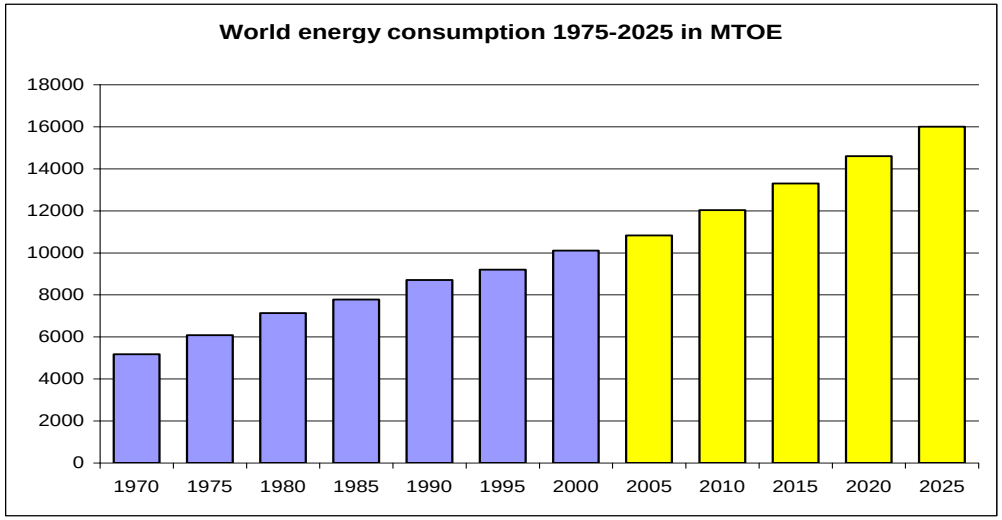
Shipping and Environmental Challenges

Development of World Energy Consumption



Energy consumption in million ton oil equivalent units (Mtoe)	The World			The European Union		
	1990	2004	Change in %	1990	2004	Change in %
Electricity generation & heat plants	2.090	3.056	52	374	429	15
Industry	2.134	2.510	18	371	378	2
Transport	1.549	2.134	38	279	361	29
Residential/ Agricultural/ Losses	2.959	3.382	24	522	588	13
Total final consumption, energy demand	8.732	11.204	28	1.546	1.756	14

Second IMO GHG (Greenhouse gas) Study 2009

PHASE 1

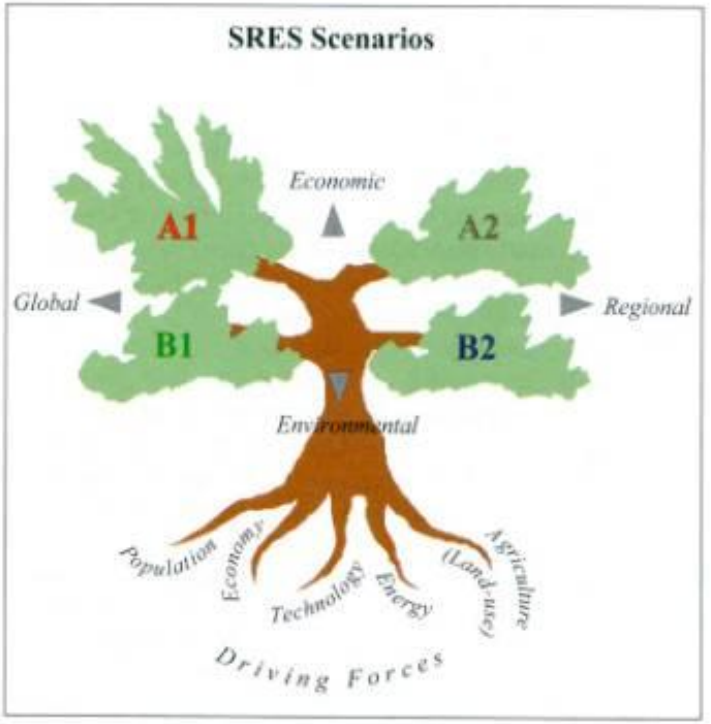
- Present day CO_2 emissions inventory
- Estimates of future CO_2 emissions
- Impacts of CO_2 emissions from International shipping on climate
- Comparison with other transport modes

PHASE 2

- Include also other GHGs (CH_4, N_2O, HFCs, PFCs, SF_6)
- Include also other relevant substances (NOx, NMVOC, CO, PM, SOx)
- Technology options for emissions reductions
- Policy options for emissions reductions
- Cost benefit/ public health considerations

Scenario Approach

- Based on IPCC SRES storylines
- Changes in economic, technology, and non-GHG regulatory mandates will affect emissions
- Assume no *explicit* regulatory policies to mitigate CO2



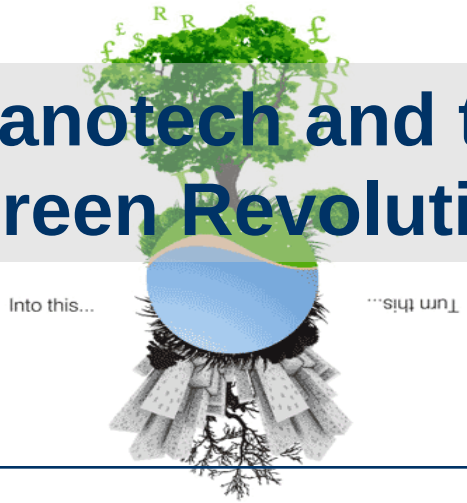
All IPCC scenarios belongs in the upper left square

Economic growth

Increased Sustainability

The Party Goes on

Nanotech and the Green Revolution



Mad Max

Back to Nature

Current and future emissions from shipping

Fleet size

- Based on data from Lloyds Register fairplay, ships >100 GT (100 777 ships for mid 2007)

Average activity (Days at sea)

- AIS and other sources (e.g. engine running hours, operators data etc)
- Fleet activity / lay-up

Average power when active

- Fully laden / party laden / ballast only / slow steaming
- Sea margin – full rpm 85-90% MCR in calm sea

Specific fuel oil consumption

- Function of engine power and age

Fuel Carbon content

- Calculated C:HC mass ratio from IMO expert group (BLG 12/6/INF.10)

Aux consumption: Similar procedure to above. Less accurate data
Boiler consumption: Based on IMO expert group assessment

