Fast waterborne transport in the emissions reduction era: in search of win-win policies

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Outline

- Introduction
- Recent developments
- In search of win-win policies
- Conclusions

Basic premise of fast waterborne transport

- There is value in speed
- Reach your destination sooner rather than later: desirable alternative
- True for both passengers and cargo
- Benefits: mainly economic, but also social

Result:

- unprecedented technological advances in fast sea transportation
  - hull design
  - hydrodynamic performance of vessels
  - engine and propulsion efficiency
  - structural analysis
  - etc
- integrated ‘door-to-door’ logistics services

Enter environmental dimension

- If little or no attention in the past, not so in the future
- “A ship has to be environmentally friendly as regards emissions”
- If true for all ships, even more so for fast ships
- Reason: emissions grow non-linear with speed

Do you really want to reduce emissions?

- GO SLOWER!
- Fast ships: prime targets

Dual targetting

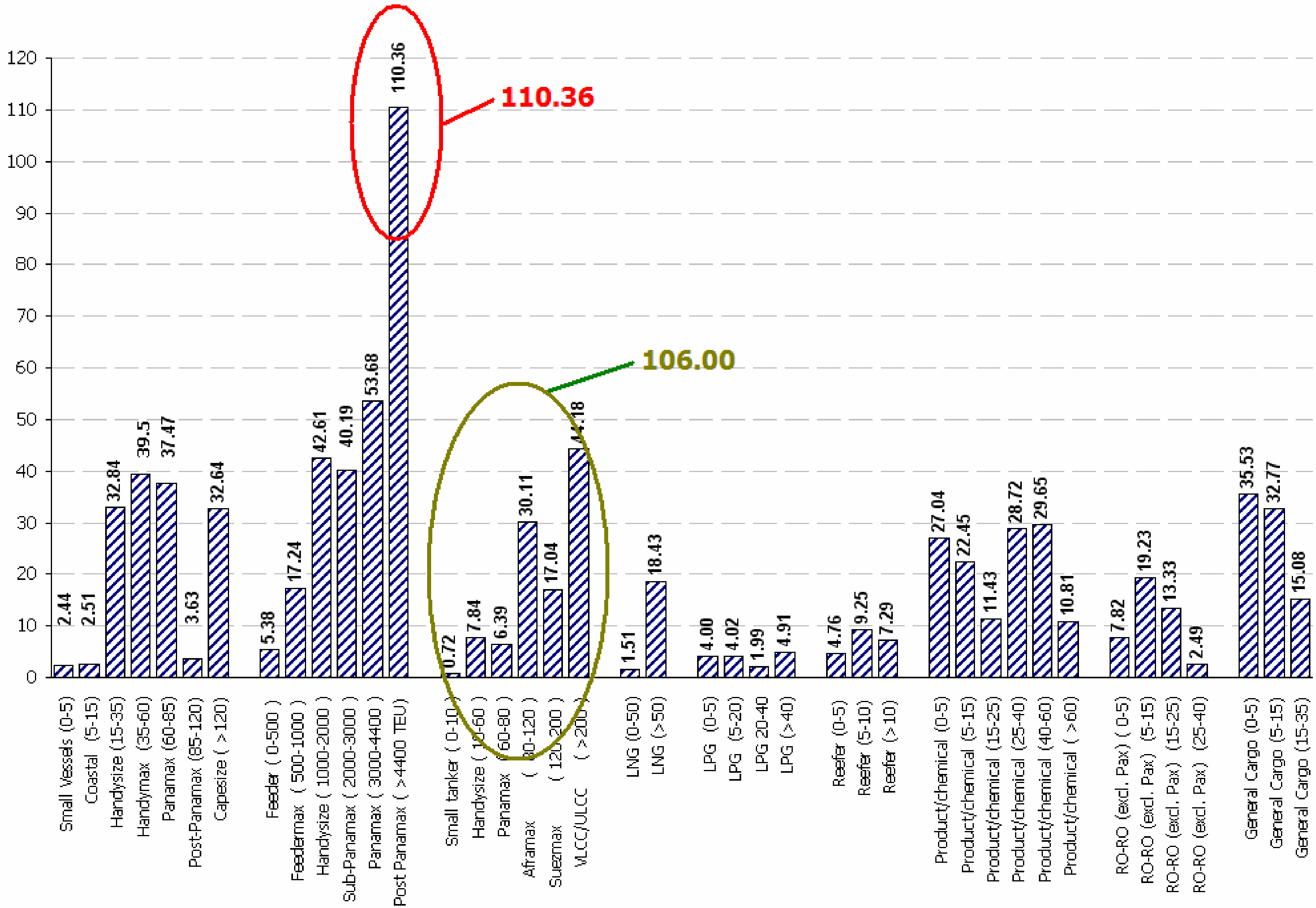
- DESIGN (STRATEGIC)
- Design new ships that are slower

- OPERATIONAL
- Operate existing ships at reduced speed

Provocative question

- Do fast ships have a future, given the drive to reduce emissions will be prevalent in the years ahead?

CO_2 emissions per vessel category (million tonnes)



GL: “An efficient ship is a green ship”

Lloyds List, 30 July 2008

- GL first suggested slowing down some three years ago – and today, the idea has been accepted by most shipping lines in the container trade, said a GL spokesman.
- “We recommend that shipowners consider installing less powerful engines in their newbuildings and to operate those container vessels at slower speeds,” he said.

