Scenarios for Fulfilling Climate Targets for 2050:

Shipping's Share of the Burden

IMSF – 2011 Hong Kong

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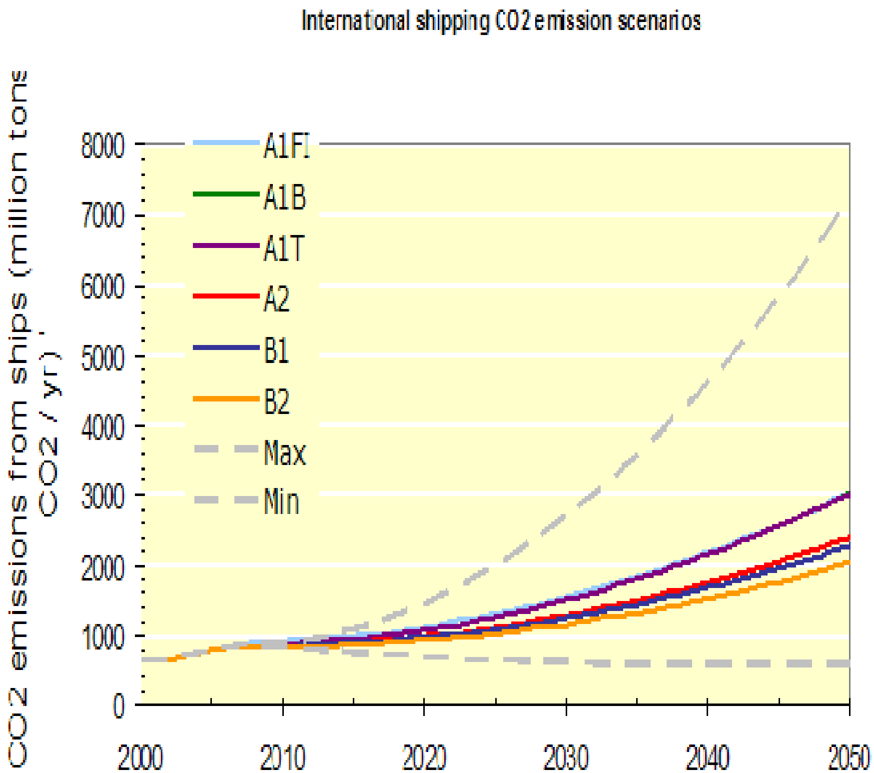
International shipping CO_2 emission scenarios until 2050 [Source: IMO 2009]

Growth figures according to IPCC scenarios

		A1B	A1F	A1T	A2	B1	B2
GDP (1)		3.9 %	4.0%	3.6 %	2.4 %	3.3 %	2.7 %
Total Transport Demand	Base	3.3 %	3.3 %	3.3 %	2.6 %	2.5 %	2.1 %
	High	5.3 %	5.3 %	5.4 %	4.2 %	4.1 %	3.5 %
	Low	1.5 %	1.5 %	1.5 %	1.2 %	1.1 %	0.9 %

Emission scenarios based on IPCC growth figures



Billion ton miles and fuel based on average of all IMO 2009 GHG scenarios

Vessel type	2007 Billion ton miles	2007 Fuel in million ton	Gram CO_2 per ton nm	2030 Billion ton miles	2030 Fuel in million ton	2030 Fuel with 22 % improve-ments in efficiency	2050 Billion ton miles	2050 Fuel in million ton	2050 Fuel with 39 % improve-ments in efficiency
General Cargo	2.382	31,7	42	3.699	49	38	5.145	68	42
Dry Bulk	16.137	57,9	11	25.060	90	70	34.856	125	76
Reefer	258	6,9	84	401	11	8	557	15	9
Container	7.501	82,3	35	22.051	242	189	55.807	612	374
Crude oil tankers	10.061	30,8	10	15.624	48	37	21.732	67	41
Oil product tankers	1.257	9,9	25	1.952	15	12	2.715	21	13
Chemical tankers	1.919	15,4	25	2.980	24	19	4.145	33	20
RoRo	485	11,6	75	753	18	14	1.048	25	15
RoPax	160	21,4		248	33	26	346	46	28
LNG	852	9,1	34	1.323	14	11	1.840	20	12
LPG	401	4,4	35	623	7	5	866	10	6
Ferry	10	1,8		16	3	2	22	4	2
Cruise	18	8,7		28	14	11	39	19	11
Yacht	0,4	1,3		1	2	2	1	3	2
Offshore	135	12,1		210	19	15	292	26	16
Service	86	18,0		134	28	22	186	39	24
Fishing	43	7,7		67	12	9	93	17	10
Sea River	16	0,5	98	25	1	1	35	1	1
Total	41.721	331,5	25	75.193	630	492	129.724	1151	702