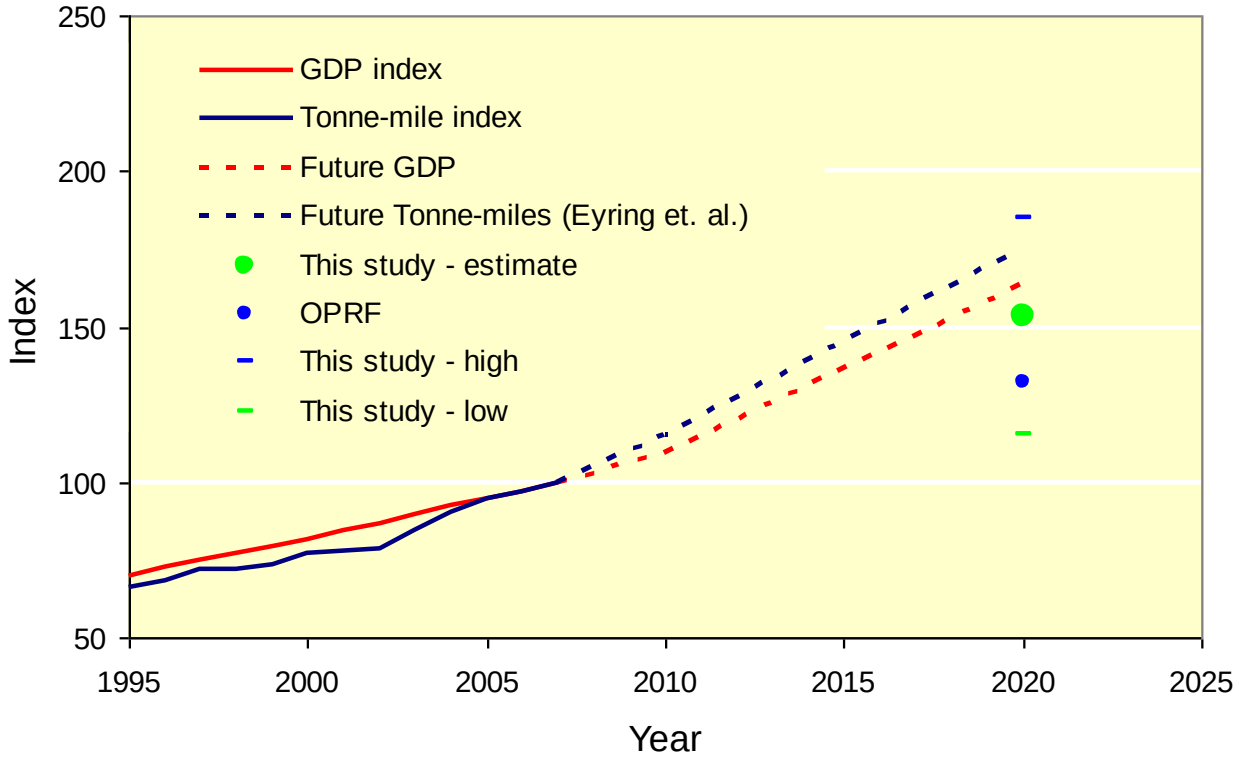
Key Driving Variables

Category	Variable	Related Elements
Economy	**Shipping transport demand** (tonne-miles/year)	Population, global and regional economic growth, modal shifts, sectoral demand shifts.
Transport efficiency	**Transport efficiency** (MJ/tonne-mile) – depends on fleet *composition*, ship *technology* and *operation*	Ship design, propulsion advancements, vessel speed, regulation aimed at achieving other objectives but that have a GHG emissions consequence.
Energy	**Shipping fuel carbon fraction** (gC/MJ fuel energy)	Cost and availability of fuels (e.g., use of residual fuel, distillates, LNG, biofuels, or other fuels).

Different values applied to three categories of ships:

- Coastwise shipping - Ships used in regional (short sea) shipping;
- Ocean-going shipping - Larger ships suitable for intercontinental trade; and,
- Container ships (all sizes).

Economic Growth Estimates



Scenario Inputs Summarized as Annual Growth Rates

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

CO_2 Emissions from International Shipping

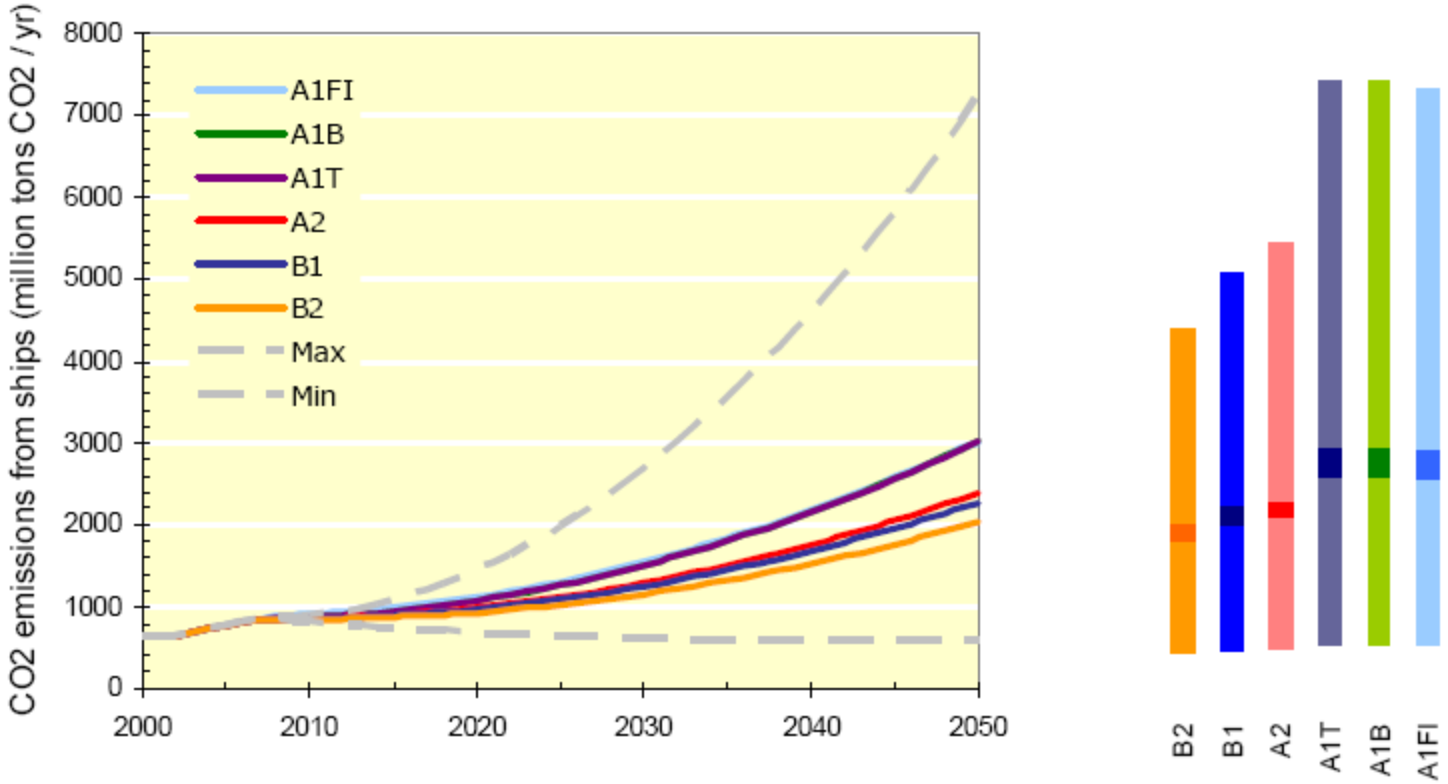
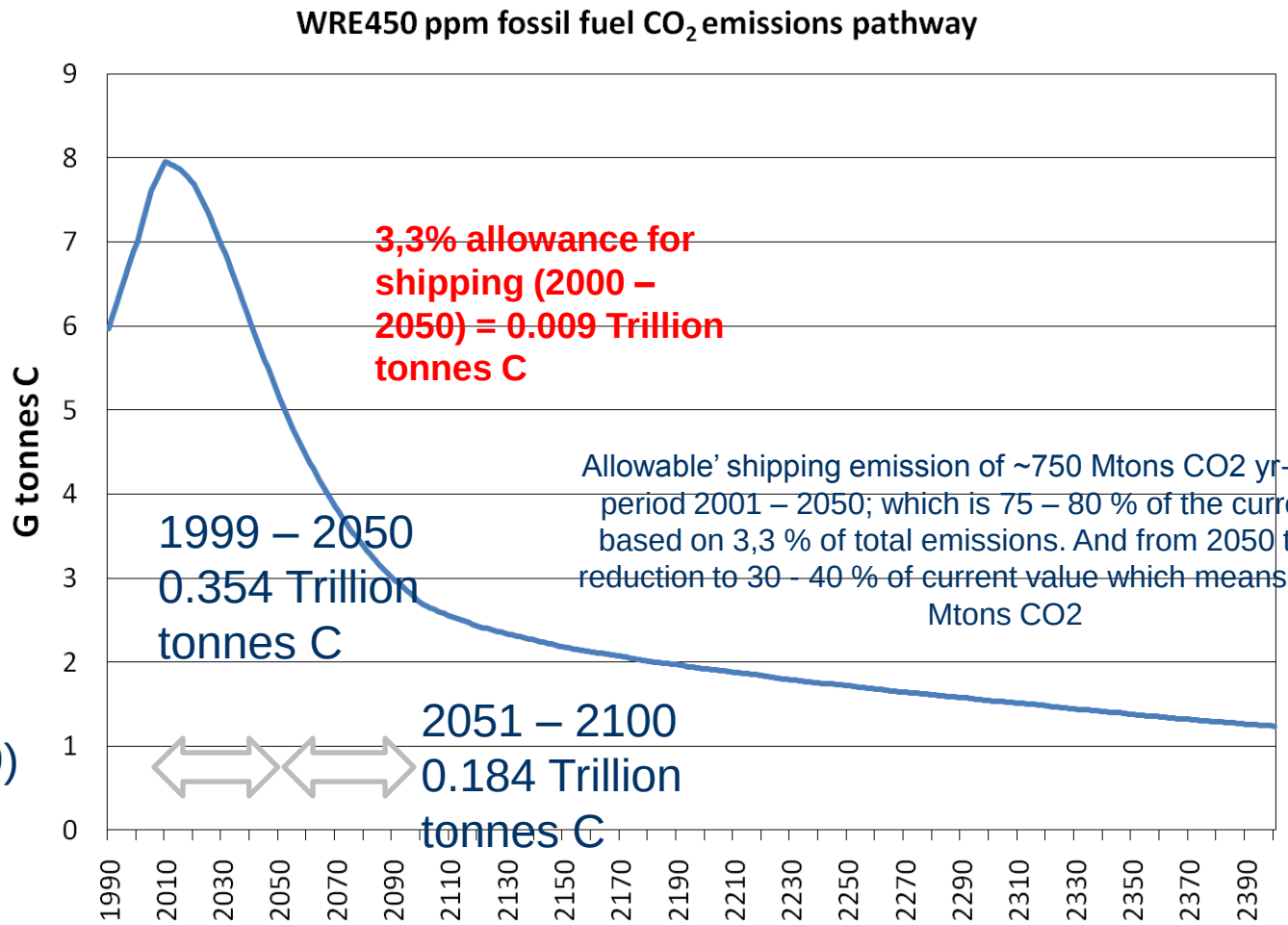