How much slower?

- From 20-25 knots, go down to 15-18 (according to a 2006 study by Lloyds Register)

- Q: Is this WIN-WIN?

Recent developments

Drive for greener shipping:

- very high on IMO agenda
- very high on agendas of individual coastal countries
- Reduction of ship emissions: top priority

Types of emissions

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

Kyoto Protocol

- United Nations Framework Convention on Climate Change -UNFCCC (1997)
- Urgent measures to reduce CO_2 emissions are necessary to curb the projected growth of GHGs worldwide
- Shipping has thus far escaped being included in the Kyoto global emissions reduction target for CO_2 and other GHGs
- Some regulation exists for SO_2, NO_x

On the positive side:

- Last year (MEPC 58) the IMO has unanimously adopted amendments to the MARPOL Annex VI regulations.
- The main changes will see a progressive reduction in SO_x 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.

Also: NOx

- Each engine, which will become subject to the provisions of regulation 13.4 of the revised MARPOL Annex VI upon its entry into force, should be certified in accordance with the requirements of the NOx Technical Code 2008.

On the not-so-positive side:

- Progress as regards regulating CO_2 and other GHGs continues to be very slow.
  - The stated objective to finalize a mandatory Energy Efficiency Design Index (EEDI) of the environmental performance of new ships has not been reached yet.
  - Same is true for the Energy Efficiency Operational Indicator (EEOI), which will be applicable to all ships.

EEDI

- Defined as

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

- Faster ships will have a less favorable EEDI than slower ships of same capacity

Problem:

- The IMO will not have reached a clear position on EEDI and EEOI in time for the United Nations Framework Conference for Climate Change (UNFCCC)- Copenhagen, December 2009

Latest MEPC (July 2009):

- Clear split between industrialized member states, and a group of developing countries including China, India and Brazil, on how to proceed.
- The latter countries spoke in favor of the principle of “Common but differentiated responsibility” (CBDR) under the UNFCCC.

CBDR

- Any mandatory regime aiming to reduce GHG emissions from ships engaged in international trade should be applicable exclusively to the countries listed in Annex I to the UNFCCC
- Therefore their strong wish is not to be included in any mandatory set of measures.

Market Based Instruments (MBIs)

- Progress: even slower
- Two main schemes:
  - Emissions Trading Scheme
  - Carbon Levy
- No agreement will be reached before the Copenhagen UNFCCC conference
- Latest IMO timetable on this issue goes into 2012

Next UNFCCC

- Copenhagen, Dec. 2009
- IMO has not yet reached a decision on how to curb GHGs
- Serious disagreement still exists, mainly between developed and developing nations
- Message of EC to IMO: Act now, or we shall act instead!

Failure of IMO to act soon

- Pressure for regional approaches
- EU: ETS for shipping?
- Has started process for air transport
- Many industry circles (most notably UGS): this would be unworkable

Measures contemplated

- Technological
  - More efficient (energy-saving) engines
  - More efficient ship hulls
  - More efficient propulsion
  - “Cold ironing” in ports
  - Cleaner fuels (low sulphur content)
  - Alternative fuels (fuel cells, biofuels, etc)
  - Devices to trap exhaust emissions (scrubbers, etc)
- Market-based instruments
  - Emissions Trading Scheme (ETS)
  - Carbon Levy- International Fund Scheme
- Operational- logistics
  - Speed reduction
  - Weather routing
  - Fleet planning
  - Other, logistics-related


SkySails
BELUGA PROJECTS

Green maritime logistics problems

- Optimal ship speed
- Optimal ship size
- Routing and scheduling
- Fleet deployment
- Fleet size and mix
- Weather routing
- Intermodal network design
- Modal split
- Transshipment
- Queueing at ports
- Terminal management
- Berth allocation
- Supply chain management

- Optimize with respect to environmental criteria
- Optimize with respect to both environmental and traditional criteria
- Try to find 'win-win' solutions

