Calculation of CO_2 Emissions for a Comparison of Transport Modes

Workshop Inland Navigation
CO_2 Emissions
Strasbourg, April 12th, 2011

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PLANCO 1990: External Cost of Transport...
on behalf of German Railways

PLANCO 2007: Economical and Ecological Comparison ...
on behalf of Water and Shipping Directorate East

The actual study confirms the general results of the year 1990:

The external costs of freight trains and inland water vessels are substantially lower than those of motor trucks.

For carbon dioxide the „ranking“ of trains / vessels depends to a large extend on the specific conditions of the particular case.

Regarding traffic noise and accidents, inland navigation has advantages over freight trains whereas for classical air pollution the contrary is true.

Selected Transport Cases

Origin	Destination	Commodity Group
Hamburg	Decin (Czech Republic)	Feedstuff
Hamburg	Salzgitter	Coal
Rotterdam	Duisburg	Coal
Rotterdam	Großkrotzenburg (Main)	Coal
Rotterdam	Dillingen (Saar)	Iron Ore
Linz	Nürnberg	Iron and Steel
Hamburg	Hannover	Mineral Oil Products
Antwerpen	Ludwigshafen	Chemicals
Rotterdam	Duisburg	Container
Rotterdam	Basel	Container
Hamburg	Berlin	Container
Hamburg	Decin (Czech Republic)	Container
Rotterdam	Stuttgart	Container

Basis of the Comparative Analyses

Motor trucks

Trucks and truck-trailer combinations with a load of 24 tons one way and an empty return trip for bulk cargo. For the transport of containers, 2 TEU are calculated in both directions.

Freight trains

For bulk cargo, block trains with total freight volumes between 1,000 tons (feedstuff) and 3,500 t (iron ore), arranged as shuttles with planned empty return trips. Container trains with 750 tons of cargo load in both directions.

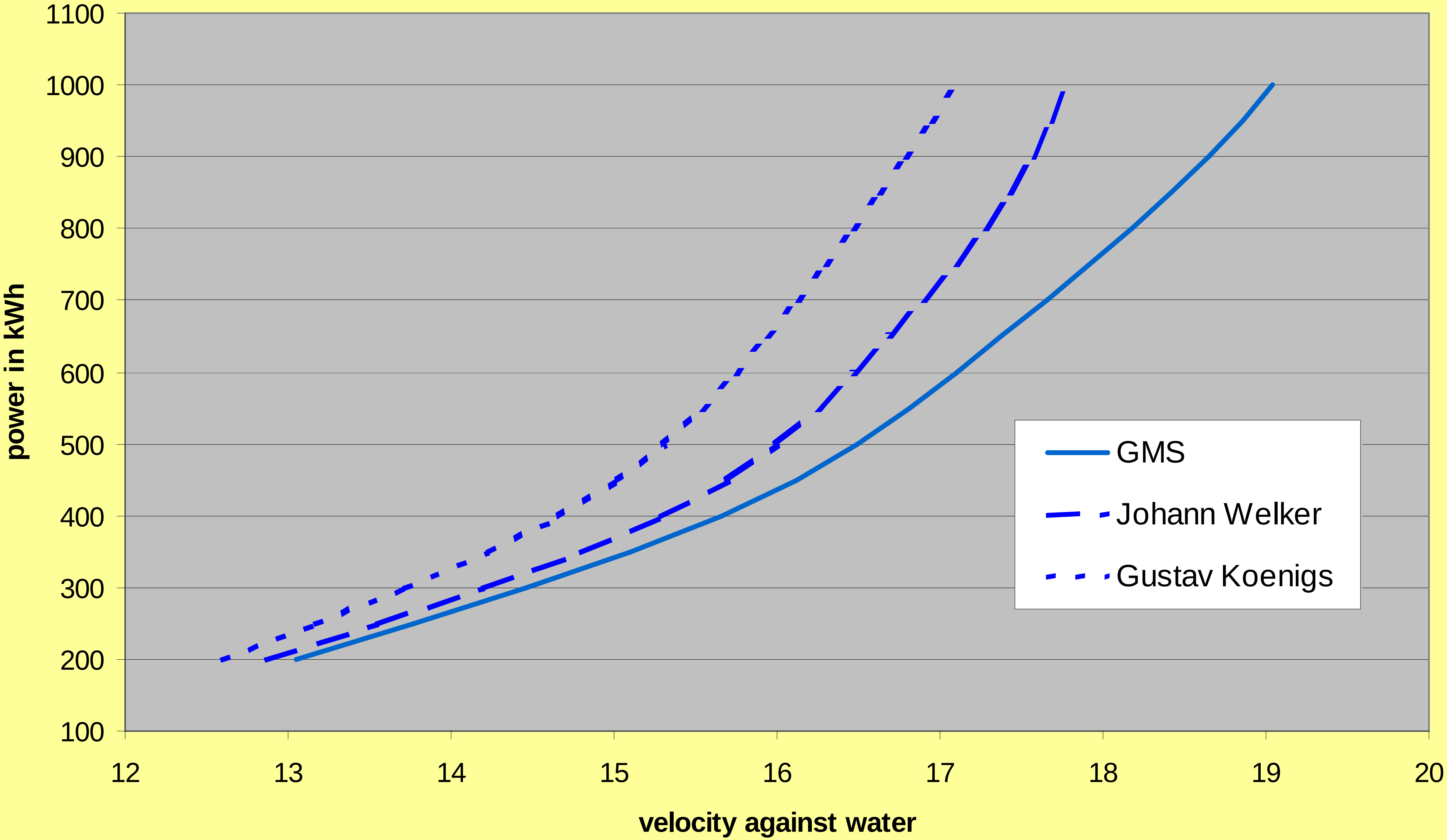
Inland vessels

Motor vessels and convoys with payloads between 1,450 tons (Elbe) and 12,000 tons (lower Rhine). Degree of capacity utilisation according to water levels. Share of empty return trips of vessels according to transport statistics, for convoys generally 100% empty return.