Figure7-7 – Trajectories of the emissions from international shipping. Columns on the right-hand side indicate the range of results for the scenarios within individual scenario families

Increase of fuel consumption from 2007 to 2050 if business as usual (IMO 2009 GHG study)

Vessel type	2007 Billion ton miles	2007 Fuel in million ton	Gram $C0_2$ per ton nm	2030 Billion ton miles	2030 Fuel in million ton	2050 Billion ton miles	2050 Fuel in million ton
General Cargo	2.382	31,7	42	3.699	49	5.145	68
Dry Bulk	16.137	57,9	11	25.060	90	34.856	125
Reefer	258	6,9	84	401	11	557	15
Container	7.501	82,3	35	22.051	242	55.807	612
Crude oil tankers	10.061	30,8	10	15.624	48	21.732	67
Oil product tankers	1.257	9,9	25	1.952	15	2.715	21
Chemical tankers	1.919	15,4	25	2.980	24	4.145	33
RoRo	485	11,6	75	753	18	1.048	25
RoPax	160	21,4		248	33	346	46
LNG	852	9,1	34	1.323	14	1.840	20
LPG	401	4,4	35	623	7	866	10
Ferry	10	1,8		16	3	22	4
Cruise	18	8,7		28	14	39	19
Yacht	0,4	1,3		1	2	1	3
Offshore	135	12,1		210	19	292	26
Service	86	18,0		134	28	186	39
Fishing	43	7,7		67	12	93	17
Sea River	16	0,5	98	25	1	35	1
Total	41.721	331,5	25	75.193	630	129.724	1151

WRE 450 ppm stabilization pathway (fossil fuel CO_2 emissions)