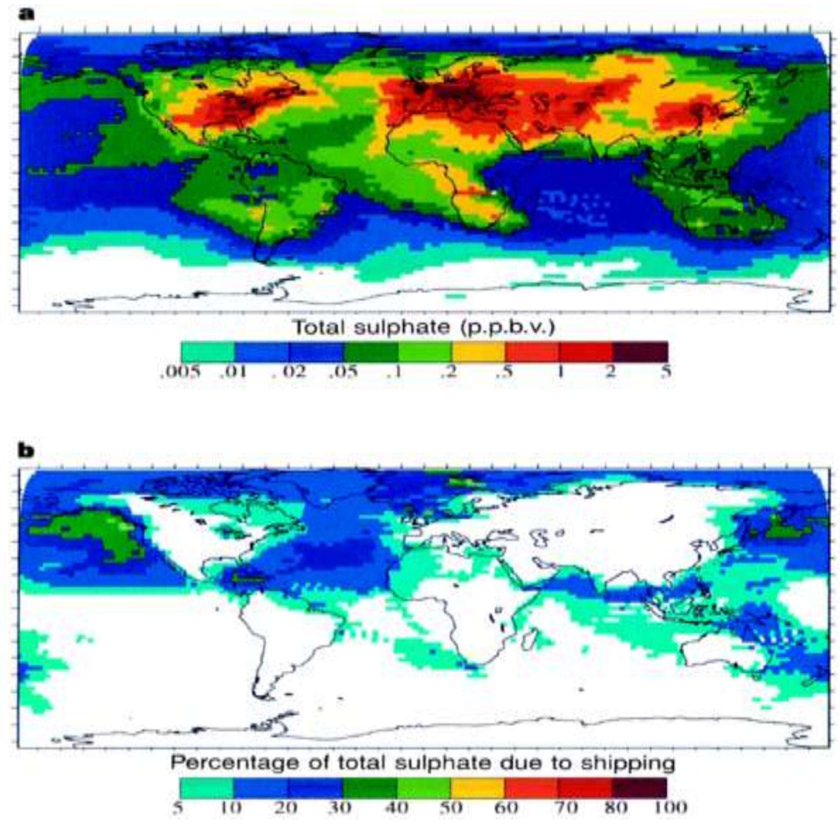
EU Green Corridors

- Freight Transport Logistics Action Plan (2007)
- Green Corridors: characterized by a concentration of freight traffic between major hubs and by relatively long distances of transport.
- Green Corridors should in all ways be environmentally friendly, safe and efficient

Past work: vast literature

R&D and studies on:

- Estimation of emissions
- Impact of emissions on world climate
- Technological means to reduce emissions
- Little on logistics



Some basics

ONE tonne of marine bunker produces:

- 3.02-3.17 tonnes of CO_2 (fuel dependent, indep. of engine type)
- 0.02*S tonnes of SO_2, where S is the % of sulphur content in fuel
- 0.057-0.087 tonnes of NO_x (engine-dependent)

Remarks

- Even *estimates* of marine bunker sales are difficult to make
- Most global emissions estimates are based on modelling

GHG emissions estimates

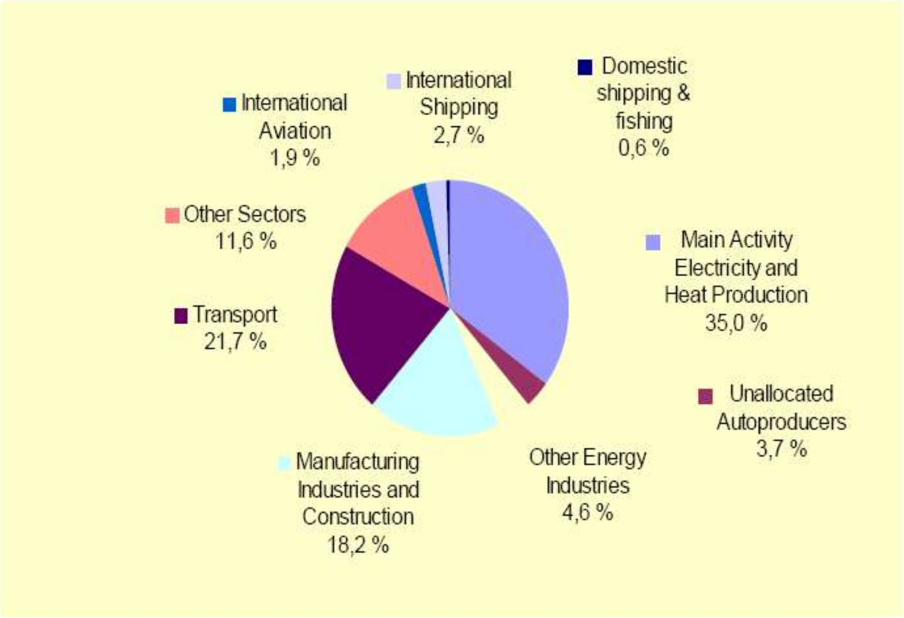
- IMO latest update (2008) of GHG study

Table 1: Consensus estimate 2007 CO_2 emissions (million tonnes CO_2). Source: Buhaug et al (2008)

	Low bound	Consensus estimate	High bound	Consensus estimate % Global CO_2 emissions
Total ship emissions[1]	854	**1019**	1224	3.3
International shipping[2]	685	**843**	1039	2.7

[1] Activity based estimate including domestic shipping and fishing, but excluding military vessels.
[2] Calculated by subtracting domestic emissions estimated from fuel statistics from the activity based total excluding fishing vessels.

