railistics

Project Report
Benchmark of Environmental Emission for Railway Hinterland Transport from the Port Of Hamburg

Working group

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Report for

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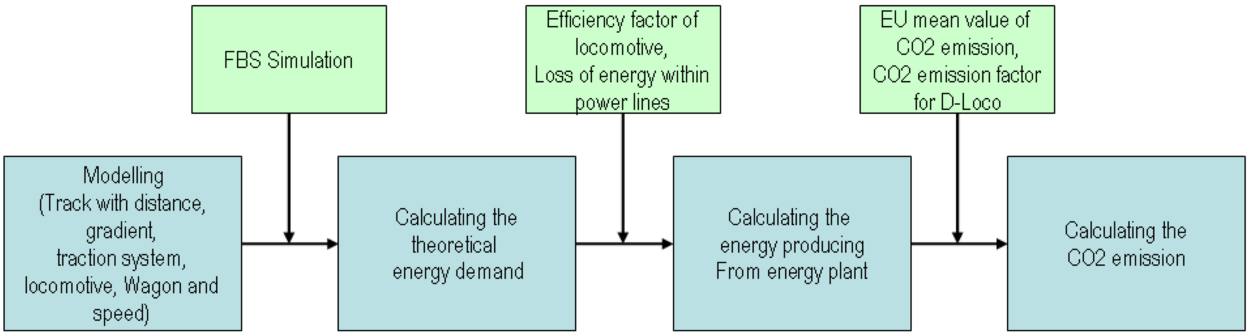
1. General

One of the most characterizing things in our modern industries is the standardized and quick exchange of goods all over the world. Ports play an important role in this world of globalized transport as they have become the "factories" for the handling of huge amounts of goods at a high level of technology and automation. But even as important as the turnover of goods in the ports is the linking of the ports to their Hinterland. The whole transport-chain has to be fast, reliable, of a high quality level and last but not least for a sustainable development it has to be environmental friendly.

For this reason Hamburg port Authority has authorised Railistics GmbH to undertake a benchmark study relating to the environmental emission (especially the emission of CO_2) between the Hamburg Port and some ports on the Adriatic Sea by railway transport. The aim of the benchmark is to independently compare the advantages and disadvantages of introducing more freight transport on railways from the Hamburg Port and from some ports on the Adriatic Sea.

2. Project Methodology



The transport corridor for benchmarking was chosen by the Hamburg Port Authority AöR. The important factors of the selected corridors are specified (distance, gradient, traction system, maximal train length) accordingly. With the software FBS (FahrplanBearbeitungsSystem) developed by iRFP (Institute for traffic planning systems, a spin-off from Dresden University Faculty of Transportation and Traffic Sciences) a sample of train running is simulated. FBS is a software for operational planning of railway systems which is used by railway undertakings, consultants and universities all over the world. From the simulation the theoretical energy demand can be calculated. Under consideration of the efficiency factor of locomotive and loss of energy within power lines the energy produced from energy plant can be calculated. By using the EU mean value of CO_2 emission for energy production and the CO_2 emission factor for diesel locomotives the CO_2 emission of a single run for the selected transport corridor can be achieved. This CO_2 emission value is used as the appraisal criterion for the benchmark.

3. Benchmark

	Hamburg – Prague	**Koper – Prague via Austria**	**Koper –Prague via Hungary**	**Hamburg – Munich**	**Koper – Munich**	**Venice – Munich (Brenner line)**	**Venice – Munich (Tauern line)**	**Hamburg – Budapest**	**Koper - Budapest**
Distance [km][1]	700	989	1020	790	610	560	574	1290	680
Relative distance (Hamburg = 100 %)	100 %	141 %	146%	100 %	77 %	71 %	73 %	100 %	53 %
Route	**Germany** (HH – Dresden) – **Czech** (-Prague)	**Slovenia** (Koper – Ljubljana) - **Austria** (Graz – Wien) – **Czech** (Breclav - Kutna Hora – Prague)	**Slovenia** (Koper – Ljubljana – Pragersko) - **Hungary** (Hodoz - Szombathely) – **Slovakia** (Bratislawa) – **Czech** (Kutna Hora – Prague)	HH – Munich	**Slovenia** (Koper – Ljubljana) – **Austria** (Villach - Tauernbahn - Salzburg) – **Munich**	**Italy** (Venezia – Verona – Brenner) **Austria** (Insbruck – Kufstein) **– Munich**	**Italy** (Venezia – Udine – Tarviso – **Austria** (Villach – Tauernbahn – Salzburg) **– Munich**	**Germany** (HH-Dresden) – **Czech** (Prague – Brno) – **Slovakia** (Bratislava) – **Hungary** (Rajka – Budapest)	**Slovakia** (Koper – Ljubljana – Pragersko) - **Hungary** (Hodoz – Boba – Budapest)
Special gradient (>12,5 ‰) [‰]	/	Koper – Presnica (Koperbahn): 25 ‰ Presnica – Divaca: 20‰	Koper – Presnica (Koper line): 25 ‰ Presnica – Divaca: 20‰	/	Koper – Presnica: 25 ‰ Presnica – Divaca: 20‰ Karawanken line: >25 ‰ Tauern line: 30 ‰	Brenner: 31 ‰	Udine – Tarvisio: 19 ‰ Tauern line: 30 ‰	/	Koper – Presnica: 25 ‰ Presnica – Divaca: 20‰