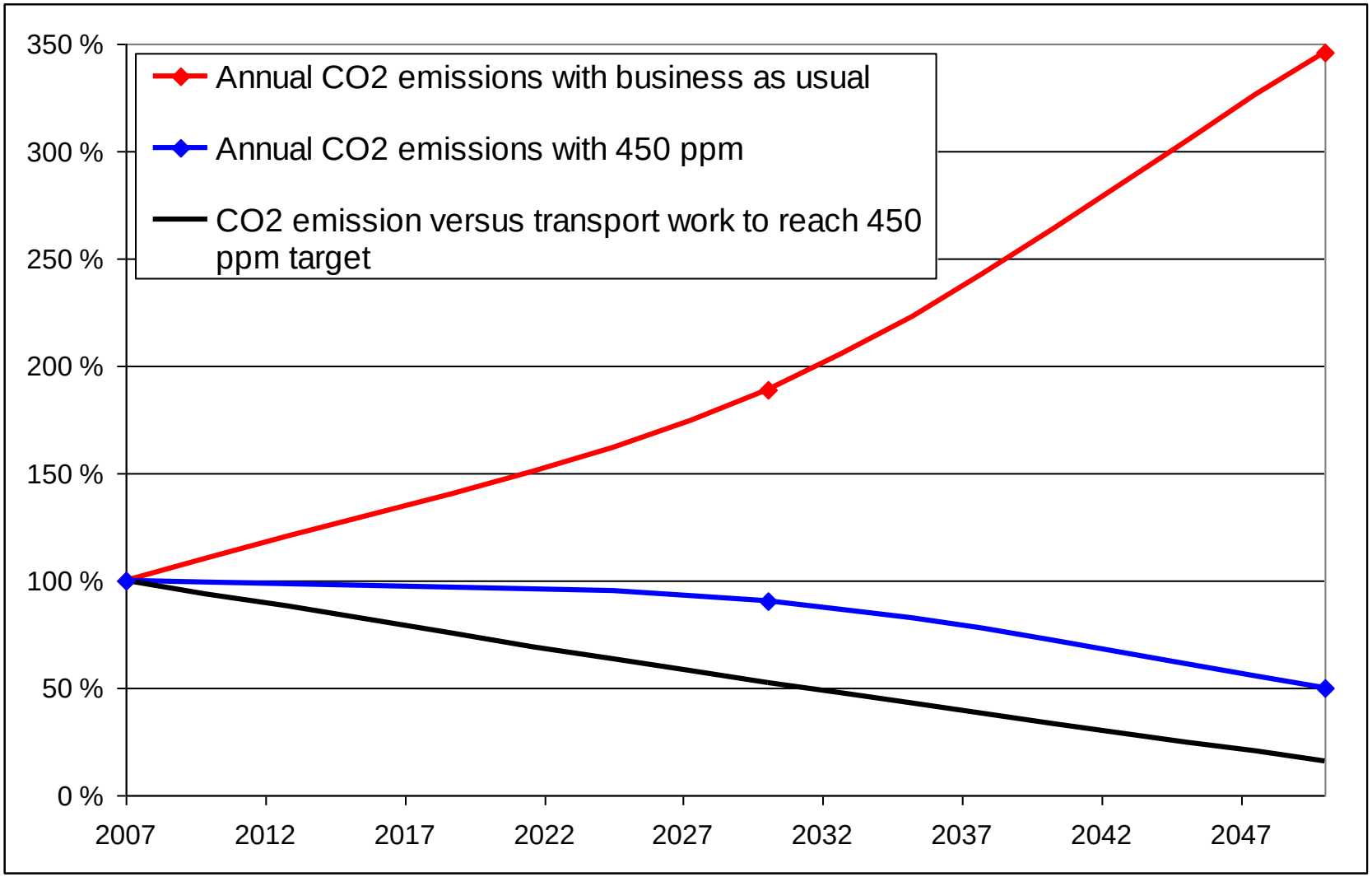


Historical emissions = 0.555 Trillion tonnes C (1751 – 1999)

IEA 2030 Bau and 450 ppm

	1990	2007	2030	
			Reference scenario	450 ppm scenario
Total Energy Demand	8 761	12 013	16 790	14 390
of which are renewables	1 124	1 515	2 376	3 159
Energy Releated CO2 emissions	20 941	28 826	40 226	26 400
Energy Sources				
Coal, Gas & Oil (fossile fuel)	7 111	9 789	13 457	9 805
Nuclear	526	709	956	1 426
Hydro	184	265	402	487
Biomasss and waste	904	1 176	1 604	1 952
Other Renewables	36	74	370	720
Energy Usage				
Power Generation (fossile fuel)	2 468	3 739	5 384	2 775
Industry	1 800	2 266	3 302	2 816
Transport	1 578	2 297	3 331	2 806
Other Sectors	2 440	2 941	3 830	5 051
Non Energy Use	475	770	942	942

Emissions from shipping up to 2050 with Business as usual and with 450 ppm target

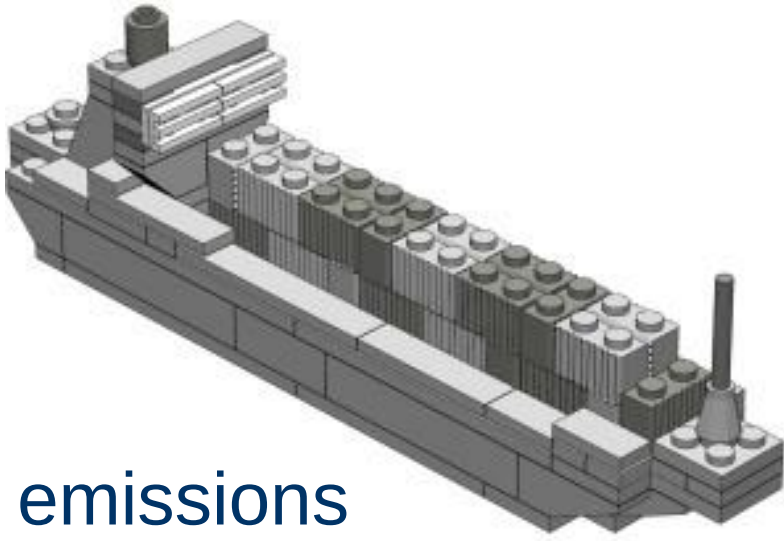


Potential reductions of CO2 emissions from shipping by using known technology and practices

DESIGN (New ships)	Saving of CO_2/tonne-mile	Combined	Combined
Concept, speed & capability	2% to 50%	10% to 50%	25% to 75%
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%		
OPERATION (All ships)			
Fleet management, logistics & incentives	5% to 50%	10% to 50%	
Voyage optimization	1% to 10%		
Energy management	1% to 10%		

Technical & Operational options for reduction of GHG emissions from ships

Improving energy efficiency – Engine technology and fuels to achieve CO_2 emission reduction



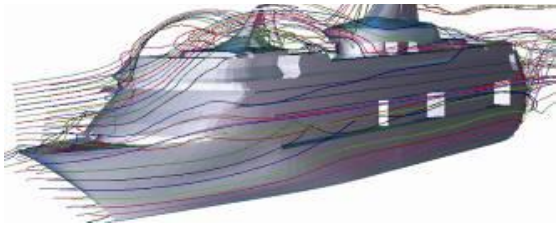
- Improving energy efficiency
- Renewable energy sources
- Fuels with less total fuel-cycle emissions

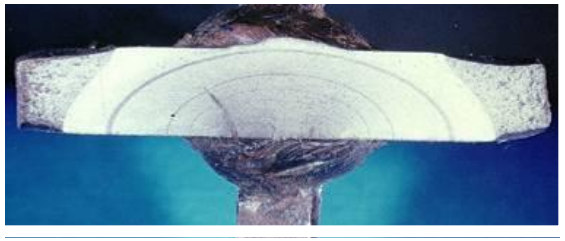
- Not considered feasible for ships: reduction of emissions through chemical conversion, capture and storage etc.

Improving energy efficiency - Design

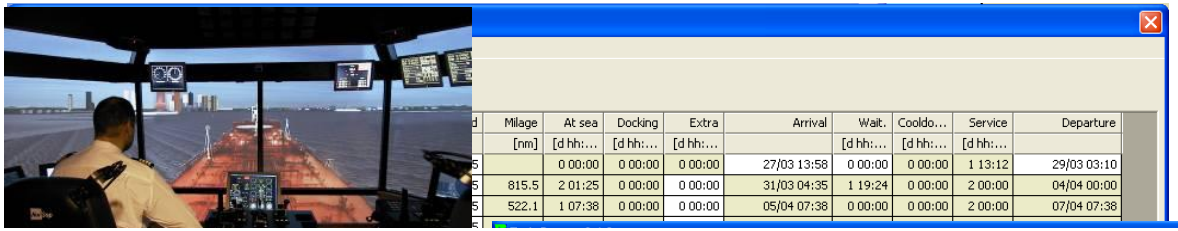



- Concept, speed & capability
- Hull and superstructure
- Power and propulsion systems