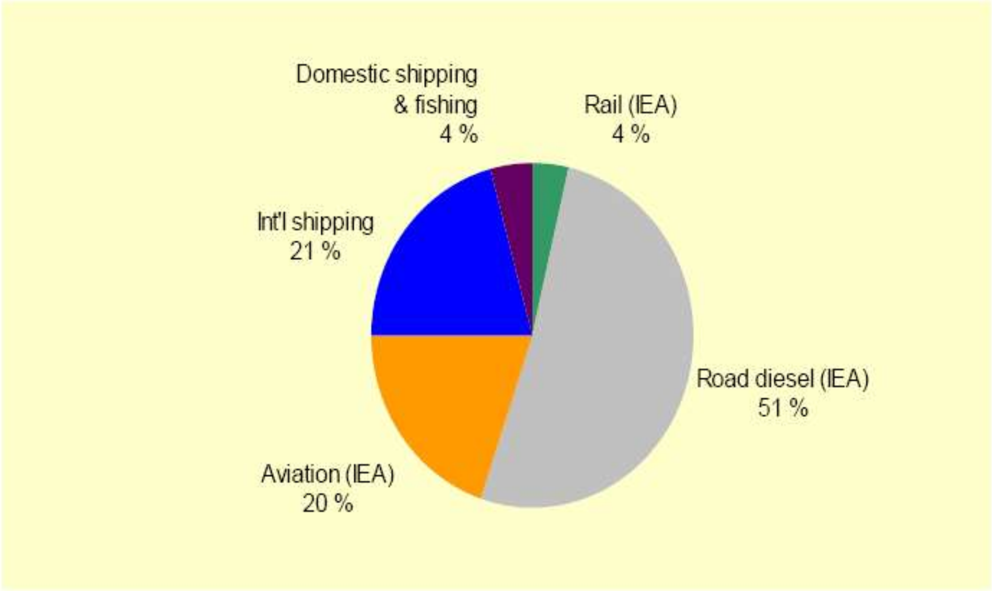
Share of global emissions



Data: International Shipping: This study. Other IEA. Reference year: 2005

MARINTEK SINTEF

Comparison with other modes (2005)



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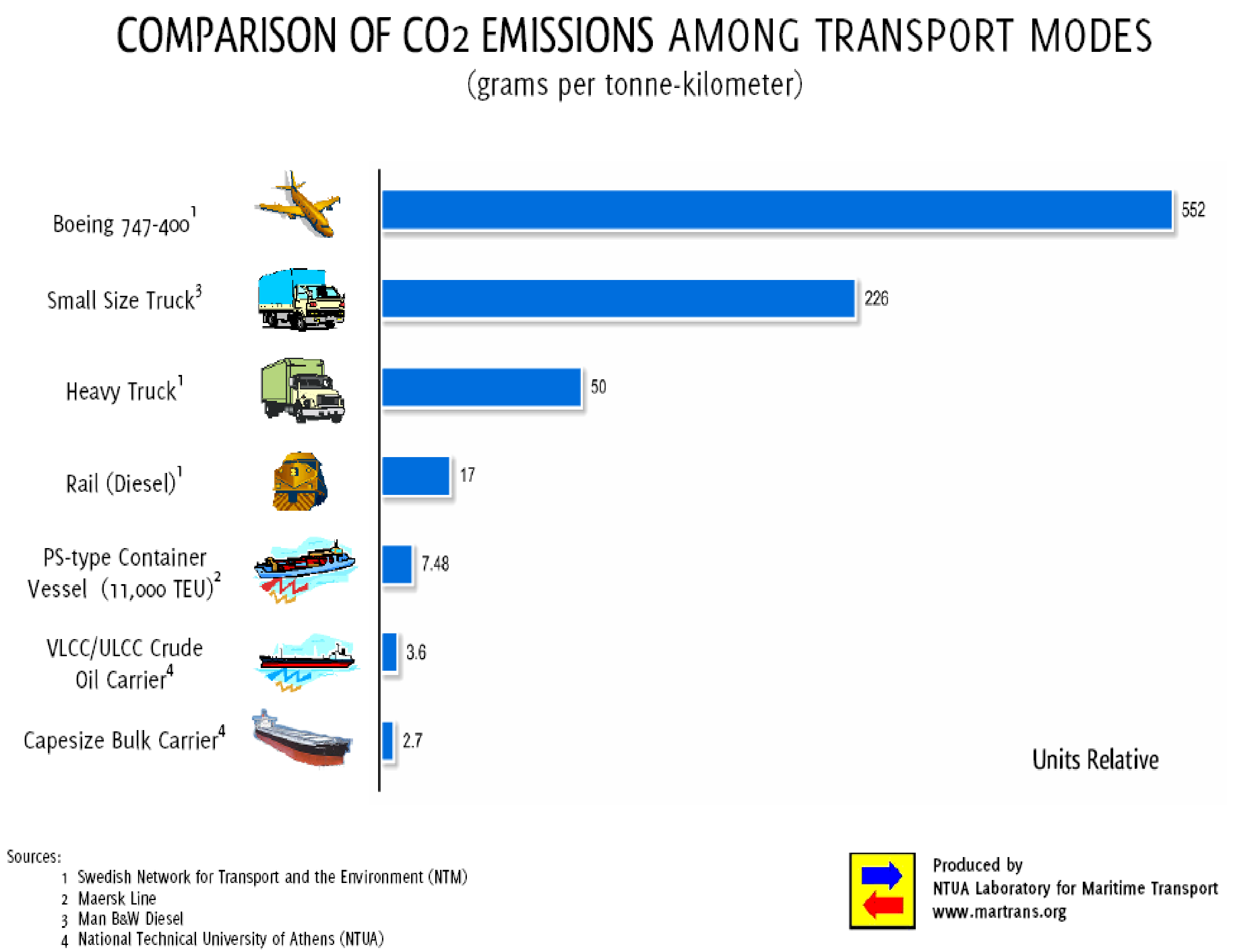
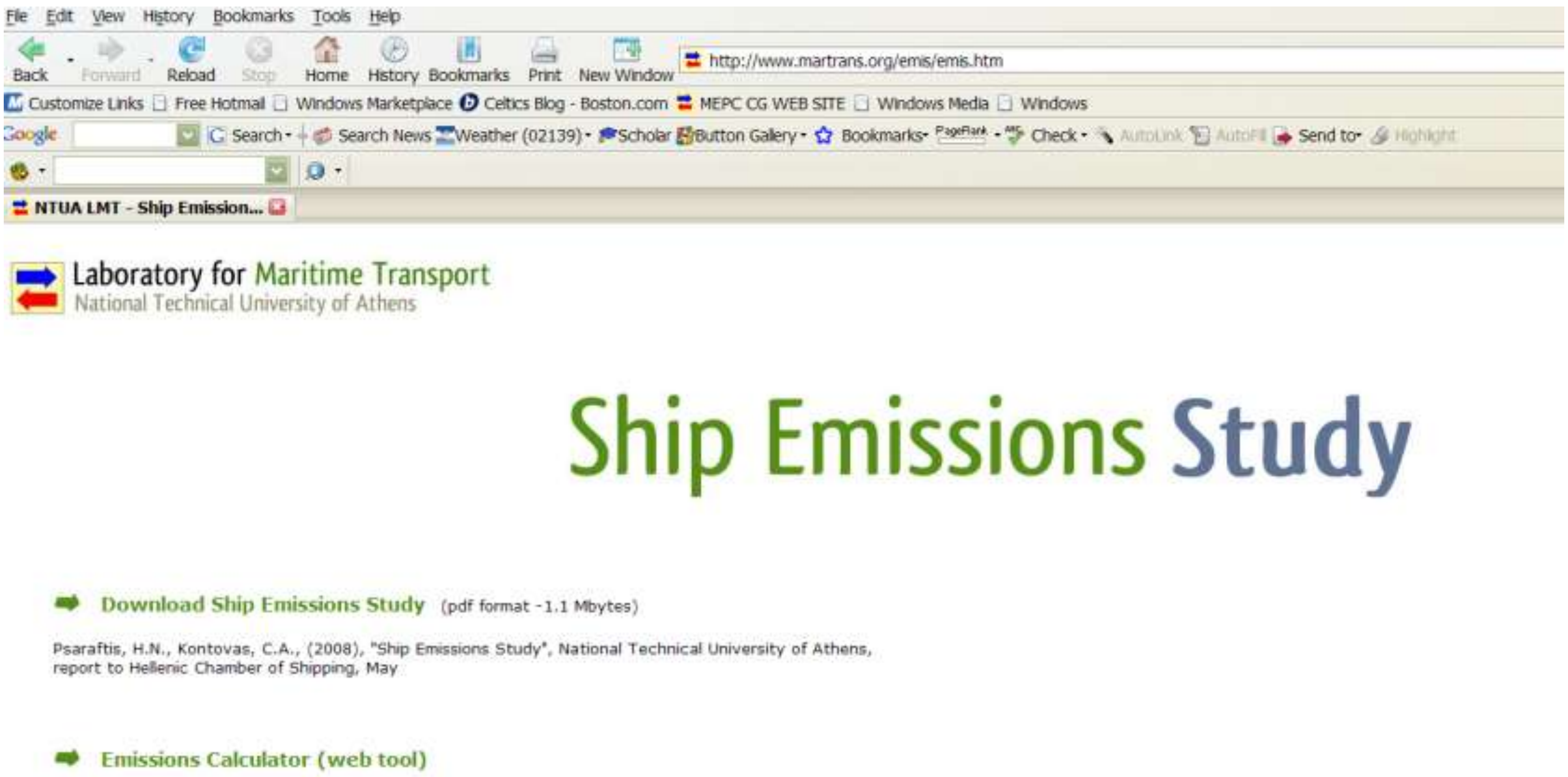


