

TRANSPORT & MOBILITY  
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TREMOVE Contact Group Meeting

21 June 2004

Inland Waterway Emission Factors

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Presentation structure (all modes)

1. Input from demand and vehicle stock modules
2. Emission factors used in TREMOVE :
  - Sources
  - Assumptions
  - Values
3. Apparent emission factors (overall g/veh.km)
4. Further work
5. Q & A / Discussion

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1. Input from demand and vehicle stock modules

Vehicle-Kilometres by ship type

influencing variables

Vehicle related :  
 ~ Vehicle type  
 ~ CCR / share in fleet (2002 -)

Usage related :  
 ~ Trip Length (>< 500 km)  
 ~ Avg. Load Factor

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1. Input from demand and vehicle stock modules

Ship types	Tanker Vessel	Pusher Craft	Dry Cargo vessel
< 250 tonnes			
250 - 400 tonnes			
400 - 650 tonnes			
650 - 1000 tonnes			
1000 - 1500 tonnes			
1500 - 3000 tonnes			
>3000 tonnes			

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2. Emission factors used in TREMOVE :  
Information Sources

- Preliminary ARTEMIS methodology
  - Calculation method fuel consumption (pre-CCR I)
  - Calculation method emissions (pre-CCR I)
  - Characteristics for pusher-tug combinations
- TNO - research (NL)
  - Characteristics for motor vessels
  - CCR - I emission reduction factors
- VITO - research (BE)
  - + 13 % for auxiliary engines
- SCENES
  - Inland Waterway Network

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2. Emission factors used in TREMOVE :  
Information Sources

Detailed Calculation Methodology (ARTEMIS-DTU) :

- (Friction) Resistance =
  - f(ship dimensions, draught, speed, waterway width and depth)
- Propulsion Power
- Engine Power
- Fuel Consumption (using specific fuel cons factors kg/kWh)
- Emissions (using specific emi factors - g/kg fuel )
  - ↳ Dutch STOWA - pre-CCR I
  - Assuming gasoil - 0.2% sulphur

Thus need for input values

- ~ ship dimensions
- ~ speed, draught, waterway width and depth

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2. Emission factors used in TREMOVE :  
Information sources

Input for ship dimensions :

	Length	Breadth	Draught	max weight	% draught (no load)
motorship < 250	38.85	5.31	2.42	353	0.45
motorship 250-400	53.65	6.63	2.42	546	0.54
motorship 400-650	59.84	7.06	2.54	700	0.51
motorship 650-1000	70.95	8.33	2.81	963	0.59
motorship 1000-1500	80.35	8.2	2.69	1181	0.44
motorship 1500 - 3000	86.99	9.39	2.86	1475	0.45
motorship > 3000	106.95	11.25	3.35	2711	0.42
Pusher < 3000	185	11.40	2.50	4000	0.4
Pusher > 3000	190	22.8	2.5	7700	0.4

Pusher < 3000 = GMS ship + one Europe II barge (in line)  
 Pusher > 3000 = Pusher ship + 2 ' barges  
 No further disaggregation of > 3000 pushers possible in veh stock module

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2. Emission factors used in TREMOVE :  
Assumptions

	"Shallow"	"Deep"
	• Ship draught + 1 m • 6 * Ship width • not for pusher > 3000	• 6m depth • 100m width • (pusher > 3000 350 m)
<b>Loaded</b> (max draught)	11 km/h over land	13 km/h over land
<b>Empty</b> (min draught)	12 km/h over land	15 km/h over land

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2. Emission factors used in TREMOVE :  
Values for 1500-3000 ton motorship

	"Shallow"	"Deep"
	• Ship draught + 1 m • 6 * Ship width • not for pusher > 3000	• 6m depth • 100m width • (pusher > 3000 350 m)
<b>Loaded</b> (max draught)	12.4 kg CO2 /vkm	12.3 kg CO2 /vkm
<b>Empty</b> (min draught)	7.8 kg CO2 /vkm	10.1 kg CO2 /vkm

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## 2. Emission factors used in TREMOVE : Assumptions

Estimate needed for % fully loaded and % empty :  
Estimated as being equal to avg ship load factor

Avg emi factor (shallow) = 7.8 + avg load factor \* 12.4

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## 2. Emission factors used in TREMOVE : Assumptions

Thus : Assumed a linear relationship

Avg load factor 100% Load

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## 2. Emission factors used in TREMOVE : Assumptions