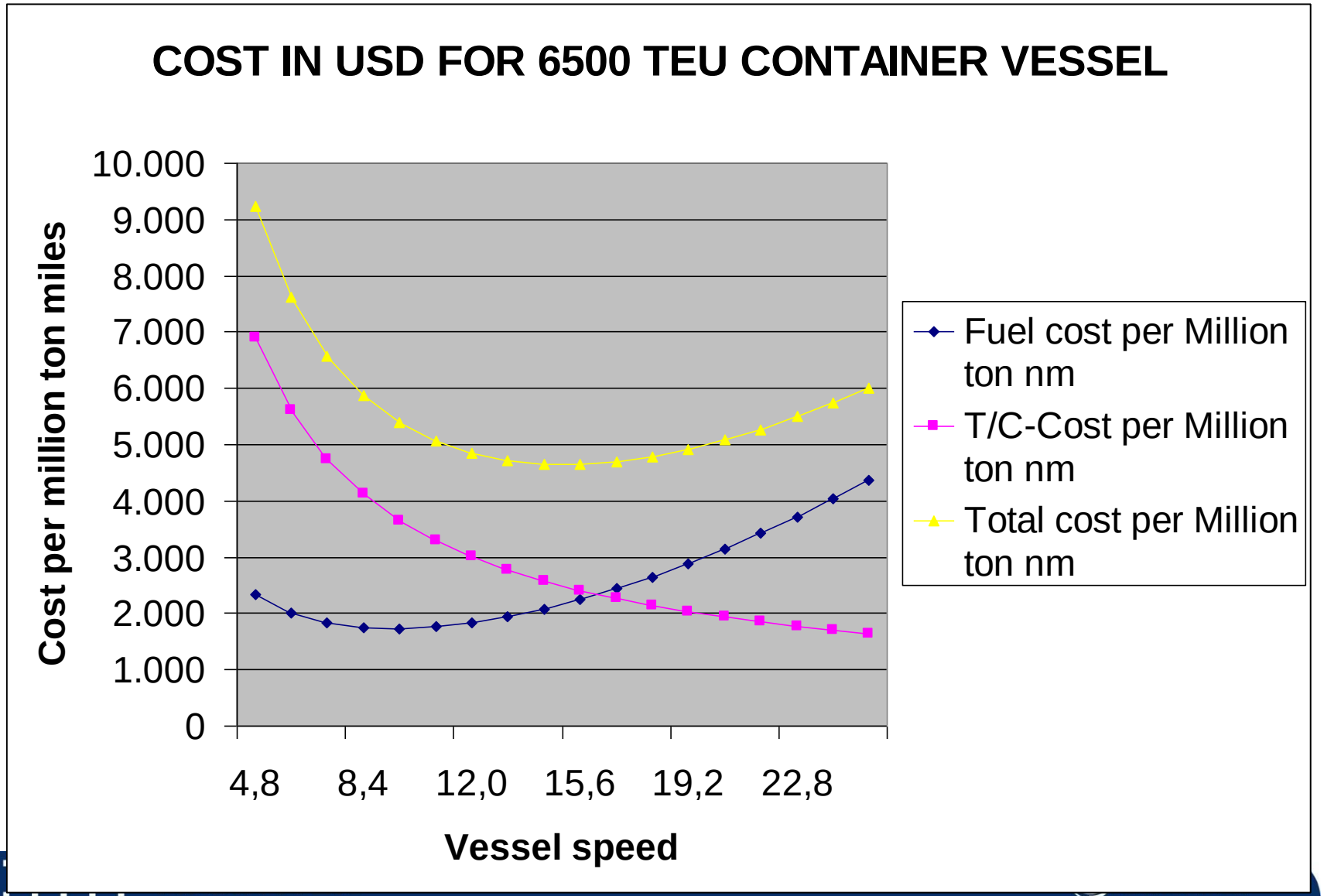
Improving energy efficiency - Operations



	Milage	At sea	Docking	Extra	Arrival	Wait.	Cooldo...	Service	Departure
	[nm]	[d hh:...	[d hh:...	[d hh:...		[d hh:...	[d hh:...	[d hh:...	
5		0 00:00	0 00:00	0 00:00	27/03 13:58	0 00:00	0 00:00	1 13:12	29/03 03:10
5	815.5	2 01:25	0 00:00	0 00:00	31/03 04:35	1 19:24	0 00:00	2 00:00	04/04 00:00
5	522.1	1 07:38	0 00:00	0 00:00	05/04 07:38	0 00:00	0 00:00	2 00:00	07/04 07:38

- Fleet management, logistics & incentives
- Voyage optimization
- Energy management

Vessel type with biggest reduction potential both per vessel and in total



Optimizining 80 000 dwt container vessel, both with focus on cost and environmemt

Engine size	60.227
Average power auxilliary engine	2.500
Service speed	25,3
Gram Fuel per kwh	190
Dwt	80.084
Load each way	40.042
MCR at service speed	90 %
MCR in port and slow zones	10 %
Cargo transported per year	4.100.000
One Way distance	12.500
Days in port & slow zones per Roundtrip	13,5
Fuel Cost	400
Cargo value per ton	5.000
Interest rate	5,0 %
Emission price CO_2 per ton	0
T/C - per day	30.000
Wind&wave&engine adjust factor low speed	0,050

		Lowest Emissions	Optimized cost & Emissions	Lowest cost		Designed service speed
One way journey in weeks	17	9	7	5	4,5	4
Speed	4,8	9,6	13,2	18,0	21,6	25,3
Power equal speed in power of three	110,592	884,736	2299,968	5832,000	10077,696	16194,277
Extra Resistance factor waves & wind	13,01	2,17	1,38	1,10	1,03	1,00
Hull factor power	3,35	3,35	3,35	3,35	3,35	3,35
Basic required power	4.814	6.438	10.608	21.546	34.886	54.204
Required Power & Auxillary	7.314	8.938	13.108	24.046	37.386	56.704
Roundtrips per year	1,5	2,9	3,8	4,9	5,7	6,4
Days at sea per Roundtrip	217	109	79	58	48	41
Days in port & slow zones per R.trip	14	14	14	14	14	14
Days at sea at service speed	330	311	299	284	273	264
Days in port & slow zones	21	39	51	66	77	87
Days per year	350	350	350	350	350	350
Annual fuel per vessel	11.566	13.758	19.284	32.913	48.722	70.512
Annual cargo tonnage transported per vessel	121.728	229.841	303.518	392.412	454.076	512.538
Number of Vessels needed	33,7	17,8	13,5	10,4	9,0	8,0
Annual Fuel Consumption	389.566	245.424	260.497	343.880	439.929	564.051
Power per hour in % of MCR	8,0 %	10,7 %	17,6 %	35,8 %	57,9 %	90,0 %
CO2 Emissions in ton per Million ton nm	23,9	15,1	16,0	21,1	27,0	34,7
Fuel cost per Million ton nm	3.041	1.916	2.033	2.684	3.434	4.402
T/C-Cost per Million ton nm	6.901	3.655	2.768	2.141	1.850	1.639
Capital cost per Million ton nm	6.316	3.343	2.533	1.956	1.692	1.499
Total cost included capital per ton nm	16.257	8.914	7.333	6.781	6.975	7.540

