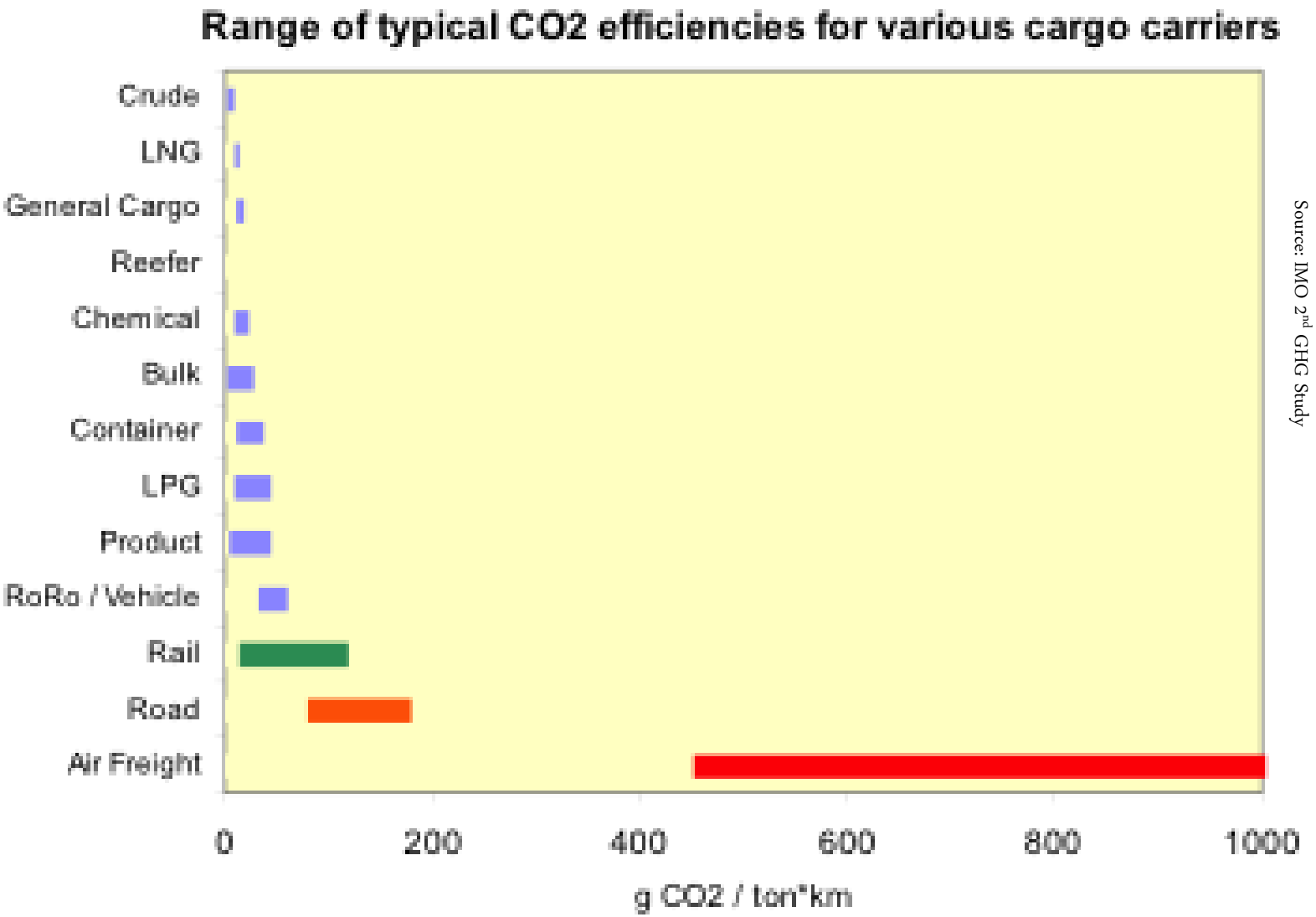
Prof. Albert Bressand

CENTER FOR ENERGY,
MARINE TRANSPORTATION
AND PUBLIC POLICY

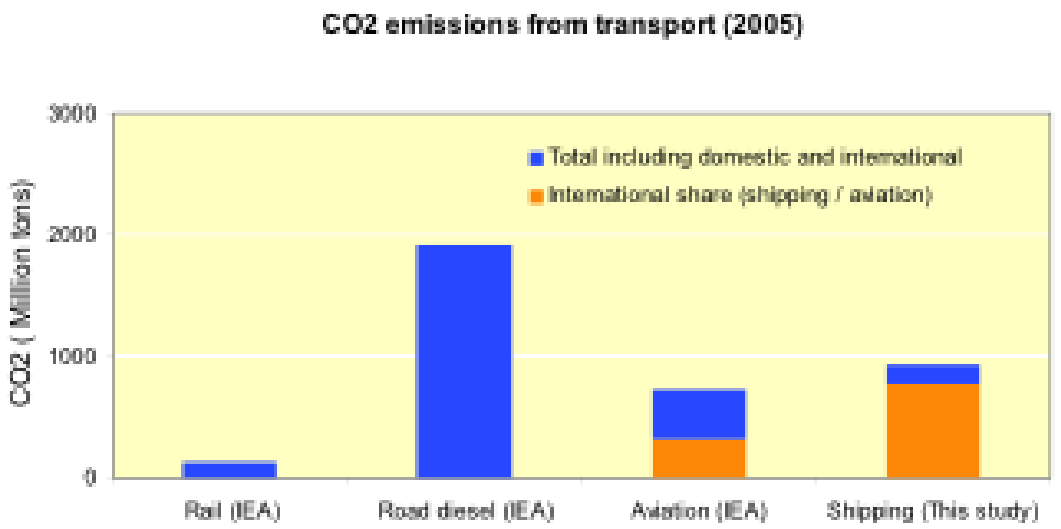
Aviation vs Maritime : CO2 Efficiency



Aviation vs Maritime: emission trends

Change in the 90-08 period	International Maritime	International Aviation
World Total	+ 63%	+ 76%
Annex I countries	+ 13.5 %	+57.2 %
Non Annex I	+ 158%	+111.2%