Energy Consumption of Inland Vessels

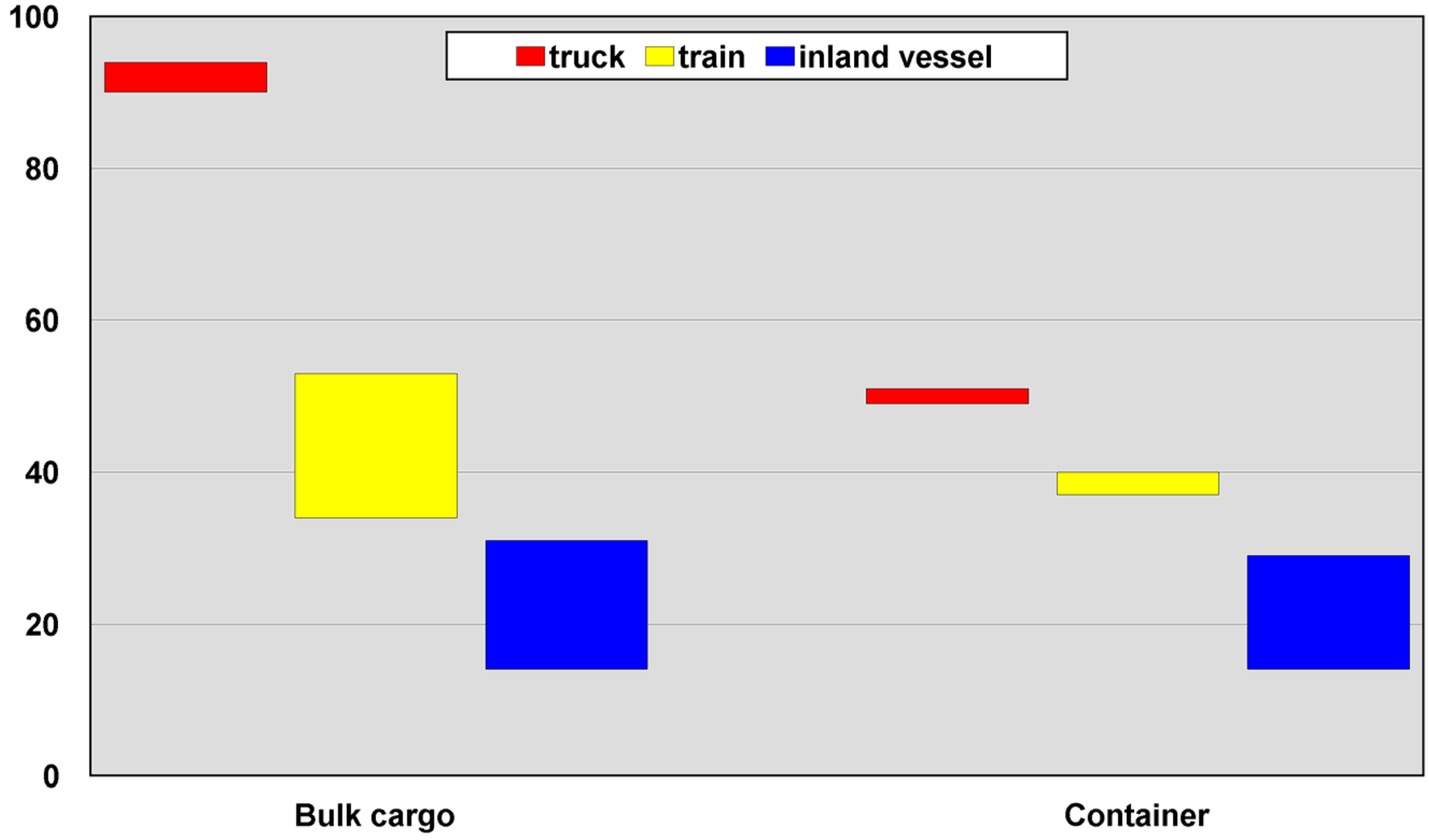
- Energy consumption of inland vessels depends mainly on the type of ship/convoy, the cruising speed relative to the water, the effective vessel draft and the dimensions of the waterways used.
- Bigger vessels and convoys consume considerably less energy per ton-km than smaller vessels.
- Existing studies often use too simplified approaches and assessments. The resulting figures on average fuel consumption per ton-km are thus often over-estimated.

Energy Consumption of Inland Vessels

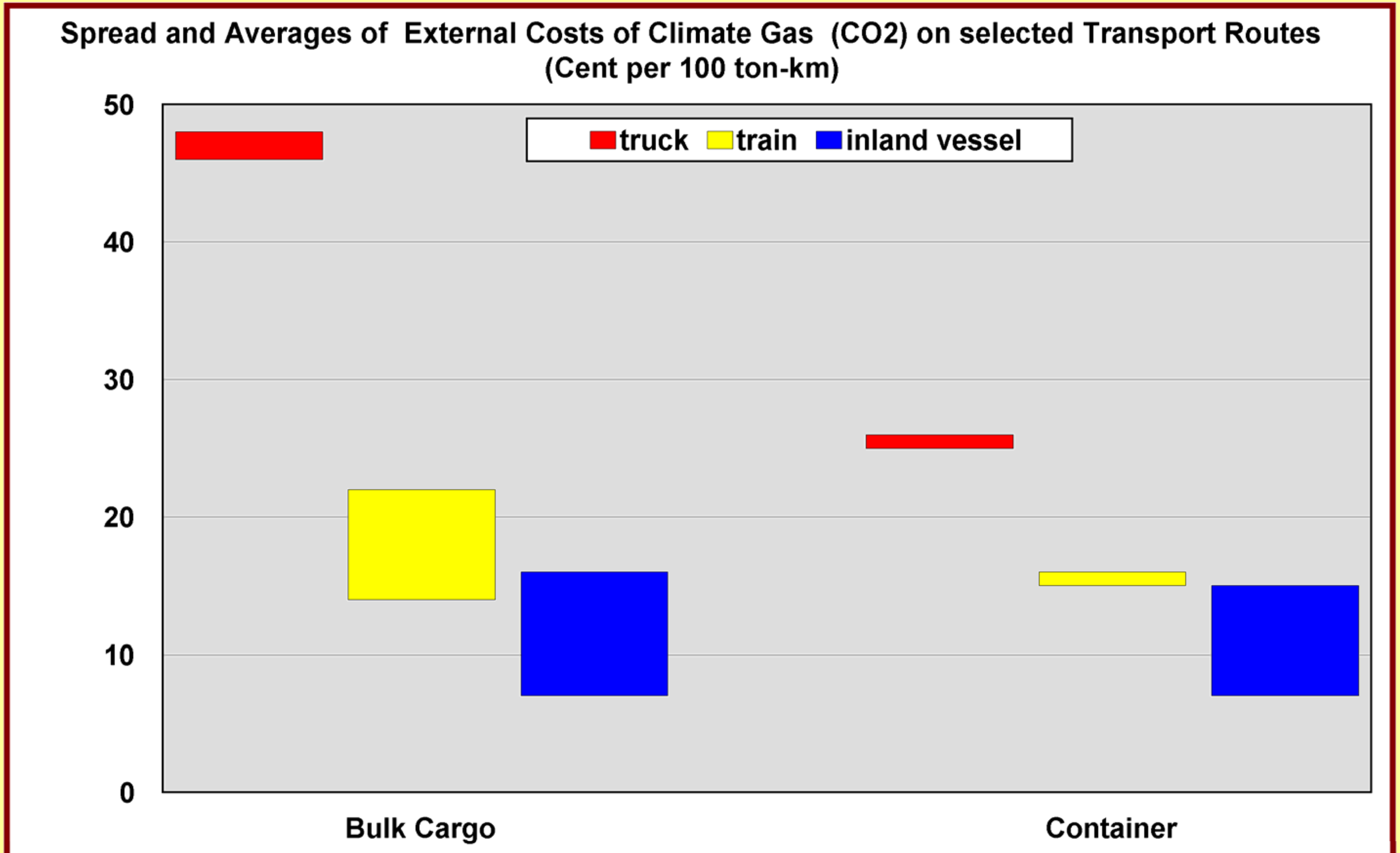


2,5 m draft; water depth 7,5 m, *not really shallow water*

Spread and Avergages of Primary Energy Consumption on Selected Transport Routes
(Megajoule per 100 ton-km)



MAX	94	53	31	50	40	29
AVERAGE	92	43	23	50	39	22
MIN	90	34	14	49	37	14



MAX	48	22	16	26	17	15
AVERAGE	47	18	12	26	16	11
MIN	46	14	7	25	15	7

Basis Circumstances for Calculating Emissions

Methodology of Estimation of Emission-Factors

- Every motor has its specific emission-factor, but for specific types of motors these factors are rather similar.
- For the complete fleet of inland vessel the emission-factors were estimated. Input data were given by the GL, motor building companies, the German Ministry of Transport, Building, and Urban Development, and the Central Commission for the Navigation of the Rhine.