COMPARISON OF CO2 EMISSIONS AMONG TRANSPORT MODES
(grams per tonne-kilometer)
Boeing 747-400[1]
Small Size Truck[3]
Heavy Truck[1]
Rail (Diesel)[1]
PS-type Container Vessel (11,000 TEU)[2]
VLCC/ULCC Crude Oil Carrier[4]
Capesize Bulk Carrier[4]
552
226
50
17
7.48
3.6
2.7
Units Relative
Sources:
1 Swedish Network for Transport and the Environment (NTM)
2 Maersk Line
3 Man B&W Diesel
4 National Technical University of Athens (NTUA)
Produced by
NTUA Laboratory for Maritime Transport
www.martrans.org

NTUA ship emissions study

www.martrans.org/emis/emis.htm



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LABORATORY FOR MARITIME TRANSPORT
Ship Emissions Calculator

VESSEL DETAILS

SELECT SHIP TYPE	Dry Bulk Carrier	SELECT SHIP SIZE	Handysize BC	Slow Speed En
ROUTE	Tubarao-Rotterdam	TRIP DISTANCE	4974 nm	9232 km
PAYLOAD (tonnes)	25000	DWT (tonnes)	27000	

OPERATIONAL DETAILS

STATE	TIME (days)	SPEED (knots)	FUEL OIL S %	FUEL OIL Consumption (tonnes/day)	DIESEL OIL S %	DIESEL OIL Consumption (tonnes/day)
SEA LADEN	15.94	13	3.5	24	1.5	0
SEA BALLAST	15.94	13	3.5	24	1.5	0
PORT (loading,discharging)	4		3.5	4.5	1.5	0