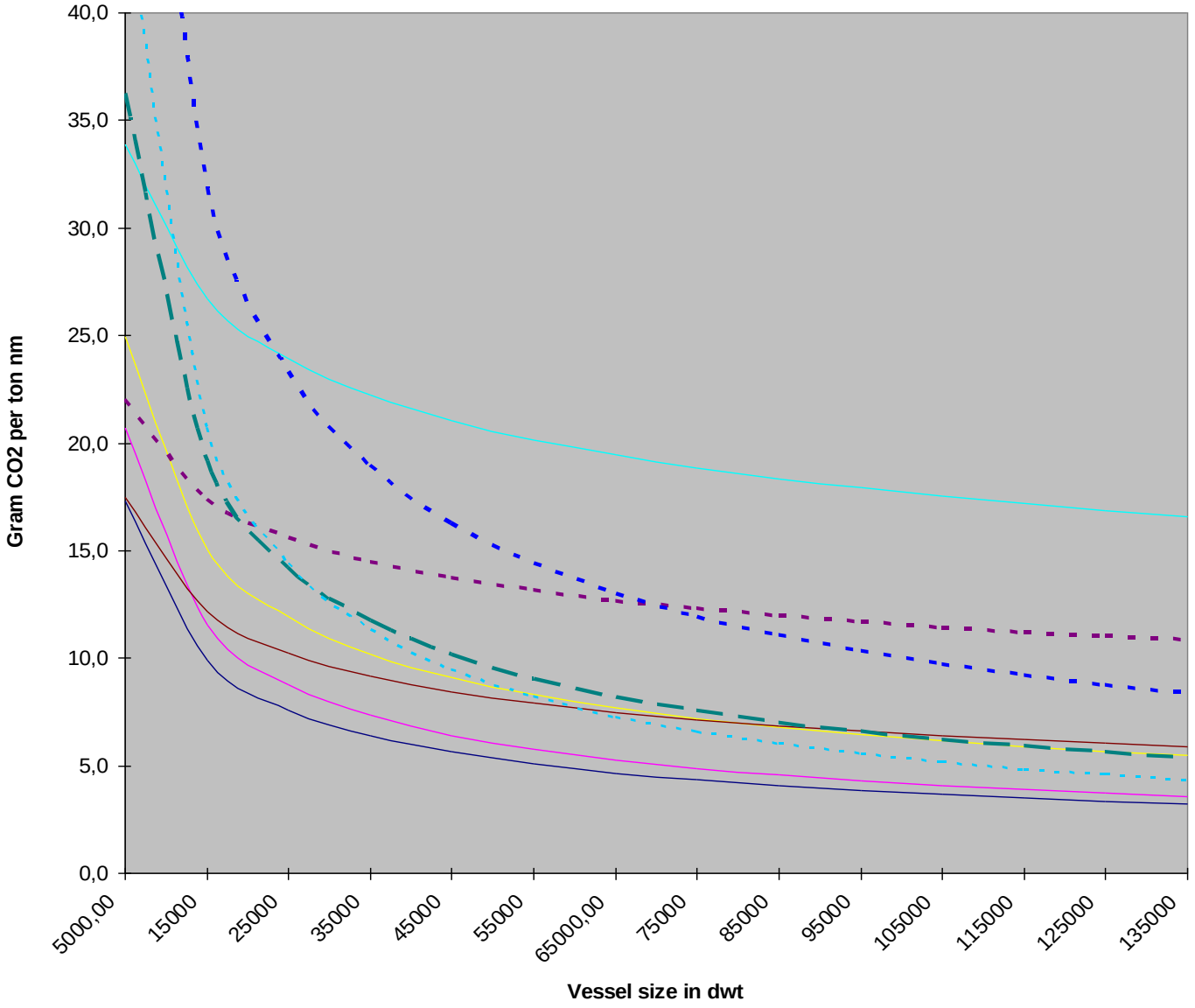
Overview of policy proposals currently debated by IMO

- A mandatory design index called EEDI which gives specifies the maximum allowed emissions for all new vessels to be built
- An operational indicator called EEOI to measure the real operational performance of all cargo transporting vessels
- A ship energy efficiency management plan called SEEMP which shall be used as a common working tool to make ships more energy efficient.
- A fuel levy or an emission trading scheme which both will make using fuel more expensive since this cost will come on top of today's bunker price.

Energy Efficiency Design Index - EEDI as currently debated by IMO

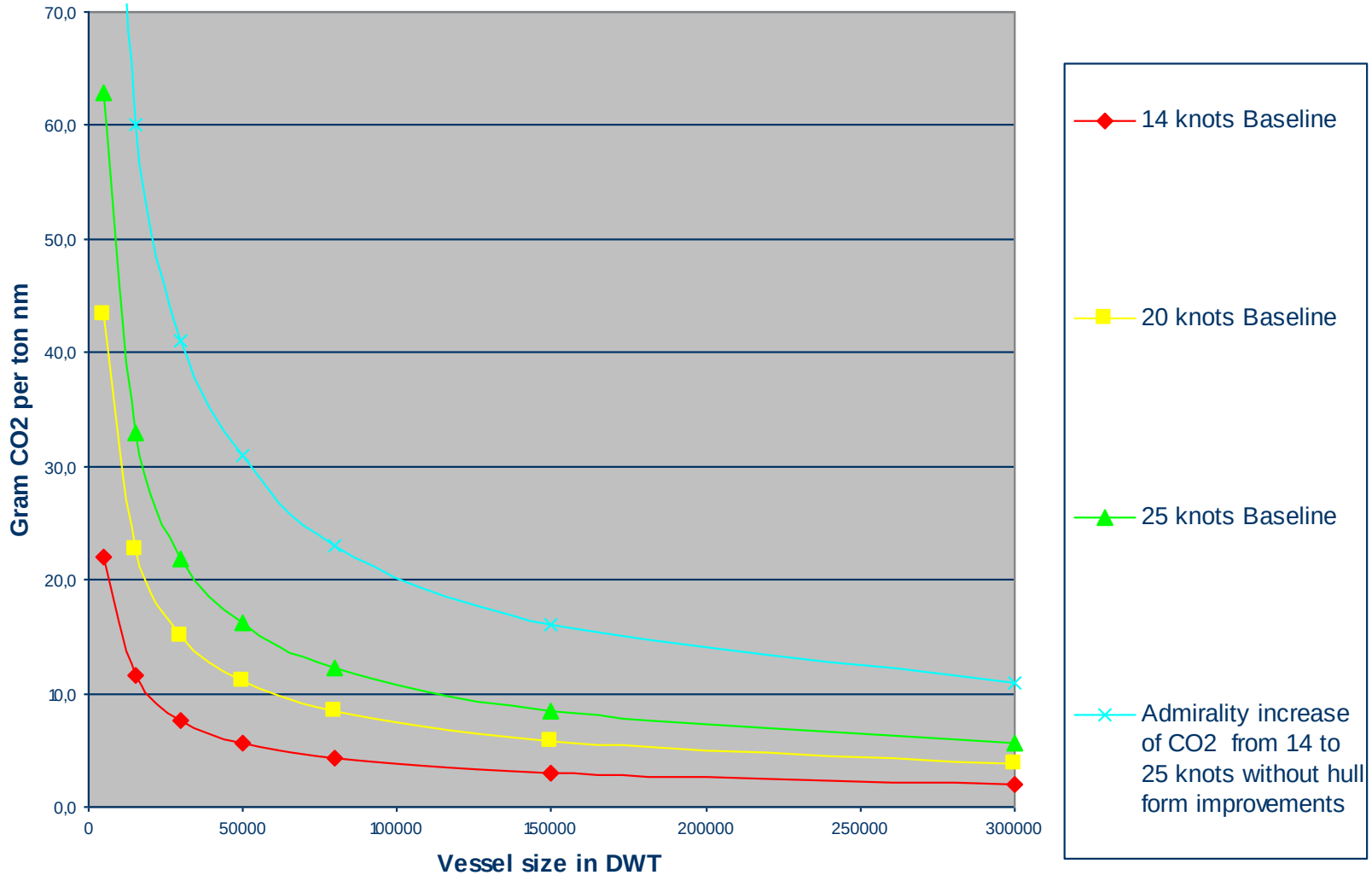
- Vessels are grouped into vessel types, and for each type the baselines are calculated based on the average of the existing vessels built during the last 10 years.
- Speed is not included in the formula, but since the regression curves are calculated based upon the existing vessel speed for each of the types, the suggested scheme will enable, vessels types which sail fast today, to do the same in the future.
- It's assumed that the thresholds for new vessels to be built will be 100 – 110 % of the baseline for the first 3 to 5 years and within ten years 60 – 80 % of today's baselines
- Grouping all cargo vessels into six groups which are Dry Bulk, Tankers, Gas Carriers, Containers, General Cargo Ships, Ro-Ro cargo ships. The Ro-Ro group might be further divided into three sub groups as proposed on MEPC 59 (volume, weight and car carriers).
- If a vessel can falls between two of these categories the guidelines says that it belongs in the group which gives the strictest requirements (lowest allowable emissions)