Basis Circumstances for Calculating Emissions

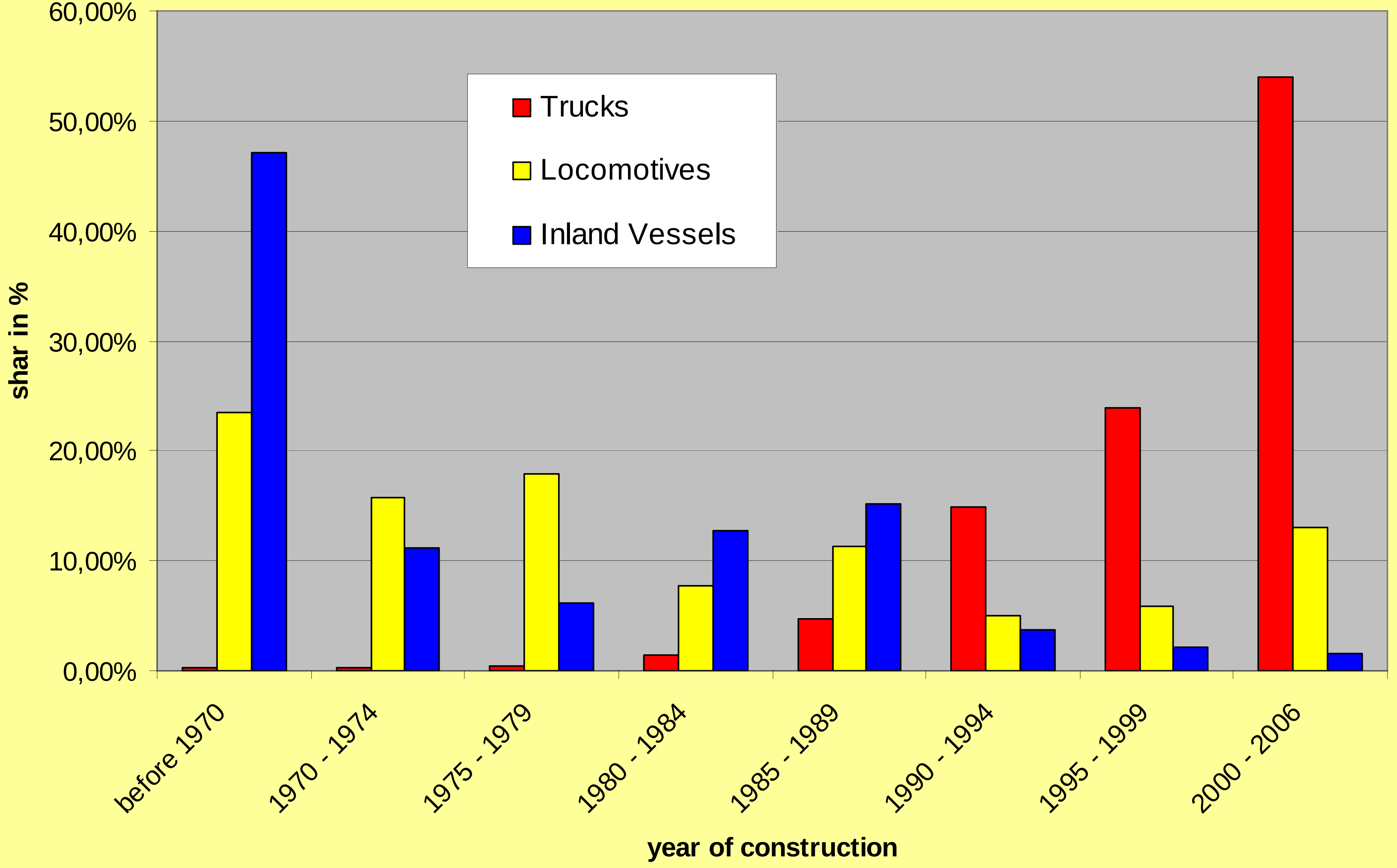
Comparison of the results with other studies

Emissions in g/kWh

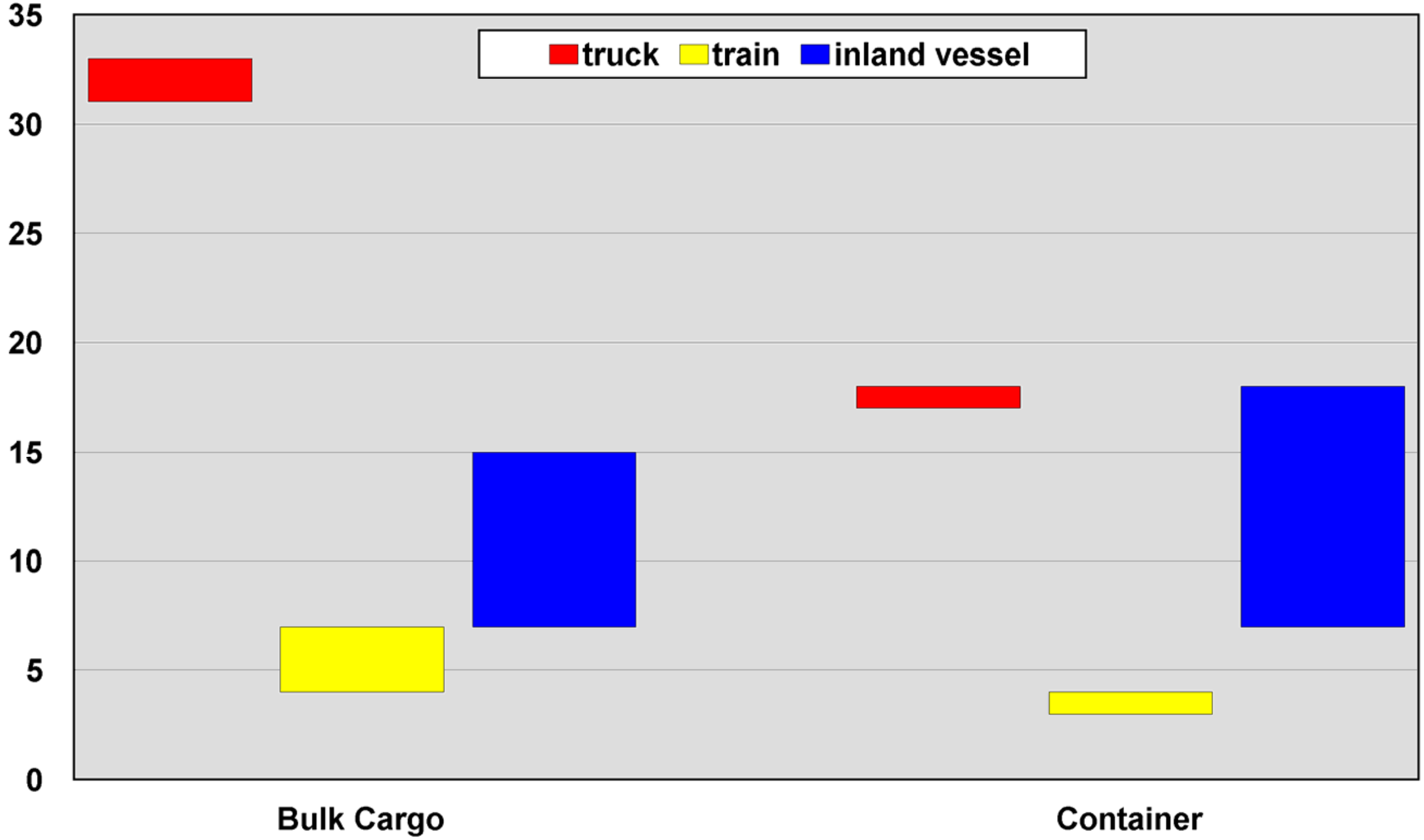
Source	CO	HC	NO_X	PT
Planco 2007	1,56	0,79	9,56	0,22
GL 1998	2,60	0,60	9,00	0,20
VBD 2001	1,16	0,68	9,60	0,20
ifeu 2005	n.A.	0,94	12,00	0,34