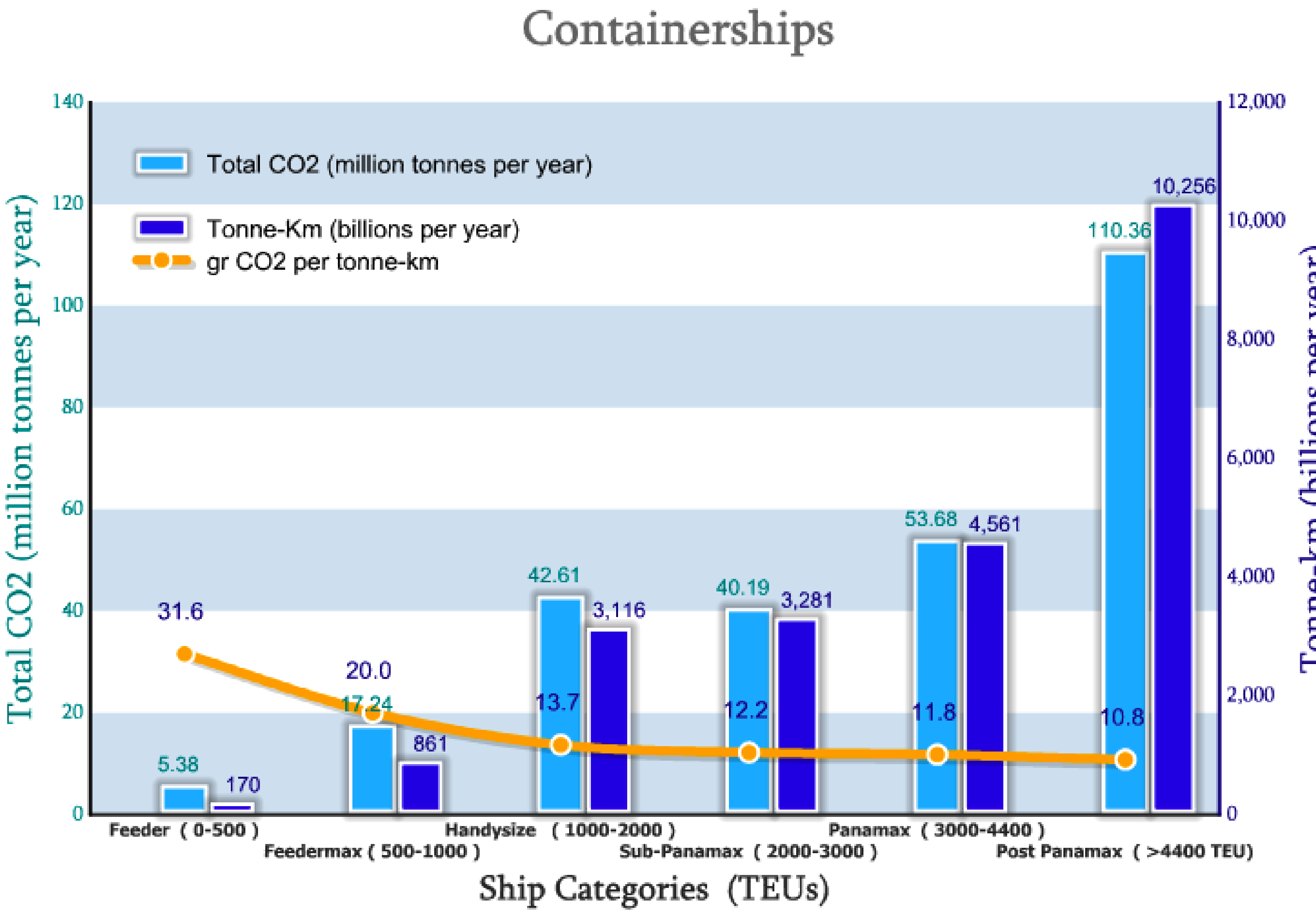
EMISSIONS

	CO2	SO2	NOx
ROUNDTRIP EMISSIONS KG PER tonne TRANSPORTED	99.31	2.19	2.73
ROUNDTRIP EMISSIONS GRAMS PER LADEN tonne-MILE	19.97	0.44	0.55
ROUNDTRIP EMISSIONS GRAMS PER LADEN tonne-KM	10.76	0.24	0.30

SHOW/HIDE DETAILED RESULTS | CALCULATE | HELP | ABOUT

DETAILED RESULTS

				EMISSIONS CO2	SO2	NOx
				tonnes	tonnes	tonnes
TOTAL BALLAST-LADEN DISTANCE		nm	9,948.00			
LADEN tonne-MILES		tonne*nm	124,350,000.00			
TIME IN PORT		days	4.00			
TRIP DURATION	SEA-LADEN	days	15.94			
TRIP DURATION	SEA-BALLAST	days	15.94			
TOTAL RTRIP DURATION		days	35.88			
CONSUMPTION FO	SEA LADEN	tonnes	382.62	1,212.89	26.78	33.29
CONSUMPTION DO		tonnes	0.00	0.00	0.00	0.00


Containerships
Total CO2 (million tonnes per year)
Tonne-Km (billions per year)
gr CO2 per tonne-km
Total CO2 (million tonnes per year)
Tonne-km (billions per year)
140
120
100
80
60
40
20
0
12,000
10,000
8,000
6,000
4,000
2,000
0
31.6
20.0
13.7
12.2
11.8
10.8
5.38
170
17.24
861
42.61
3,116
40.19
3,281
53.68
4,561
110.36
10,256
Feeder (0-500)
Feedermax (500-1000)
Handysize (1000-2000)
Sub-Panamax (2000-3000)
Panamax (3000-4400)
Post Panamax (>4400 TEU)
Ship Categories (TEUs)