Estimate needed for % vkm on shallow water :  
No EU wide dB on ship movements linked to local waterway depths and widths

Assumptions  
100% deep : AT and HU (Donau); CH Rhine; CZ (Moldau)  
75 % deep : BE, DE, IT, NL, NO

Avg emi factor(vessel type) = % shallow \*(7.8 + avg load factor \* 12.4)  
+ % deep \*(10.1 + avg load factor \* 12.3)

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## 2. Emission factors used in TREMOVE : Values : Shallow ; Fully Loaded

	CO	VOS	NOx	PM	SO2	CO2	N2O	CH4	NMVOs
Cargo 1	5	5	93	6	5	4866	1	0	5
Cargo 2	6	6	120	8	7	6259	1	0	6
Cargo 3	7	7	138	9	8	7182	2	0	7
Cargo 4	9	9	175	12	10	9120	2	0	9
Cargo 5	10	10	210	14	12	10935	2	0	10
Cargo 6	12	12	238	16	13	12423	3	0	12
Cargo 7	17	17	337	22	19	17572	4	1	16
Pusher 1*6	50	50	991	66	56	51639	11	2	46
Pusher 7	54	54	1077	72	61	56174	12	2	52

grammes per veh.km

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## 2. Emission factors used in TREMOVE : Values : Shallow ; Empty

	CO	VOS	NOx	PM	SO2	CO2	N2O	CH4	NMVOs
Cargo 1	3	3	50	3	3	2831	1	0	3
Cargo 2	4	4	82	5	5	4293	1	0	4
Cargo 3	5	5	91	6	5	4751	1	0	5
Cargo 4	6	6	117	8	7	6101	1	0	6
Cargo 5	7	7	132	9	8	6912	2	0	7
Cargo 6	7	7	150	10	8	7806	2	0	7
Cargo 7	10	10	203	14	12	10604	2	0	10
Pusher 1*6	24	24	486	32	28	25334	6	1	23
Pusher 7	37	37	743	50	42	38780	9	1	36

grammes per veh.km

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## 2. Emission factors used in TREMOVE : Values : Deep ; Fully Loaded

	CO	VOS	NOx	PM	SO2	CO2	N2O	CH4	NMVOs
Cargo 1	4	4	89	6	5	4622	1	0	4
Cargo 2	6	6	114	8	6	5946	1	0	6
Cargo 3	7	7	132	9	7	6864	2	0	7
Cargo 4	8	8	166	11	9	8675	2	0	8
Cargo 5	10	10	200	13	11	10452	2	0	10
Cargo 6	12	12	236	16	13	12337	3	0	12
Cargo 7	18	18	355	24	21	19062	4	1	17
Pusher 1*6	37	37	731	49	41	38121	8	1	36
Pusher 7	54	54	1077	72	61	56174	12	2	52

grammes per veh.km

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## 2. Emission factors used in TREMOVE : Values : Deep ; Empty

	CO	VOS	NOx	PM	SO2	CO2	N2O	CH4	NMVOs
Cargo 1	3	3	59	5	4	3586	1	0	3
Cargo 2	5	5	106	7	6	5512	1	0	5
Cargo 3	6	6	119	8	7	6184	1	0	6
Cargo 4	7	7	149	10	8	7760	2	0	7
Cargo 5	8	8	167	11	9	8707	2	0	8
Cargo 6	10	10	195	13	11	10171	2	0	10
Cargo 7	14	14	281	19	16	14639	3	1	13
Pusher 1*6	29	29	586	39	33	30545	7	1	28
Pusher 7	37	37	743	50	42	38780	9	1	36

grammes per veh.km

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## 2. Emission factors used in TREMOVE : Values :CCR - I standard (2002)

- Reduction factors for CCR - I technology  
Derived comparing TNO figures from 2002 engine measurements with Artemis assumptions

HC	50.00%
CH4	50.00%
NMHC	50.00%
NOx	42.00%
PM	60.00%
SOx	100.00%
N2O	100.00%
CO2	100.00%
CO	100.00%

- CCR - I ships will be introduced in vehicle stock module (+ 2.5% per year)

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## 4. Further work

- Implementation in model code and input updated emission factors  
CCR-I penetration
- Further contacts with
  - NL government
  - BE and EU inland navigation organisations
  - TNO
- Country inputs, especially on activity on shallow vs deep waterways, welcome !!!

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