Basis Circumstances for Calculating Emissions

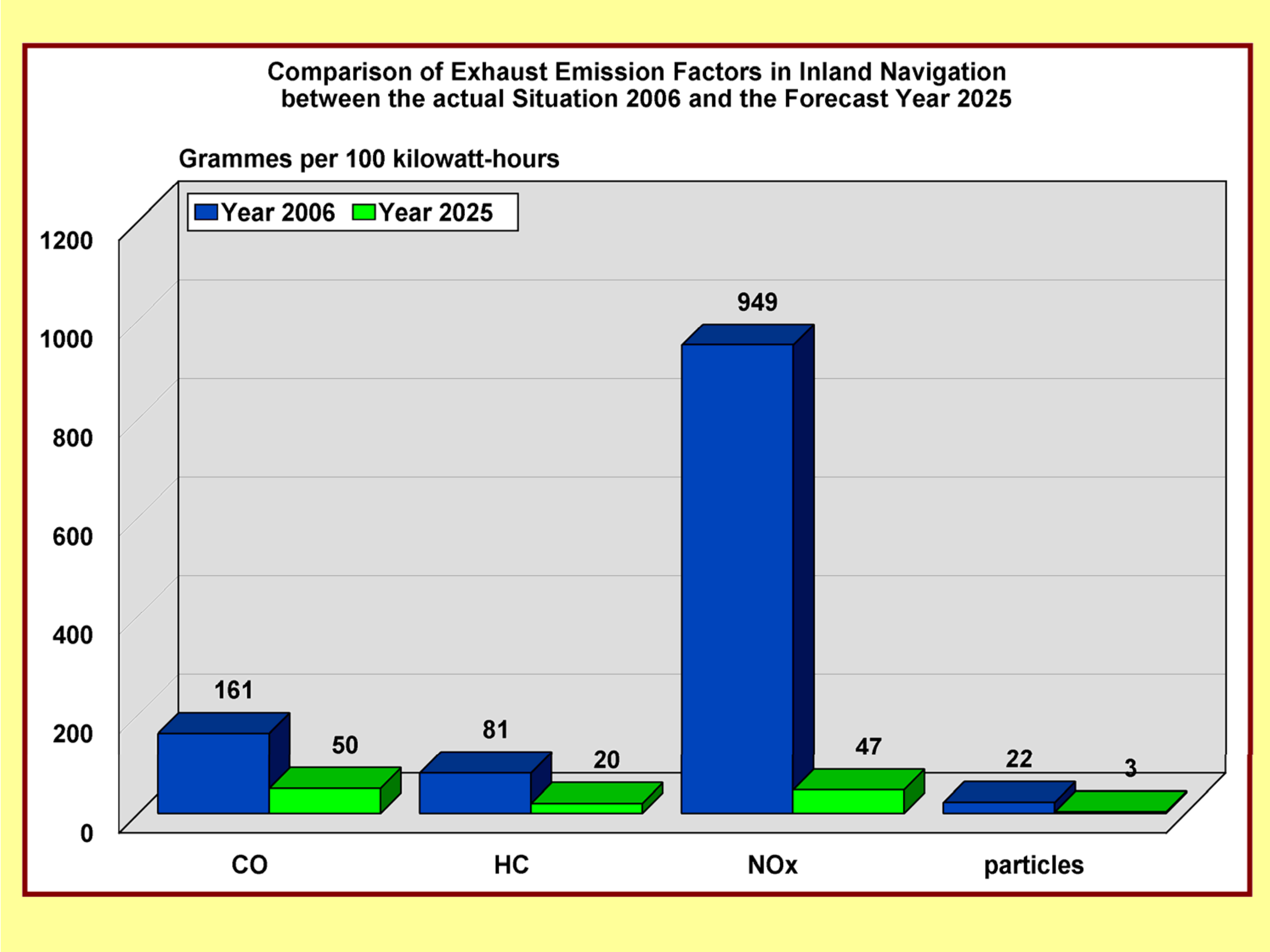
Age of the Modal Fleets



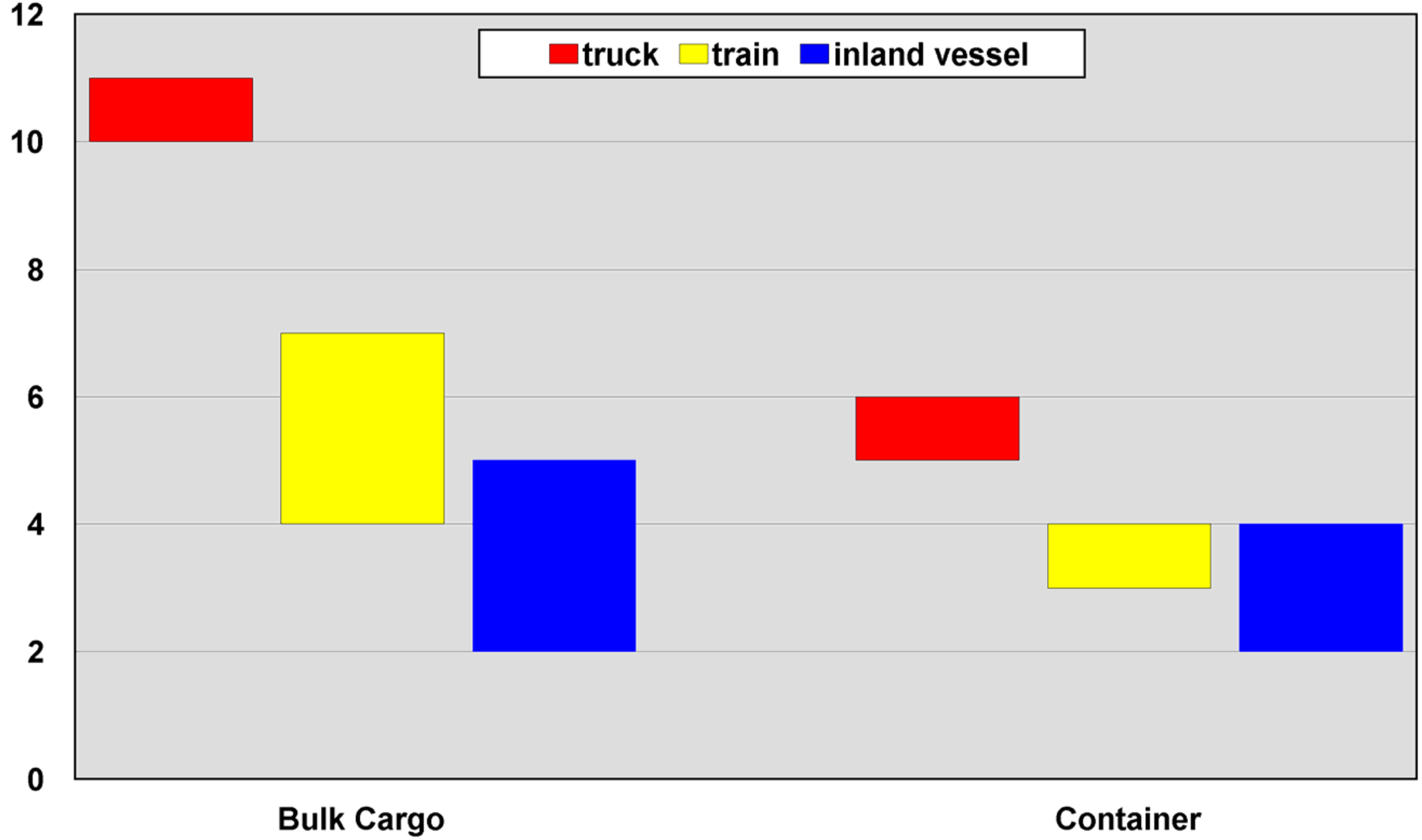
Spread and Averages of External Costs of Air Pollution ((NOx, SO2, NMHC, CO, particles) on selected Transport Routes in 2006 (Cent per 100 ton-km)



MAX	32	6	16	17	4	18
AVERAGE	32	5	12	17	4	12
MIN	31	4	7	17	3	7

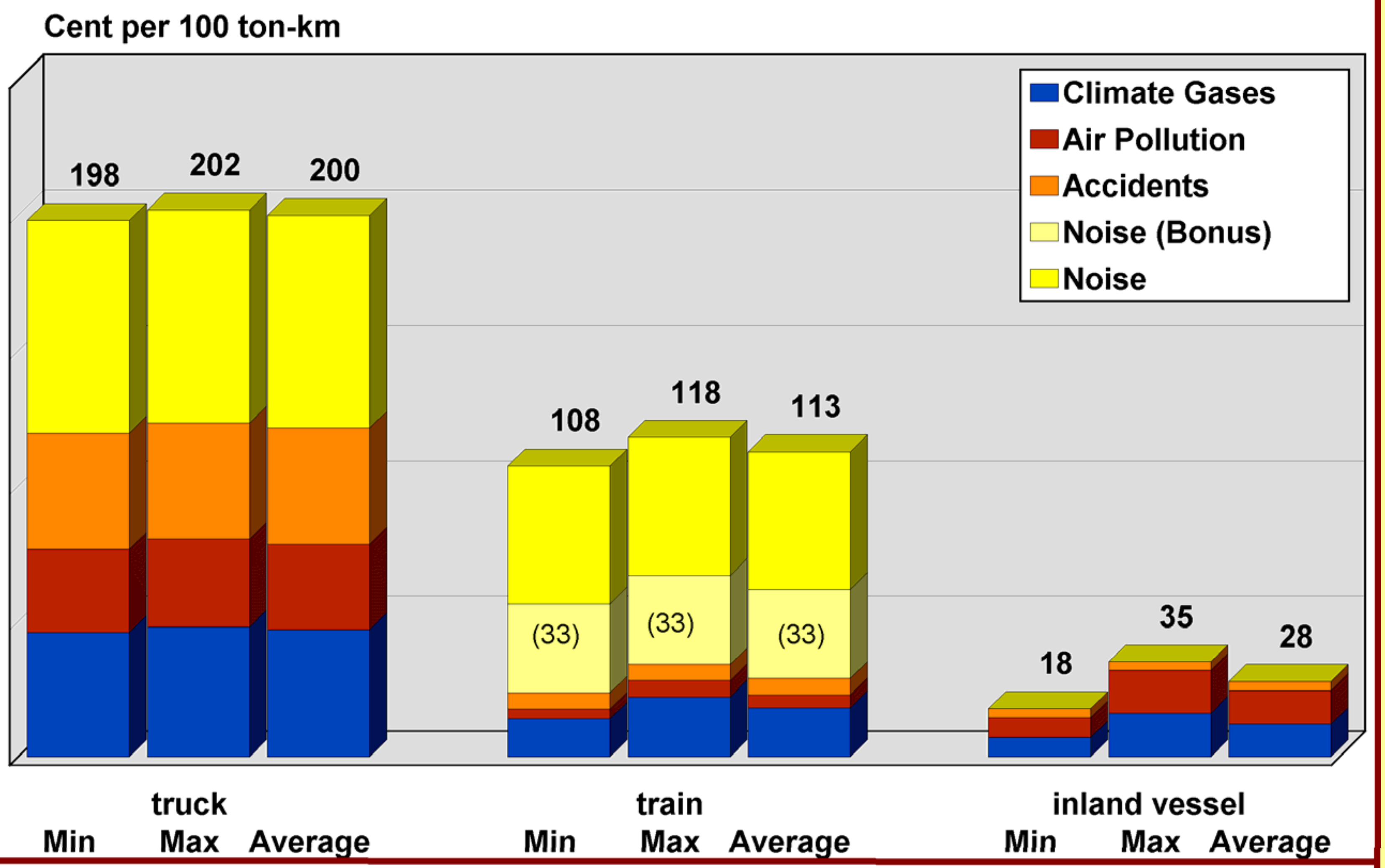

Comparison of Exhaust Emission Factors in Inland Navigation
between the actual Situation 2006 and the Forecast Year 2025
Grammes per 100 kilowatt-hours
Year 2006
Year 2025
1200
1000
800
600
400
200
0
161
50
81
20
949
47
22
3
CO
HC
NOx
particles

Spreads and Averages of External Costs of Air Pollution (NOx, SO2, NMHC, CO, particles) on selected Transport Routes in the Forecast Year 2025 (Cent per 100 ton-km)



