

# Numerical modelling of air pollutants and greenhouse gases emissions in intermodal transport chains

Mónica M. Ramalho and Tiago A. Santos

## Supplementary Materials

**Table S1.** Vehicle characteristics and corresponding variables.

<b>WFEU</b>	Average weight of one cargo unit in tonnes.	
<b>Truck</b>		
<b>Variable</b>	<b>Description</b>	
<b>TruClass</b>	Truck weight class: gross weight of truck in tonnes.	
<b>TruFuel</b>	‘DIE’ for diesel trucks. ‘LNG’ for liquefied natural gas trucks.	
<b>TruEuro</b>	Truck’s EURO Class 0-6.	
<b>TruSFOC</b>	Truck’s engine specific fuel consumption in g/kWh.	
<b>TruPME</b>	Truck’s engine power in kW.	
<b>Train</b>		
<b>Variable</b>	<b>Description</b>	
<b>TraGreen</b>	‘Y’ for trains equipped with DPF+ EGR/SCR. ‘N’ for trains not equipped with DPF+EGR/SCR.	
<b>TraCap</b>	Train’s capacity in number of trailers/FEUs.	
<b>TraFuel</b>	‘DIE’ for diesel trains. ‘ELE’ for electric trains.	
<b>TraUt</b>	Train’s capacity utilization factor.	
<b>TraFC</b>	Train’s engine fuel consumption in kg fuel/h.	
<b>Inland Vessel</b>		
<b>Variable</b>	<b>Description</b>	
<b>IwwStage</b>	Vessel’s CCNR <sup>1</sup> (I or II) or Stage (V) emission class.	
<b>IwwFuel</b>	‘EN590’ – Gas oil (EN590 compliant fuel) ‘LNG’ – Liquefied Natural Gas ‘MeOH’ - Methanol	
<b>IwwEAT</b>	Vessel’s emissions abatement technologies. ‘DPF’ - Diesel Particulate Filter ‘SCR’ - Selective Catalytic Reduction ‘EGR’ - Exhaust Gas Recirculation ‘HAM’ - Humid Air Motor ‘DPF+SCR’ ‘DPF+HAM’ ‘NULL’ – No emission abatement technology installed	
<b>IwwRating</b>	Vessel’s main diesel engine speed rating. ‘MS’ – Medium Speed      ‘SS’ – Slow Speed ‘HS’- High Speed	
<b>IwwCap</b>	Vessel’s freight capacity in number of trailers/FEUs.	
<b>IwwUt</b>	Vessel’s freight capacity utilization factor.	
<b>IwwPME</b>	Vessel’s main engine power in kW.	

<b>IwwSpeed</b>	Vessel’s speed at 100%MCR in clean hull and calm water, in knots.	
<b>Short Sea Vessel</b>		
<b>Variable</b>	<b>Description</b>	
<b>SssTyp</b>	‘G’ – General Cargo      ‘C’ – Container ‘R’ – Ro-Ro      ‘P’ – Ro-Pax	
<b>SssLpp</b>	Vessel’s length between perpendiculars in m.	
<b>SssB</b>	Vessel’s breadth in m.	
<b>SssD</b>	Vessel’s design draft (maximum) in m.	
<b>SssDead</b>	Vessel’s deadweight in tonnes.	
<b>SssCap</b>	Vessel’s freight capacity in number of trailers/FEUs.	
<b>SssUt</b>	Vessel’s freight capacity utilization factor.	
<b>SssTier</b>	IMO NO <sub>x</sub> emission standard 1-3.	
<b>SssRating</b>	Vessel’s main diesel engine speed rating. ‘MS’ – Medium Speed      ‘SS’ – Slow Speed ‘HS’- High Speed	
<b>SssPME</b>	Vessel’s main engine propulsive power in kW.	
<b>SssPAE</b>	Vessel’s auxiliary engine power in kW.	
<b>SssSpeed</b>	Vessel’s speed at 100%MCR with clean hull and calm water, in knots.	
<b>TPort</b>	Number of hours at each terminal.	
<b>MEoutECA</b> <b>AEoutECA</b> <b>MEinECA</b> <b>AEinECA</b>	<b>Fuel</b>	‘HFO’ – Heavy fuel oil (2.6%S) ‘LSHFO’ – Low Sulphur Heavy Fuel Oil (1%S) ‘VLSFO’ – Very Low Sulphur Fuel Oil (0.5%S) ‘ULSFO’ – Ultra Low Sulphur Fuel Oil (0.1%S) ‘MDO’ – Marine Diesel Oil ‘LNG’ – Liquefied Natural Gas ‘MeOH’ - Methanol
	<b>DPF</b>	‘Y’ – Diesel particulate filter is installed for the exhaust. ‘N’ – No DPF is installed for the exhaust.
	<b>WS</b>	‘Y’ – Water scrubbing (fresh/sea water) is installed. ‘N’ – No WS is installed.
	<b>SCR</b>	‘Y’ – Selective Catalytic Reduction is installed. ‘N’ – No SCR is installed.
	<b>EGR</b>	‘Y’ – Exhaust Gas Recirculation is installed. ‘N’ – No EGR is installed.

<sup>1</sup> Central Commission for the Navigation on the Rhine

**Table S2.** Emission factors chosen by the software SA in both emission scenarios.

	<b>Scenario 1</b>	<b>Scenario 2</b>
<b>Road links</b>	EURO IV – 3.5 g/kWh NOx, 0.02 g/kWh PM Sulphur limit 10 ppm = 0.000019551 g SO2/g fuel 3.1805 g CO2/g fuel	EURO VI LNG – 0.4 g/kWh NOx, 0.01 g/kWh PM Sulphur content 3.5 ppm 3.10 g CO2/g fuel
<b>Rail Links</b>	3151.5 kg CO2/tonne fuel 0.019551 kg SO2/tonne fuel 1.2 kg PM/ tonne fuel 63 kg NOx/tonne fuel	3151.5 kg CO2/tonne fuel 0.019551 kg SO2/tonne fuel 1.2 kg PM/ tonne fuel 63 kg NOx/tonne fuel
<b>IWW Links</b>	sfcB = 175 g/kWh sfcAE = 185 g/kWh 3.1805 g CO2/g fuel Sulphur limit 10 ppm = 0.000019551 g SO2/g fuel 8.3 g/kWh NOx for ME 11.2 G/kWh NOx for AE 0.16 g/kWh PM for ME 0.18 g/kWh PM for AE	sfcB = 156 g/kWh sfcAE = 156 g/kWh 3.116 g CO2/g fuel 0.0000317 g SO2/g fuel 1.3 g/kWh NOx for ME and AE 0.02 g/kWh PM for ME and AE
<b>SSS Links</b>	sfcB = 185 g/kWh sfcAE = 185 g/kWh 3.163 g CO2/g fuel for ME 3.255 g CO2/g fuel for AE 0.00978 g SO2/g fuel for ME 0.0014 g SO2/g fuel for AE 10.5 g/kWh NOx for ME 11.2 g/kWh NOx for AE 0.78 g/kWh PM for ME 0.18 g/kWh PM for AE	sfcB = 156 g/kWh sfcAE = 156 g/kWh 3.116 g CO2/g fuel 0.0000317 g SO2/g fuel 1.3 g/kWh NOx for ME and AE 0.02 g/kWh PM for ME and AE