- These greenhouse gas emission growth figures stand in sharp contrast to the required total global reductions (IPCC 2007).
- It is a controversial issue how the annual greenhouse gas reductions shall be taken across sectors.
- Given a scenario where all sectors accept the same percentage reductions, the total shipping emissions in 2050 may be no more than 15% - 50% of current levels based on the required 50 – 85 % reduction target set by the IPCC (2007).
- Moreover, provided that the demand for sea transport follows the predicted tripling of world trade, it can easily be deduced that the amount of CO_2 emitted per ton nautical mile (1 nm = 1.852 km) will then (as a minimum) have to be reduced from 20 – 25g to 4 g of CO_2 per ton nautical mile by 2050.
- This is a reduction by a factor of 5 and a seemingly substantial challenge. The question is thus how to make it come about.

Measures to achieve the 450 ppm required reductions

- Technical design indexes as discussed by IMO
- A fuel levy or an emission trading scheme called MBM or MBI which will make using fuel more expensive since this cost will come on top of today's bunker price
- Reducing Speed
- Economy of scale
- Change the focus from reducing maritime transport emissions (sub-optimization) to reducing total transport emissions.
- New technologies

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Reductions in greenhouse gas emissions and cost by shipping at lower speeds

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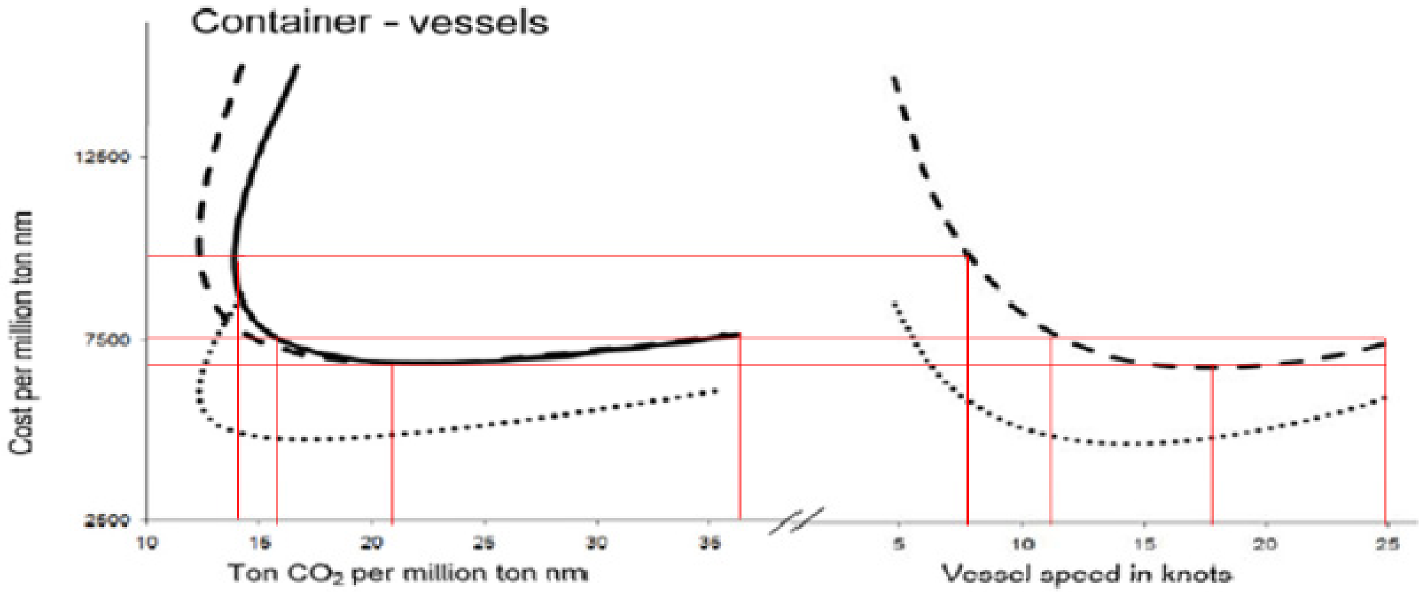
The paper presents investigations on the effects of speed reductions on the direct emissions and costs of maritime transport. The focus has been directed to identifying emissions and cost for the global fleet as a function of speed under various priorities