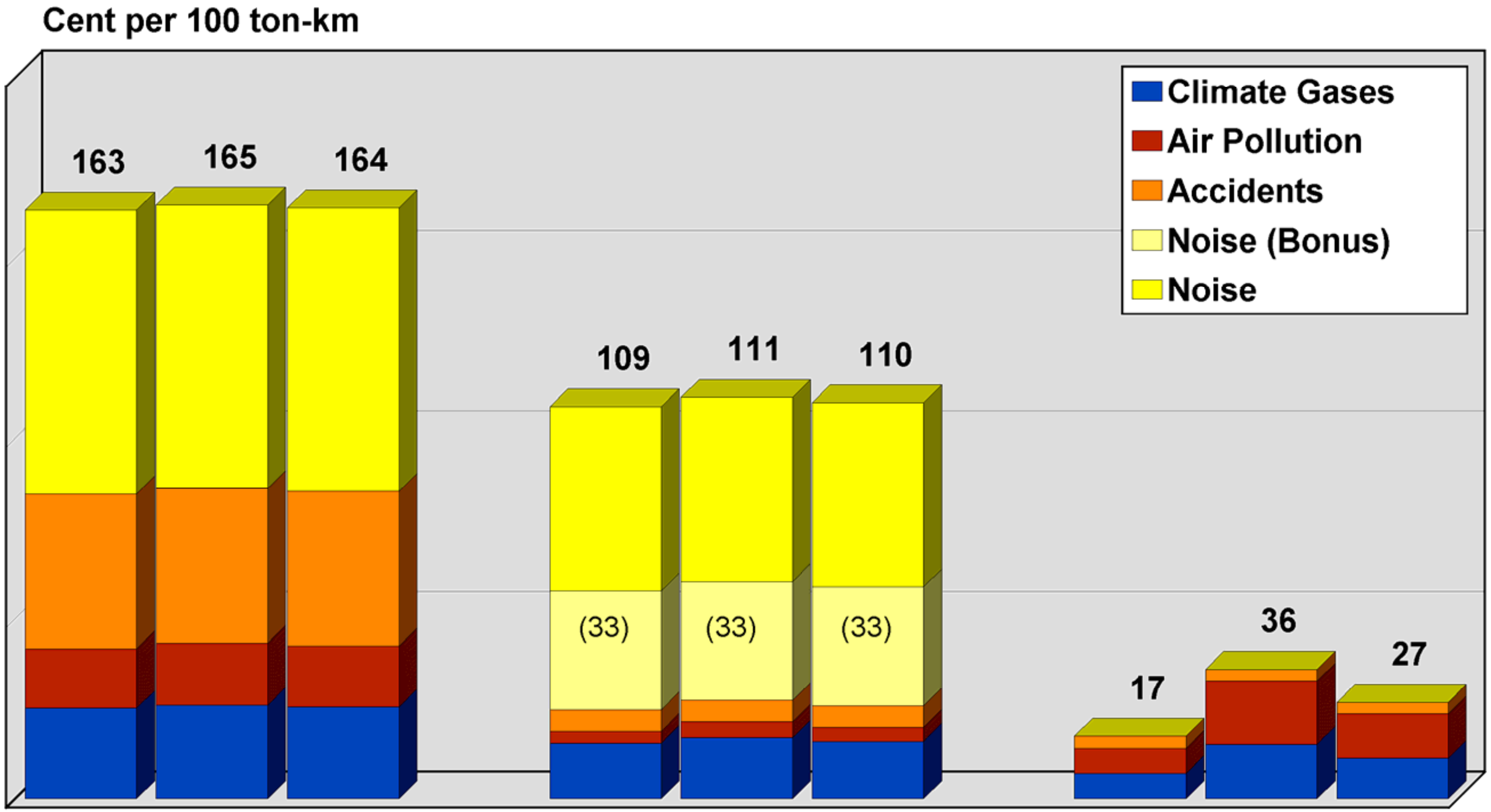
MAX	11	6	5	6	4	5
AVERAGE	10	5	3	6	4	3
MIN	10	4	2	5	3	2

Spreads and Average Values of Total External Costs of Bulk Freight Transport on Selected Routes