Proposed IMO EEDI plotted per vessel type

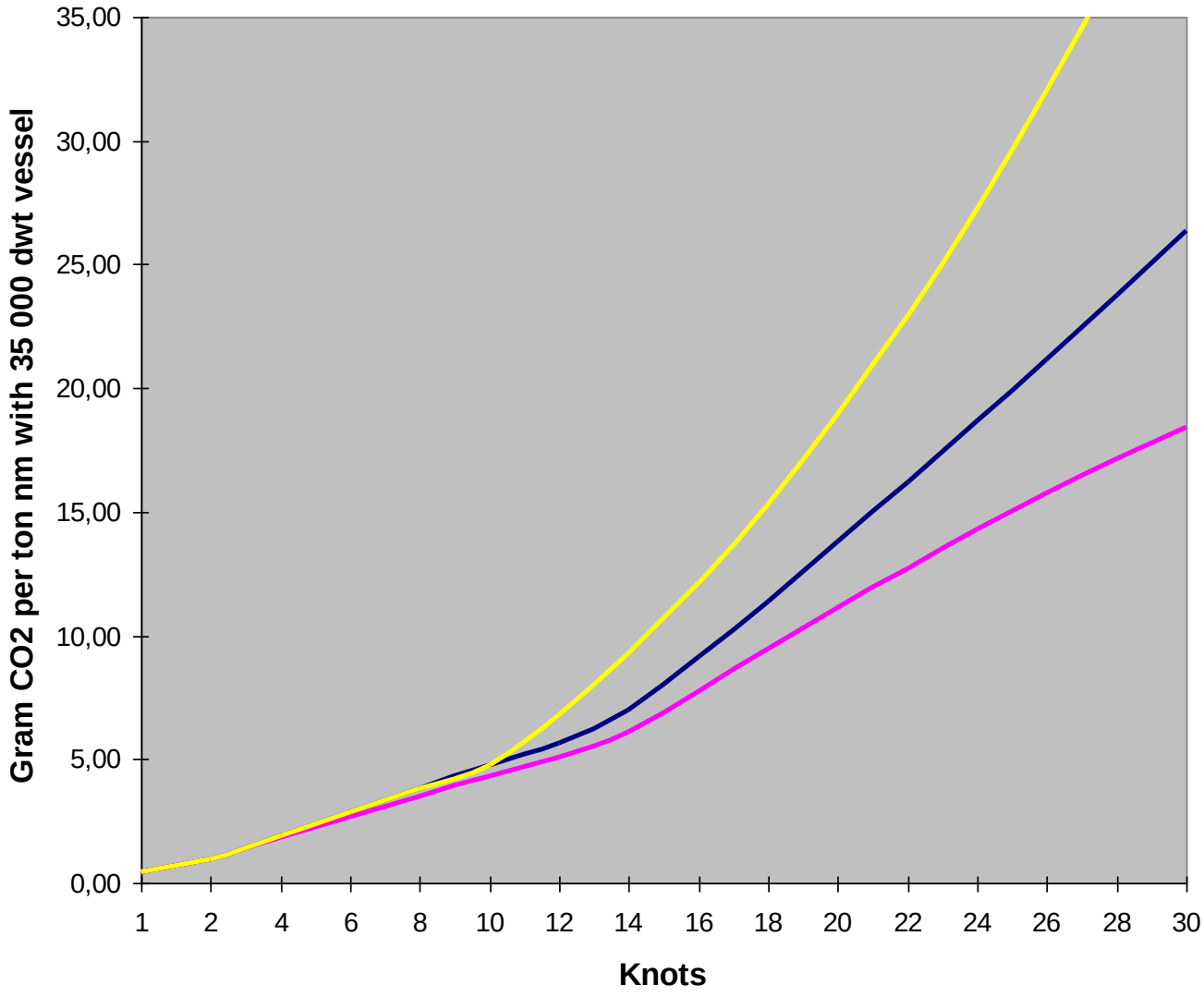


- Dry bulk carriers
- Tankers
- Gas carriers
- Container ships 65 % dwt basis
- Container baseline based on 100% dwt utilzation
- General cargo ships
- Ro-Ro car carriers
- Ro-Ro volume carriers
- Ro-Ro weight carriers