The model approach

- The modeling approach used involved the assumption that the total transport volumes are constant.
- While fuel and emission calculations in previous studies is based on the so-called cubic law of the vessel speed based on calm water conditions the model used includes the added resistance created by wave and wind (sea state).
- In this study the CO_2 emissions from building additional vessels has been included (actually the emission from building all vessels)
- In this study, both the cost of the shipping lines and for the cargo owners, including the capital cost of the goods, has been calculated.

Container Post Panamax



Vessel speed	Cost per million ton nm	Ton CO_2 per million ton nm	Reduction in %
25 knots	7600	37	
18 knots	6900	22	40 %
12 knots	7600	16	56 %
8 knots	9500	14	62%

Annual emissions as a function of varying priorities.

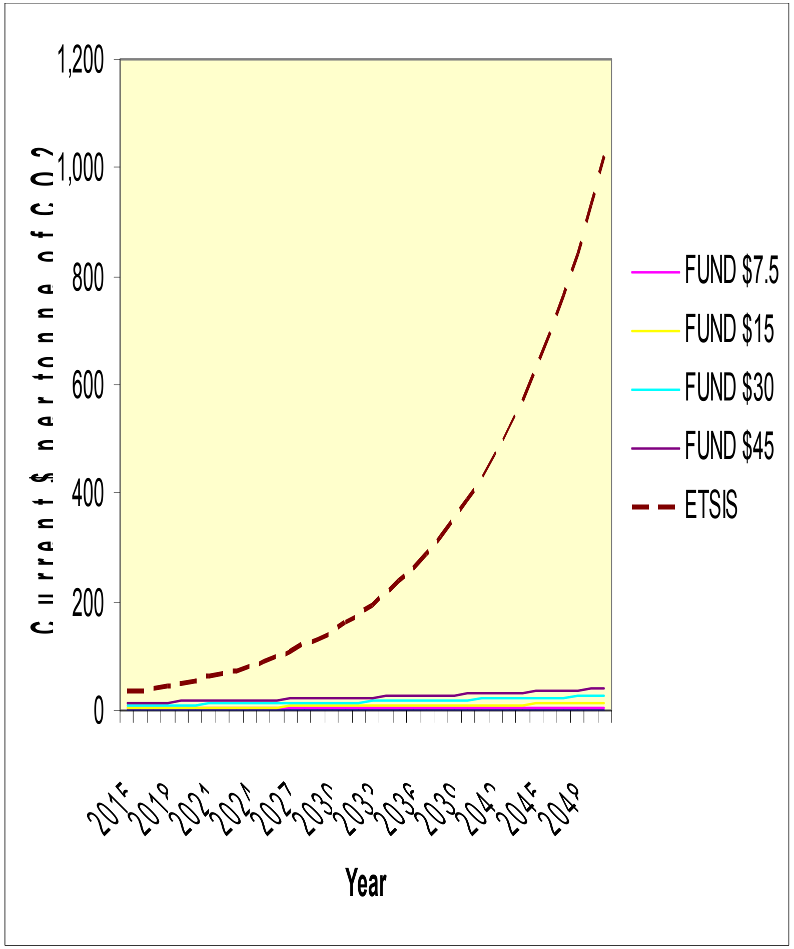
Vessel type and CO_2 emission in million tons	Design speed	Mini-mizing cost	Abatement cost = 0 USD/ton	Abatement cost = 20 USD/ton	Abatement cost = 50 USD/ton	Mini-mizing CO_2
RoRo	39	92 %	85 %	77 %	67 %	54 %
Container	269	60 %	44 %	41 %	39 %	38 %
Bulk	289	90 %	87 %	80 %	74 %	65 %
Other cargo vessels	368	78 %	67 %	62 %	58 %	52 %
All other vessels	157	100 %	100 %	100 %	100 %	100 %
Total	1122	907	804	755	716	659
Total in % of AS IS		81 %	72 %	67 %	64 %	59 %