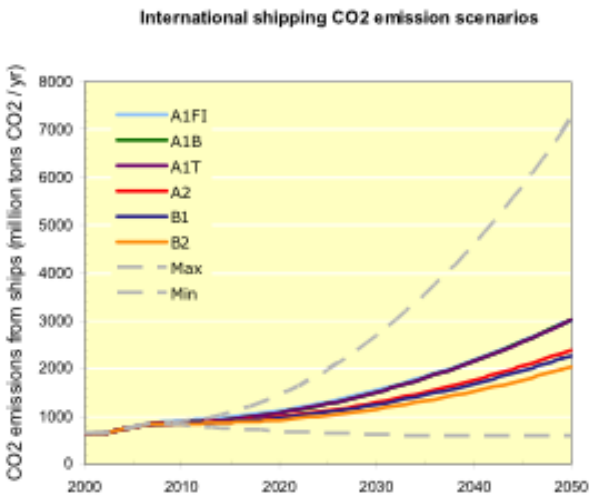
(source IEA 2010

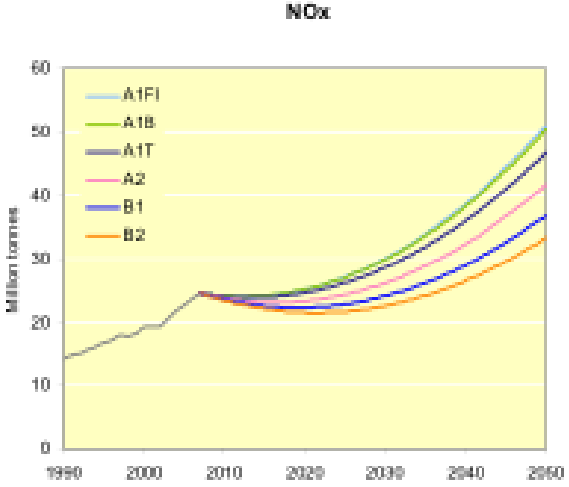


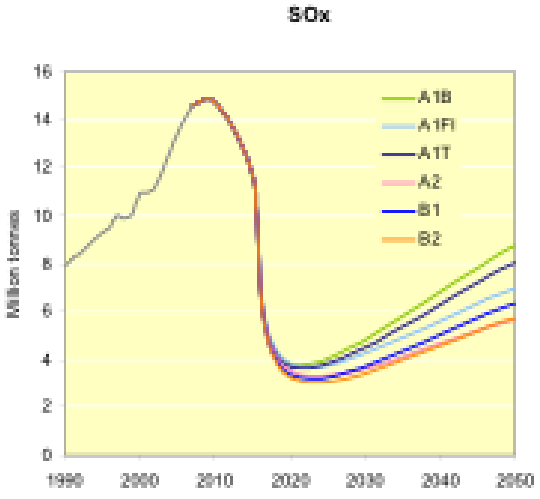
Source: IMO 2nd GHG Study

Emissions from international shipping

- In 2007 international shipping emitted
  - 870 Mt of CO2, 20 Mt of NOx, 12 Mt of SOx
- Projected growth
  - CO2: b/w 150% and 250% increase by 2050
    SOx and Nox increase after 2020