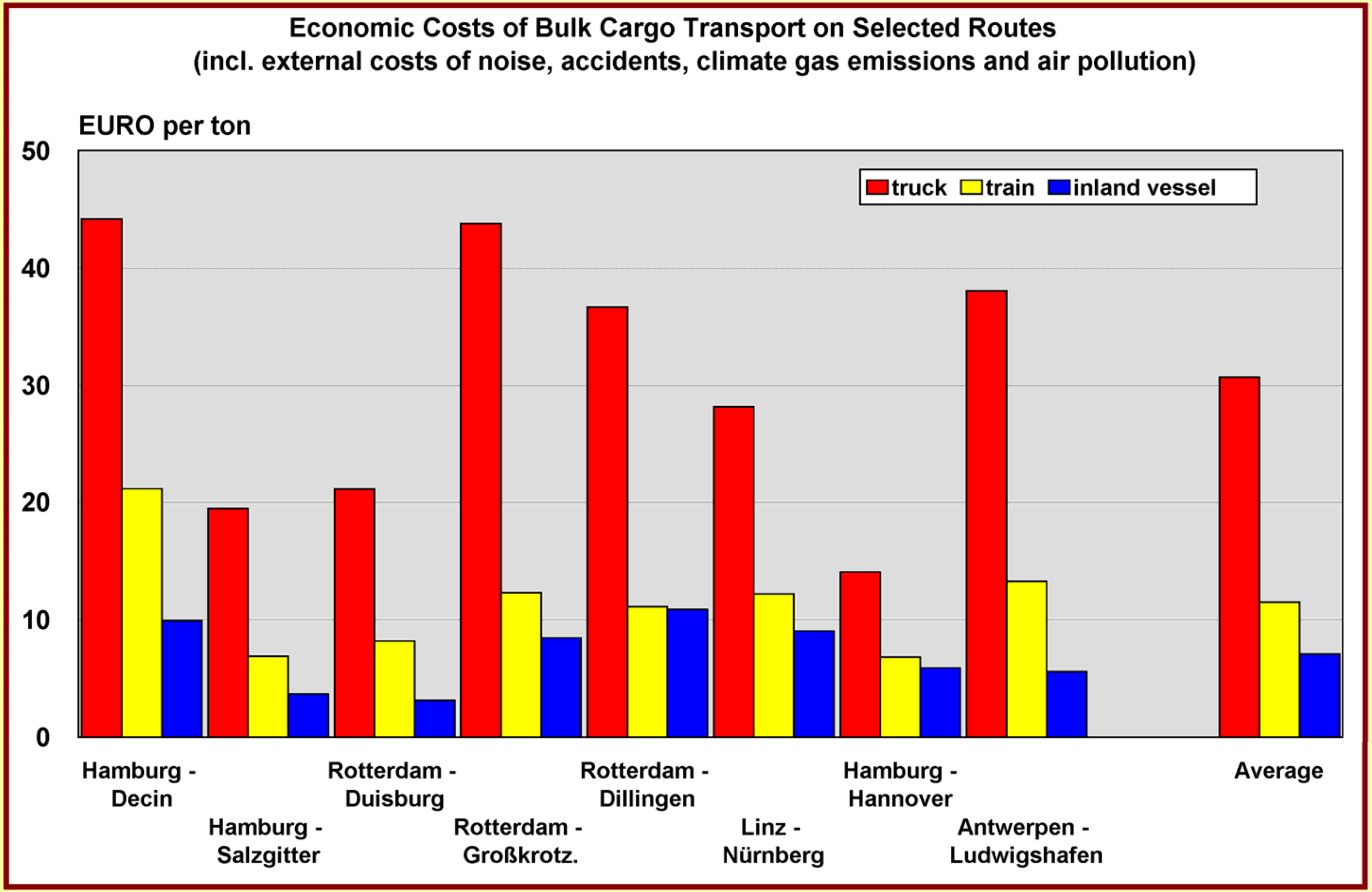


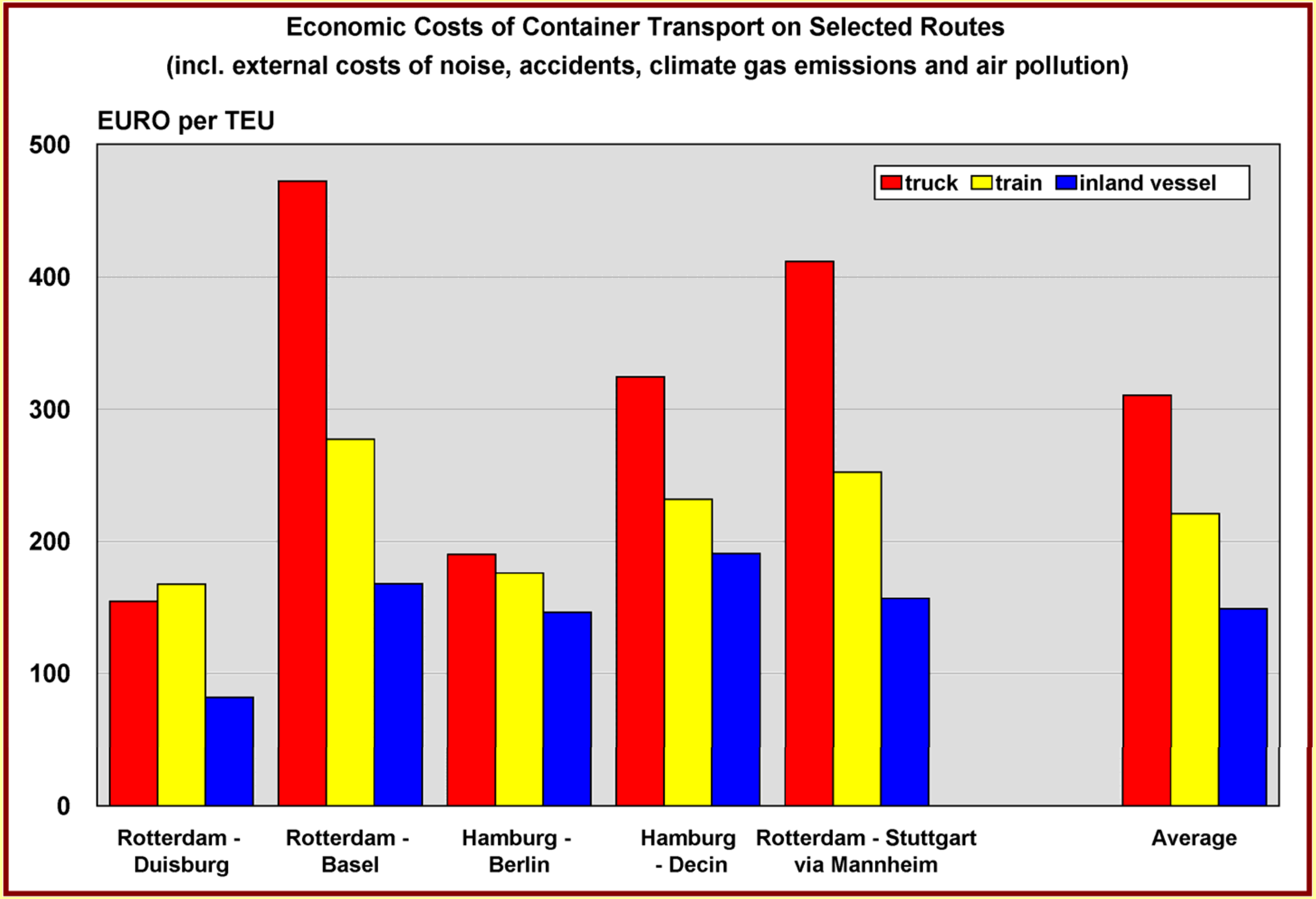
	truck Min	truck Max	truck Average	train Min	train Max	train Average	inland vessel Min	inland vessel Max	inland vessel Average
Accidents	43	43	43	6	6	6	3	3	3
Noise	79	79	79	84	84	84	0	0	0
Air	31	32	32	4	6	5	7	16	12
Climate	46	48	47	14	22	18	7	16	12

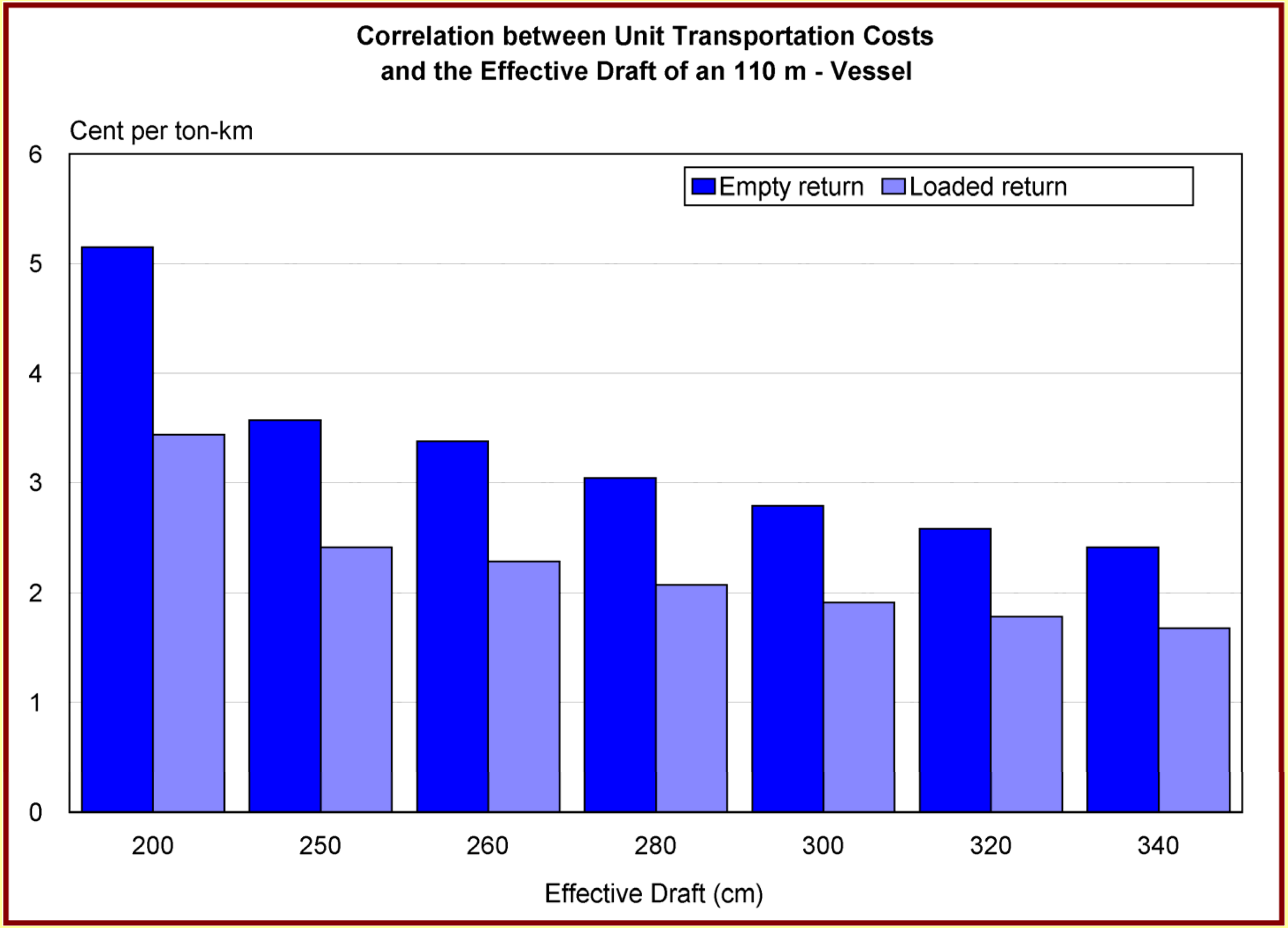
Spread and Averages of Total External Costs of Container Freight Transport on Selected Routes