EEDI baselines as a function of speed and vessel size



Emission as a Function of vessel speed

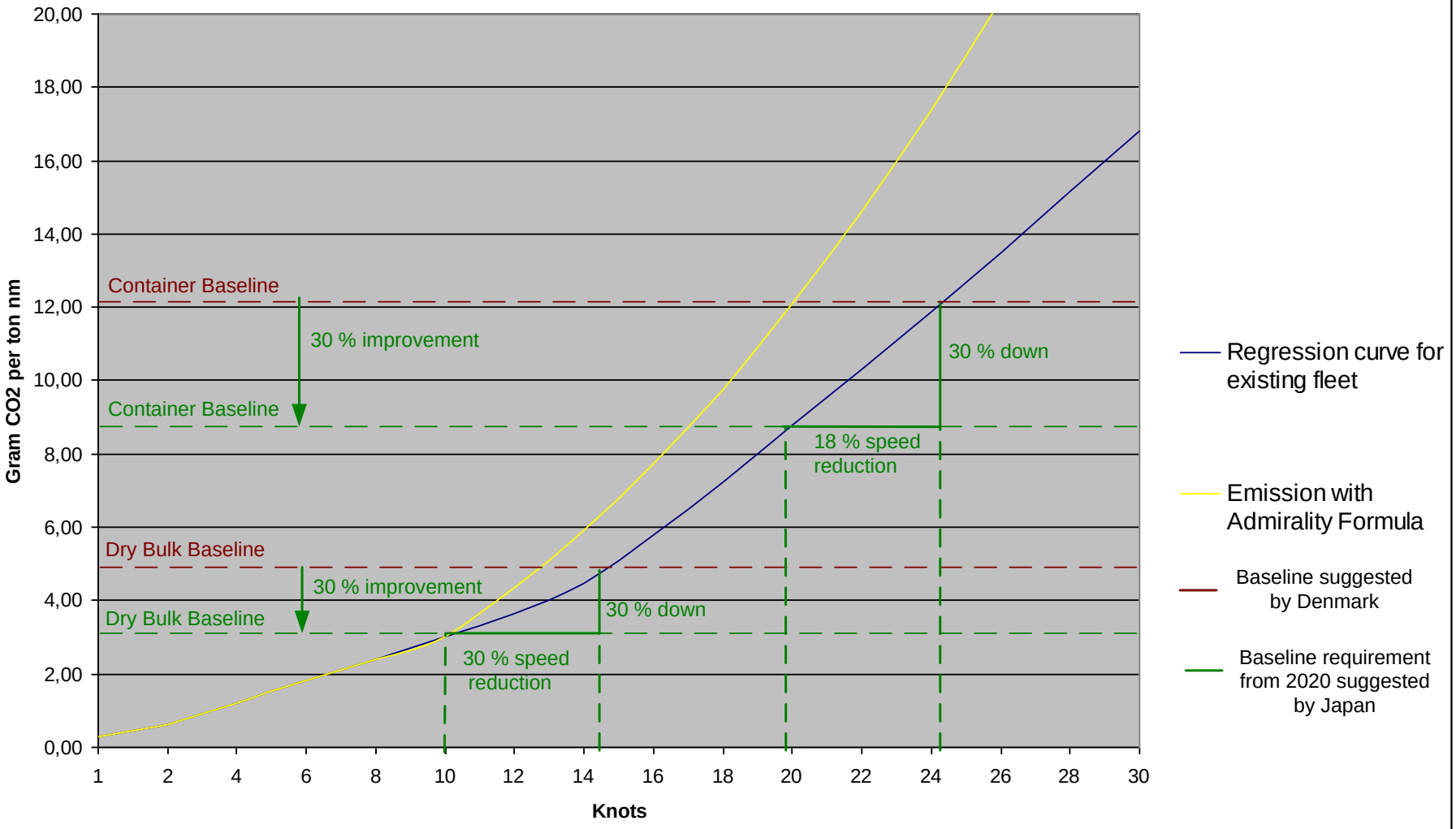


Regression curve for existing world cargo fleet

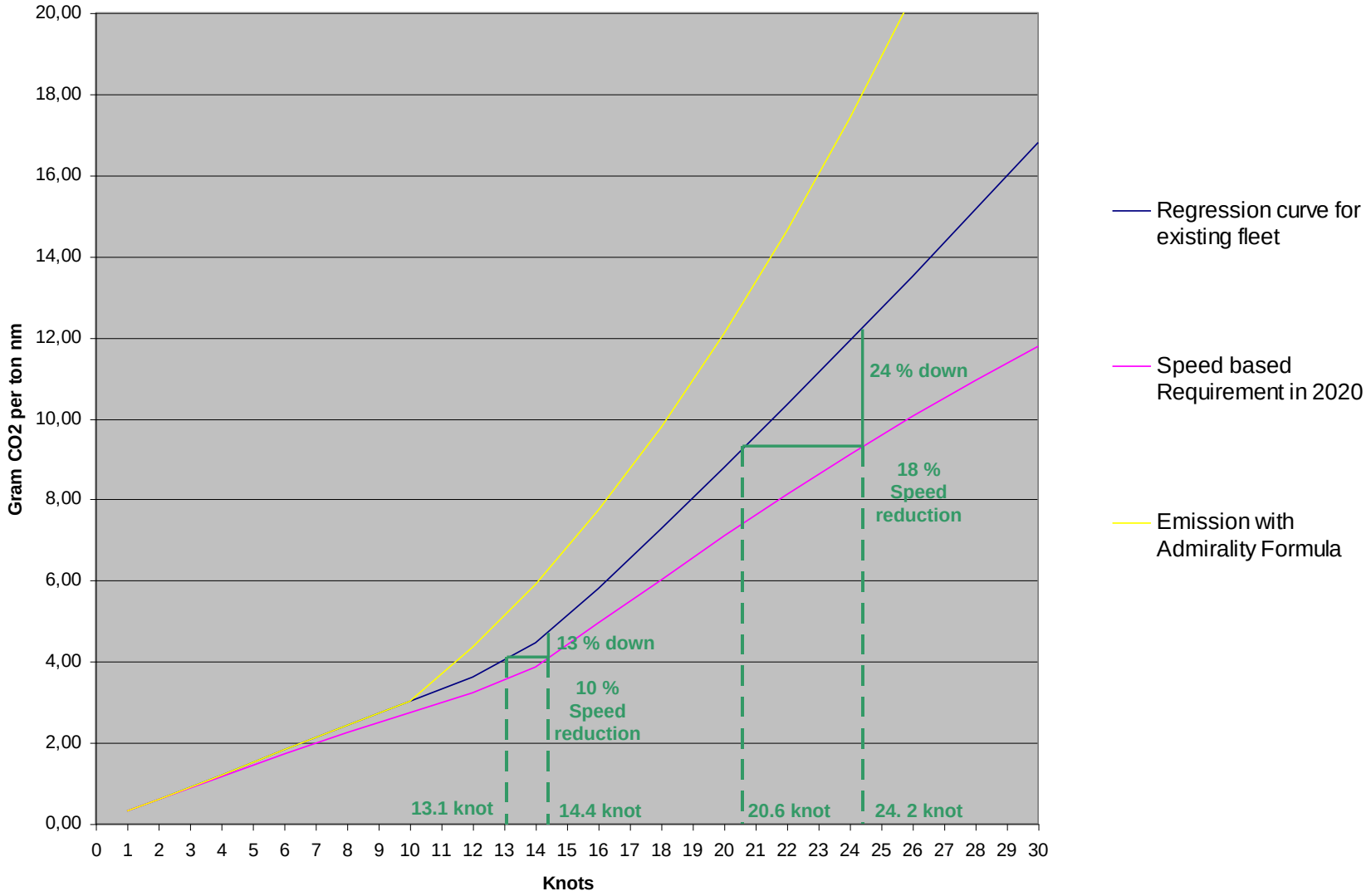
IMO requirement from 2020 ?

Emission with Admerality Formula

Emission as a function of Speed 75 000 dwt and consequence of 30% flat improvement requirement



Emission as a function of Speed 75 000 dwt and consequence of 30% flat improvement requirement



EEOI used as an integrated measure with EEDI and SEEMP