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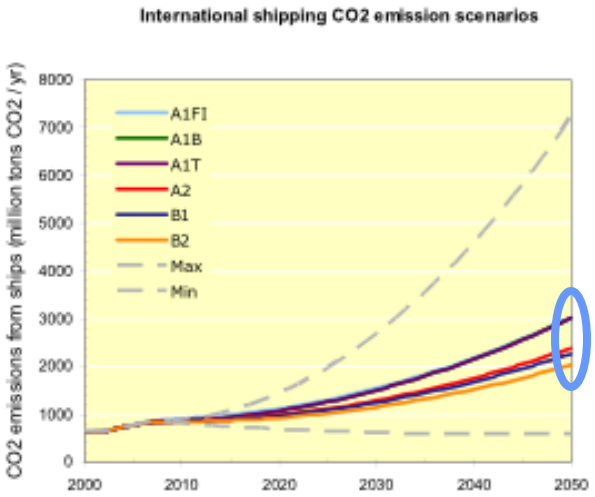

- **Total shipping** in 2007:1.065 GtCO2,
- 3.3% of total world emissions that year
- If it were a country, would have rank 5th largest emitter in 2007, between Japan (1.3Gt) and Germany (0.95 Gt)

(source IMO 2nd GHG Study)

Sulfur Emissions and Revised MARPOL Annex VI

- MARPOL Annex VI
  - Adopted in 1997, entered into force in May 2005
  - Decision to revise in July 2005, revision adopted in 2008
- Sox emissions (under revised MARPOL Annex VI)
  - Global Sulfur Cap of 3.5% effective 2012, 0.5 % effective 2020 (subject to feasilbity study no later than 2018)
  - Within ECAs: 1% starting 2010, 0.1% starting 2015
- Current ECAs:
  - North Baltic Sea, North Sea
  - North America (entry into force 2012)
  - Puerto Rico and US Virgin Islands area (tbc at MEPC 62)

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NOx Emissions and Revised MARPOL Annex VI

Tier	Ship construction date on or after	Total weighted cycle emission limit (g/kWh) n = engine's rated speed (rpm)		
		n < 130	n = 130 - 1999	n ≥ 2000
I	1 January 2000	17.0	$45.n^{-0.2}$ e.g., 720 rpm – 12.1	9.8
II	1 January 2011	14.4	$44.n^{-0.23}$ e.g., 720 rpm – 9.7	7.7
III	1 January 2016*	3.4	$9.n^{-0.2}$ e.g., 720 rpm – 2.4	2.0

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Fuel Price Impacts of Revised MARPOL Annex VI

Emission Type		kg / tonne of Fuel
SOx	Residual fuel oil	54
	Marine diesel oil	10
NOx	Slow-speed diesel engines	~ 85
	Medium-speed diesel engines	~ 56
	Boilers	7
CO2	Residual fuel oil	3130
	Marine diesel oil	3190

(source IMO 2nd GHG Study)

- Impacts are hard to predict (many factors incl availability of supply)
  - Intercessional group established at MEPC 61to study availability
- IMO estimates estimates x2 increase in price of marine distillates by 2020 (1200$ vs. aprox 600$ today)
- CO2 is less sensitive to distillate fuel switching → need something else

Reducing Shipping's GHG
Fuel options

Fuel option	Comment (source : IMO 2nd GHG Study)	Can it help?
Coal to liquid	Carbon fraction similar to diesel fuel BUT emits more at production higher than petroleum fuels	Probably not
Oil	Well, that's the one being used today. Distillate have less Sulfur but about the same CO2	No.
Gas (LNG)	15% less CO2 emissions Low sulfur and NOx Significantly cheaper than distillate	Yes. Good candidate !
Nuclear	No CO2 but major political and security challenges	Probably not
Biomass	1st gen cld be used as substitute or in combination with existing fuels More expensive than oil-derived fuels for shipping at the moment	Possibly (depends on supply and its impact on price)
Renewable	Emissions free Could be used onboard (solar, wind) As well as stored (using H)	Yes but unlikely to become full substitute at this stage

Reducing Shipping's GHG
Design and Operational Measures

- Design
  - Concept, propulsion, coating, low carbon fuel, exhaust etc
- Operational:
  - Fleet Mgt, Logistics, Voyage optimization, Energy Mgt
- Combined potential b/w 25% and 70% reduction !
- **BUT** there are non-price barriers
  - access to capital, reluctance to invest in opportunities with long pay back periods, ownership and operational structure, crew training and motivation, contract structures , access to information by decision makers etc.
- Market Based Measures as a important complement

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Reducing Shipping's GHG
Market Based Measures

- 10 Market based measures under discussion at IMO
- Levy based ($/ton of fuel)
  - With reduction objective and use of carbon markets (e.g GHG Fund)
  - With objective of energy efficiency (LIS, VES, PSL)
- Trading Based
  - Cap-and-Trade (Global ETS)
  - Efficiency Trading (SECT)

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