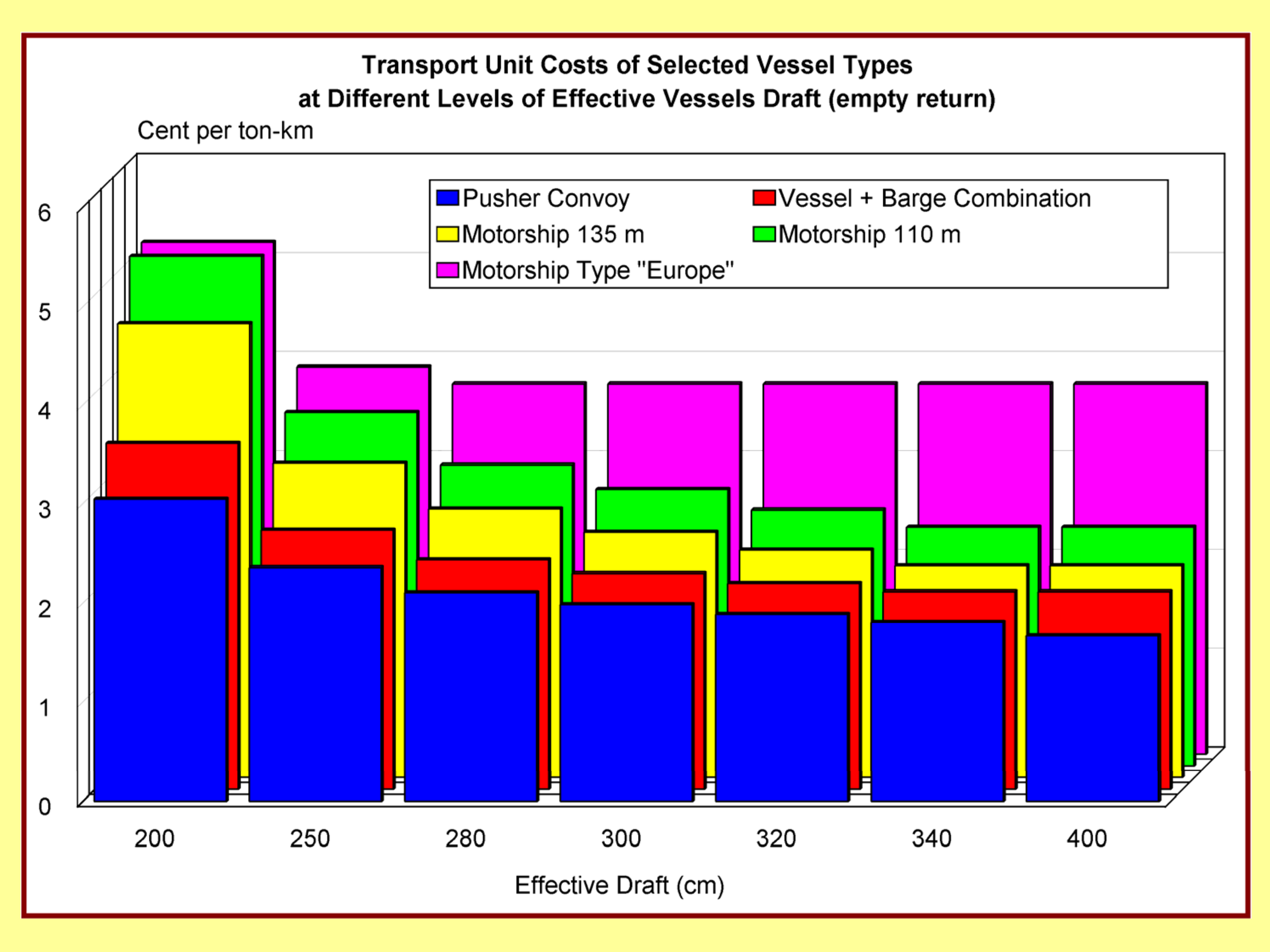


	truck			train			inland vessel		
	Min	Max	Average	Min	Max	Average	Min	Max	Average
Accid.	43	43	43	6	6	6	3	3	3
Noise	79	79	79	84	84	84	3	3	3
Air	17	17	17	3	4	4	7	18	12
Climate	25	26	26	15	17	16	7	15	11


Economic Costs of Bulk Cargo Transport on Selected Routes
(incl. external costs of noise, accidents, climate gas emissions and air pollution)
EURO per ton
50
40
30
20
10
0
truck
train
inland vessel
Hamburg - Decin
Hamburg - Salzgitter
Rotterdam - Duisburg
Rotterdam - Großkrotz.
Rotterdam - Dillingen
Linz - Nürnberg
Hamburg - Hannover
Antwerpen - Ludwigshafen
Average


Economic Costs of Container Transport on Selected Routes
(incl. external costs of noise, accidents, climate gas emissions and air pollution)
EURO per TEU
500
400
300
200
100
0
truck
train
inland vessel
Rotterdam - Duisburg
Rotterdam - Basel
Hamburg - Berlin
Hamburg - Decin
Rotterdam - Stuttgart via Mannheim
Average


Correlation between Unit Transportation Costs
and the Effective Draft of an 110 m - Vessel
Cent per ton-km
6
5
4
3
2
1
0
Empty return
Loaded return
200
250
260
280
300
320
340
Effective Draft (cm)



Transport Unit Costs of Selected Vessel Types
at Different Levels of Effective Vessels Draft (empty return)
Cent per ton-km
Pusher Convoy
Vessel + Barge Combination
Motorship 135 m
Motorship 110 m
Motorship Type "Europe"
0
1
2
3
4
5
6
200
250
280
300
320
340
400
Effective Draft (cm)

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Thank you for your kind Attention!

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