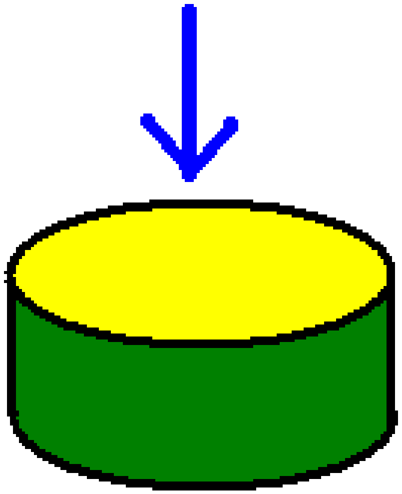
In search of WIN-WIN policies

- “Win-win” is a nice set of words

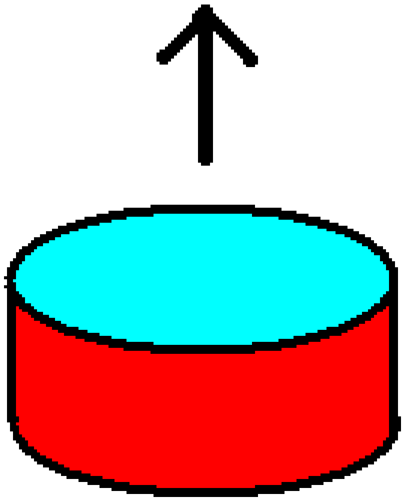
- Finding win-win solutions may not always be easy.

The ‘push-down, pop-up’ principle

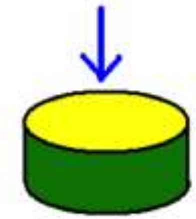
- If you push one button down,



- At least another one will pop up



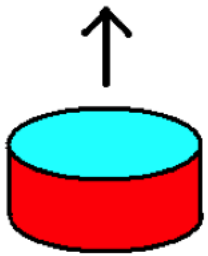
Button no. 1: speed reduction



- Savings in fuel costs
- Means to reduce emissions
- Pick up slack in containership overcapacity

- Killing 3 birds with one stone?

‘Pop-up’ effects of speed reduction



Will need:

- Either more ships
- Or bigger ships
- Or both

To maintain same level of throughput

Trade-offs at stake

- Operational measures to reduce emissions may have ramifications as regards the logistical supply chain
- Measures such as speed reduction or others will generally entail costs, such as in-transit inventory and others (eg, more ships to carry the same cargo).

In-transit inventory costs

- Hauling cargo at a reduced speed will entail additional in-transit inventory costs for the shipper.
- Such inventory cost is incurred during the time the cargo is in transit, and is equal to a factor of IC ($/tonne/day), times the transit time, times the amount of cargo.
- $IC = P*R/365$, where P is the CIF price of the cargo, and R is the cargo owner's cost of capital.

Example (high-valued cargoes)

- Assume CIF = $20,000/tonne
- And R = 8%
- Each day of delay in the delivery of one tonne of that cargo incurs a cost of $4.38 to the shipper
- Total can be in the hundreds of millions of dollars

100 CONTAINERSHIPS GOING 21 KNOTS (case A)

- Transit time (one way) = 100 hrs = 4.17 days
- Round trip = 8.33 days
- Number of round trips per year (assuming 365 days operation): 43.8
- Tonnes carried each year (per ship): 43.8*50,000 = 2,190,000.
- Times 100 ships = 219,000,000.
- Total fuel burned/year/ship: 115 tonnes/day*365 = 41,975 tonnes
- Times 100 ships = 4,197,500 tonnes
- Total fuel cost (x$600) = $2,518,500,000.

105 SHIPS GOING 20 KNOTS (case B)

- Transit time (one way) = 105 hrs = 4.375 days
- Round trip = 8.75 days
- Number of round trips per year (assuming 365 days operation): 41.714
- Tonnes carried each year (per ship): 41.714*50,000 = 2,085,714.
- Times 105 ships = 219,000,000 tonnes.
- Total fuel burned/year/ship: 100 tonnes/day*365 = 36,259 tonnes
- Times 105 ships = 3,807,256 tonnes
- Total fuel cost (x$600) = $2,284,353,741, **REDUCED**.

A or B better?

- B reduces CO_2 emissions by 1,237,073 tonnes per year (versus A)
- Fuel cost difference: $128,299 per additional ship per day
- If sum of additional cargo inventory costs plus other additional operational costs of these ships (including the time charter) is less than $128,299 a day, then case B is overall cheaper.

Case of expensive cargo, high fuel prices, high charter rates (2007)

- If P= \$20,000/tonne (CIF price of cargo)
- P=\$600/tonne (price of fuel)
- OC= \$20,000/day (charter rate for Panamax ship- 2007)
- Cost of capital = 8%
- Then Δ(inventory costs)= \$200,000,000/yr
- Δ(charter costs)=\$45,625,000/yr
- Then case B is more expensive!