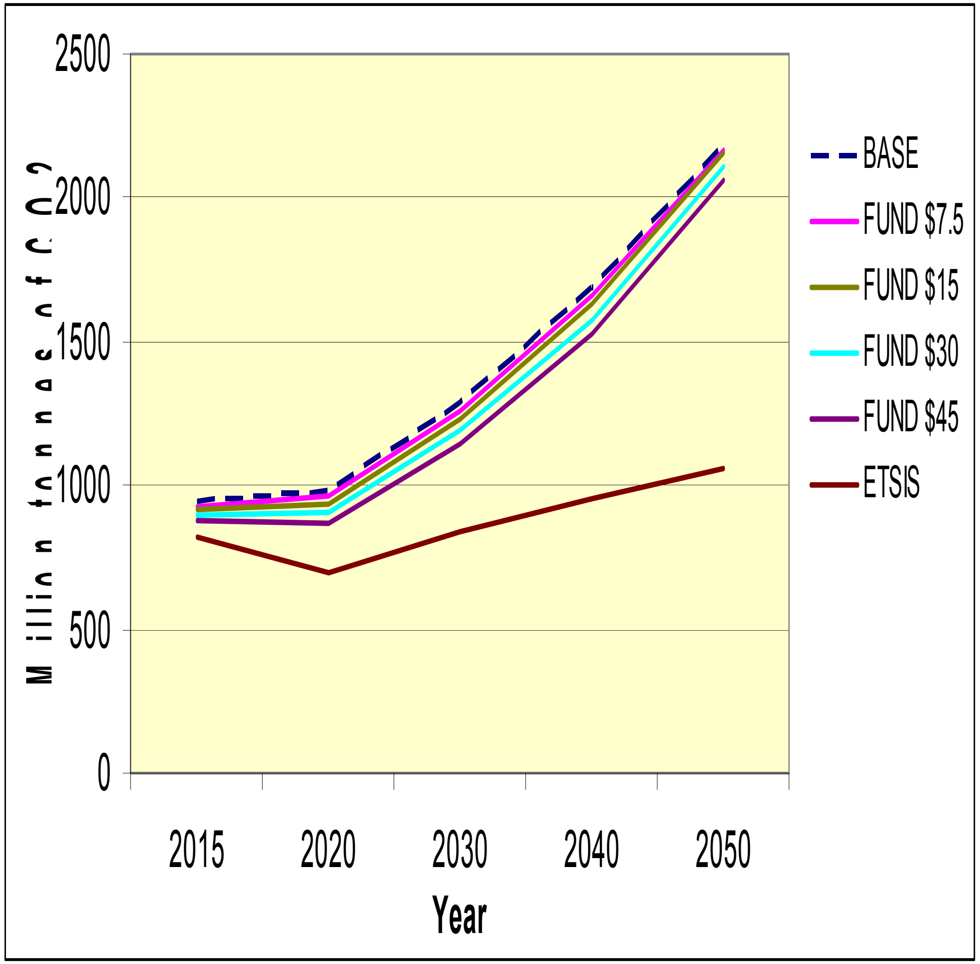
- The Market Based Instruments are based on the assumption that higher fuel prices will incite operators to reduce speeds, and studies such as that of Corbett et al (2009) have investigated how the fuel price influences speed decisions taken by the shipping lines, with the conclusion that higher fuel prices result in speed reductions.

- The data from the present investigation indicates that things may be more complex and that the impact of fuel prices on speed decisions has been overestimated. Such a statement is based on Pareto solutions - where cost and emissions are optimized - being found for speeds below current service speeds (reference level).

- From the shipping markets, it is also well known that in a good market, ship-owners will tend to operate at full speed in order to maximize income at both high and low fuel prices. Reduced speeds, on the other hand, are used to save costs and reduce available capacities in a depressed market.

Key findings in MBM study (Anger et al (2010) for MEPC 60





Recommendation

- Speed reductions enforced through speed limits
- Used worldwide for road transport, but a maritime application has not been among the main measures considered by IMO for GHG reductions.
- Speeds limits as an average speed limit measured between waypoints in ports of departure and port of arrival through existing identification and tracking systems (AIS) technology.
- Speed limits will have to be gradually lowered to enable the shipyards to add the extra capacity needed.
- No fuel levies to pay if average voyage speed is bellow the speed
- If the speed is above, the payment will be based on:
  - The Calculated Fuel consumption
  - A fuel levy per ton as a function of the speed above the speed limit and the size of the vessel

Calculating Economy of scale effects

Key figures 2007

Vessel type	Billion ton miles	No of ships 2007	Average dwt 2007 fleet	Average dwt for largest vessels	No. of ships if only largest vessels	Average gram CO_2 2007 fleet per ton nm	Average gram CO_2 if only largest vessels per ton nm	Million ton of CO_2 2007 fleet	Million ton of CO_2 if only largest vessels
General Cargo	2 382	17 280	4 641	25 341	3 165	42,2	24,4	100	58
Dry Bulk	16 137	7 523	52 549	172 251	2 295	11,4	7,0	184	113
Reefer	258	1 226	5 397	16 075	412	84,8	65,3	22	17
Container	7 501	4 398	34 186	105 995	1 418	34,8	28,2	261	212
Crude oil	10 061	2 053	142 914	295 237	994	9,7	7,0	98	70
Oil products	1 257	4 906	10 154	112 054	445	25,0	13,3	31	17
Chemicals	1 919	3 868	15 771	47 614	1 281	25,4	17,8	49	34
RoRo	485	2 410	7 189	44 603	388	75,8	25,7	37	12
LNG	852	265	70 063	76 346	243	33,9	33,3	29	28
LPG	401	1 103	11 551	53 262	239	34,8	22,5	14	9
Sea River	16	1 169	1 136	7 446	178	99,1	36,5	2	1
Total	41 269	46 201	23 520	81 271	11 059	20,0	13,8	826	571

Reduction Potential up to 2050	Reduction Potential	
Economy of Scale	0 - 30 %	Average 20 g CO_2 per ton nm, if only largest vessels 14 g CO_2 per ton nm (Lindstad et al 2011)
Fleet Mix	0 + 20 %	Increased Containerization (Lindstad et al 2011)
Speed Reductions	0 - 40 %	Energy Policy Paper by Lindstad et al (2011)
Scheduling and Voyage optimization	0 - 10 %	IMO 2009 GHG study
Combined carriers	0 - 10 %	Reinvent OBO and general cargo concepts enabling higher payload -dwt ratios and better roundtrip utilizations
Technical improvements	0 - 40 %	IMO 2009 GHG study
Energy Management	0 - 10 %	IMO 2009 GHG study

Change the focus from reducing maritime transport emissions (sub-optimization) to reducing total transport emissions.

Key Emission figures based on real figures (and not those generally refered to within the maritime society)

Airbus A380 Freighter						Boeing 747-Freighter			
Distance	4400	4400	5600	5600	8300	4400	4400	5600	5600
Max Take off	590	590	590	590	590	442	442	442	442
Fuel when landing	15	15	15	15	15	10	10	10	10
Fuel used	113	103	152	137	225	108	97	127	120
Operating Empety	250	250	250	250	250	192	192	192	192
Cargo	150	105	150	105	100	132	92,4	113	92,4
Actual take off weight	528	473	567	507	590	442	442	442	415
Utilization percentage	100	70	100	70	100	100	70	100	70
Gram CO2 per nm	544	704	573	737	859	540	691	582	738
Gram CO2 per km	300	388	316	406	473	297	381	321	406

Key Emision Figures vessels

	Emissions in gram CO2 per ton km					
Vessel type and speed	10	16	18	23	25	30
4000 TEU	8		12	17	19	25
8500 TEU	6		10	14	16	21
18000 TEU	5		8	12		
45 000 dwt Open Hatch	5	7				

Total emission calculations

Asia - Europe	Speed in knots	Distance in km	Gram CO2 per km	Gram CO2 adjusted for distance	Volume	Sub total	Total	Saving
AS IS								
Airfreight	440	8886	350	350	10%	35		
Container 8 500 TEU	25	19438	16	35	90%	32	67	
Maersk approach								
Airfreight	440	8886	350	350	10%	35		
Container 18 000 TEU	23	19438	12	26	90%	24	59	12%
Alternative approach 1								
Airfreight	440	8886	350	350	10%	35		
Container 8 500 TEU	25	19438	16	35	20%	7		
Container 18 000 TEU	10	19438	6	13	70%	9	51	23%
Alternative approach 2								
Airfreight	440	8886	350	350	8%	28		
Container 4 000 TEU	30	19438	25	55	22%	12		
Container 18 000 TEU	10	19438	5	11	70%	8	48	28%