Unit Value of the Top 20 Containerized Imports at Los Angeles and Long Beach Ports, 2004

HS#	Category of Import	Value (Billions of dollars)	Weight (Thousands of short tons)	Unit Value (Thousands of dollars per ton)
84	Machinery, Boilers, Reactors, Parts	38.0	698.6	54.3
85	Electric Machinery, Sound and Television Equipment, Parts	31.7	677.0	46.8
87	Vehicles and Parts, Except Railway or Tramway	12.1	337.4	35.8
62	Apparel Articles and Accessories, Not Knit or Crochet	9.9	132.4	74.6
95	Toys, Games, and Sports Equipment and Parts	9.4	377.1	25.0
94	Furniture, Bedding, Lamps, Etc.	9.3	739.8	12.6
61	Apparel Articles and Accessories, Knit or Crochet	9.0	132.1	68.4
64	Footwear	7.8	181.4	43.0
39	Plastics and Articles Thereof	5.2	409.0	12.8
73	Articles of Iron or Steel	4.4	467.0	9.4
42	Leather Articles, Saddlery, Handbags	3.8	117.2	32.1
90	Optic, Photographic, and Medical Instruments	3.6	41.8	86.2

Moral:

- Don’t write off fast ships just yet!
- For the transportation of high-valued products, fast ships will always have a place

Cost to avert one tonne of CO_2

- BASIC QUESTION: HOW MUCH DOES IT COST TO AVERT ONE TONNE OF CO_2?

  (here ‘speed reduction’ is the measure, but question may be posed for any other measure)

CATC: how to compute it?

CATC =

- Total extra cost caused by speed reduction
  - (>0, <0, =0)

divided by

- Tonnes of CO_2 averted

Formula for CATC

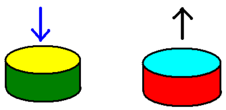
$$\mathrm{CATC} = \frac{I_C WD + \frac{2O_C}{D}}{F_{CO_2} V(V - \Delta V)(2V - \Delta V)(k_1 + k_2)} - \frac{p}{F_{CO_2}}$$

- (cheaper to avert 1 tonne of CO2 if your original speed is high)

How to use CATC criterion?

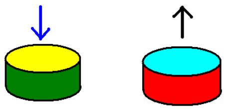
- If CATC < threshold, then speed reduction recommended
- What is an appropriate threshold?
- Connected to price of CO_2 in a possible Emissions Trading Scheme

Another ‘push down, pop up’ effect:



- In the short run, freight rates will go up once the overall transport supply is reduced because of slower speeds
- This may help the market,
- but shippers will foot the bill!
- [this fact is seldom mentioned in any of the discussions on green maritime policies].

Yet another ‘push-down, pop-up’ situation:



- Slow down at SECAs
- Use cleaner fuel at SECAs
- [ramifications as regards other modes]

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)

How about speed reduction?

- Can speed reduction at SECAs work, as a measure to reduce SO_2 emissions?
- An easy question, for which the answer is not so easy.

- [the ports of Los Angeles and Long Beach offer a 15% discount on dockage fees to vessels that voluntary reduce their speed to 12 knots as they approach or leave the ports]

Basic result

- Speed reduction in SECAs will result in more total emissions (of all gases, including SO2) and more total fuel spent *if speed is increased outside SECA to make up for lost time*.
- The reduced emissions within the SECA will be more than offset by higher emissions outside (for all gases).
- The fuel bill will also be higher.
- Plus, cargo may shift to other modes!

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!

Use cleaner fuels in SECAs

Handymax Bulk Carrier W=45,000 tn

Ship (A->B)

V=14 Kn, 30 tn/day HFO
Fuel. Cons: 33.13 tonnes
CO_2 : 105.01 tn of CO_2
3,39 grams per tonKm

Truck
(w=40 tonnes v=60 km/h)
Fuel cons=43 lt per 100 Km

We need
1,125 truck trips
that produce
6 times more CO_2
230 times more than
SO_2 saved

In search for environmentally friendly policies:

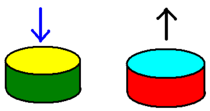
- It is clear that a holistic approach is necessary
- one that looks into and optimizes the overall supply chain instead of its individual components

Fast ships

- should be viewed not in isolation, but as parts of the overall supply chain, and be treated as components of a larger system to be optimized
- It would not make sense to reduce air pollution from fast ships, only to see air pollution on the highways increase more than its reduction at sea.

The role of ports

- No sense to have a ship burn a lot of fuel to go fast, only to have the ship wait in line to be served by a congested port.



- Yet, in the discussions at IMO and elsewhere, this particular aspect has not received the attention it deserves.
- Ports are typically treated independently.
- Work at IAPH, ESPO, etc: significant

Cold ironing

- provision of electricity to the ship by plugging into the port’s electricity supply system
- an idea that is likely to be the norm for many ports in the future

Questions

- How much air pollution will be produced by the generation of the extra shore electricity necessary for the cold ironing?
- Is that less than the emissions saved by switching off the ship's auxiliary power at port?

Conclusions

- Fast ships will receive due scrutiny as regards their potential to reduce emissions
- It will not matter much to reduce the emissions of an individual ship, but those of the intermodal chain the ship is part of.
- It would not make sense if measures to reduce emissions of ships result in traffic being diverted to other modes that pollute more.

More on emissions

- Session 6B (Wednesday)
- 5 papers

Thank you very much!

- www.martrans.org