[1] According to Railneteurope.com and operators' information

	Hamburg – Prague	Koper – Prague via Austria	Koper –Prague via Hungary	Hamburg – Munich	Koper – Munich	Venice – Munich (Brenner line)	Venice – Munich (Tauern line)	Hamburg – Budapest	Koper - Budapest
Track length with special gradient [km]	/	Koper- Presnica: 29 km Presnica – Divaca: 16 km	Koper- Presnica: 29 km Presnica – Divaca: 16 km	/	Koper – Presnica: 29 km Presnica – Divaca: 16 km Karawanken line: 24 km Tauern line: 79 km	Brenner line: 37km	Udine – Tarvisio: 89 km Tauern line: 79 km	/	Koper- Presnica: 29 km Presnica – Divaca: 16 km
Length of diesel track [km]	/	/	Pragersko – Hodos – Hegyeshalom: 289 km	/	/	/	/	/	Pragersko – Hodos – Boba: 213 km
Max. length of train [m][1]	600	500	500	600	500	540	600	600	500
Max. gross tonnage of train [t] [1]	1600	1300	1300	1600	1100	1300	1300	1600	1300
Max. Loading capacity [t] [2]	1000	800	800	1000	600	750	700	1000	800
Max. number of TEU relating to train length[3]	90	75	75	90	75	81	90	90	75

[2] Estimation
[3] Estimation based on length and weight restrictions; assumption: weight is 12t/TEU

	Hamburg – Prague	Koper – Prague via Austria	Koper –Prague via Hungary	Hamburg – Munich	Koper – Munich	Venice – Munich (Brenner line)	Venice – Munich (Tauern line)	Hamburg – Budapest	Koper - Budapest
Max. number of TEU relating to train tonnage	83	66	66	83	50	62	58	83	66
Traction	Germany: AC 15 kV Czech: DC 3 kV	**Slovenia** (Koper – Pragersko) Electric (DC 3 kV; weight restriction) **Austria:** 15 kV AC; **Czech** (Breclav – Kutna Hora) Electric (AC 25 kV) Kutna Hoha – Prague: Electric (DC 3 kV)	**Slovenia** (Koper – Pragersko) Electric (DC 3 kV; Speed restriction) **Hungary**: partly Diesel **Slovakia**: Electric (AC 25 kV **Czech** (Kuty – Kutna Hora) Electric (AC 25 kV) Kutna Hoha – Prague: Elektric (DC 3 kV)	Electric	**Slovenia** (Koper – Pragersko) Elektric (DC 3 kV; Speed restriction) **Austria, Germany**: Electric AC 15 kV	**Italy**: Elektric DC 3 kV **Austria, Germany**: Electric AC 15 kV	**Italy**: Elektric DC 3 kV **Austria, Germany**: Electric AC 15 kV	Electric	**Slovenia** (Koper – Pragersko) Electric (DC 3 kV; Speed restriction); **- Hungary**: Pragersko – Hodos – Boba: Diesel Boba – Budapest: Electric (AC 25 kV)
Locomotive details		2. locomotives for Koper-Presnica necessary 2 changes of locomotive necessary Partly single track	2. locomotives for Koper-Presnica necessary 4 changes of locos necessary parlty diesel track partly single track		2. locomotives for Koper-Presnica necessary 2. locomotives on Tauern track necessary	2. locomotives on Brenner track necessary Brenner-Basis tunnel: realistic until 2030	2. locomotives on Tauern track necessary Partly single track		2. locomotives Koper-Presnica necessary Partly single track

	Hamburg – Prague	Koper – Prague via Austria	Koper –Prague via Hungary	Hamburg – Munich	Koper – Munich	Venice – Munich (Brenner line)	Venice – Munich (Tauern line)	Hamburg – Budapest	Koper - Budapest
Codification for combined traffic	Hamburg – bad Schandau: C80/C410 Bad Schandau – Lovosice: C70/C400 Lovosice – Prague: C47/377	Koper – Ljubljana – Spielfeld: C50/358 Spielfeld – Breclav: C80/410 Breclav – Prague: C47/360	Koper – Grobelno: C 73/400 Grobelno – Pragersko: P/C 90/410 Pragersko – Hodos: P/C 80/400 Hodos – Breclav: C80/410 Breclav – Prague: C47/360	HH – Munich: C 80/410	Koper – Ljubljana: C 73/400 Ljubljana – Villach: C 50/380 Villach – Munich: C 80/410	C80/410	C80/410	Hamburg – bad Schandau: C80/410 Bad Schandau – Lovosice: C70/400 Lovosice – Bernhardsthal: C47/360 Bernhardsthal – Budapest: C 80/410	Koper – Ljubljana – Spielfeld: C50/358 Spielfeld – Budapest: C 80/410
Simulated energy demand at rail/wheel interface	17771 kWh	27466 kWh	27330 kWh	20048 kWh	23534 kWh	16773 kWh	23313 kWh	32817 kWh	18917 kWh
Energy produced by power plant	23142 kWh	36169 kWh	43928 kWh	25637 kWh	31059 kWh	22535 kWh	30899 kWh	43212 kWh	30989 kWh
CO2 emission for each run	9026 kg	14106 kg	15103 kg	9998 kg	12113 kg	8788 kg	12051 kg	16853 kg	10588 kg
CO2 emission per freight tonnage by max. loading	9,03 kg/ton	17,63 kg/ton	18,88 kg/ton	10,00 kg/ton	20,19 kg/ton	11,72 kg/ton	17,22 kg/ton	16,85 kg/ton	13,24 kg/ton
CO2 emission per TEU	108,74 kg/TEU	213,73 kg/TEU	228,83 kg/TEU	120,46 kg/TEU	242,26 kg/TEU	141,75 kg/TEU	207,77 kg/TEU	203,04 kg/TEU	160,43 kg/TEU
CO2 emission per train-km	12,89 kg/train-km	14,26 kg/train-km	14,81 kg/train-km	12,66 kg/train-km	19,86 kg/train-km	15,69 kg/train-km	20,99 kg/train-km	13,06 kg/train-km	15,57 kg/train-km

4. Results of Benchmark

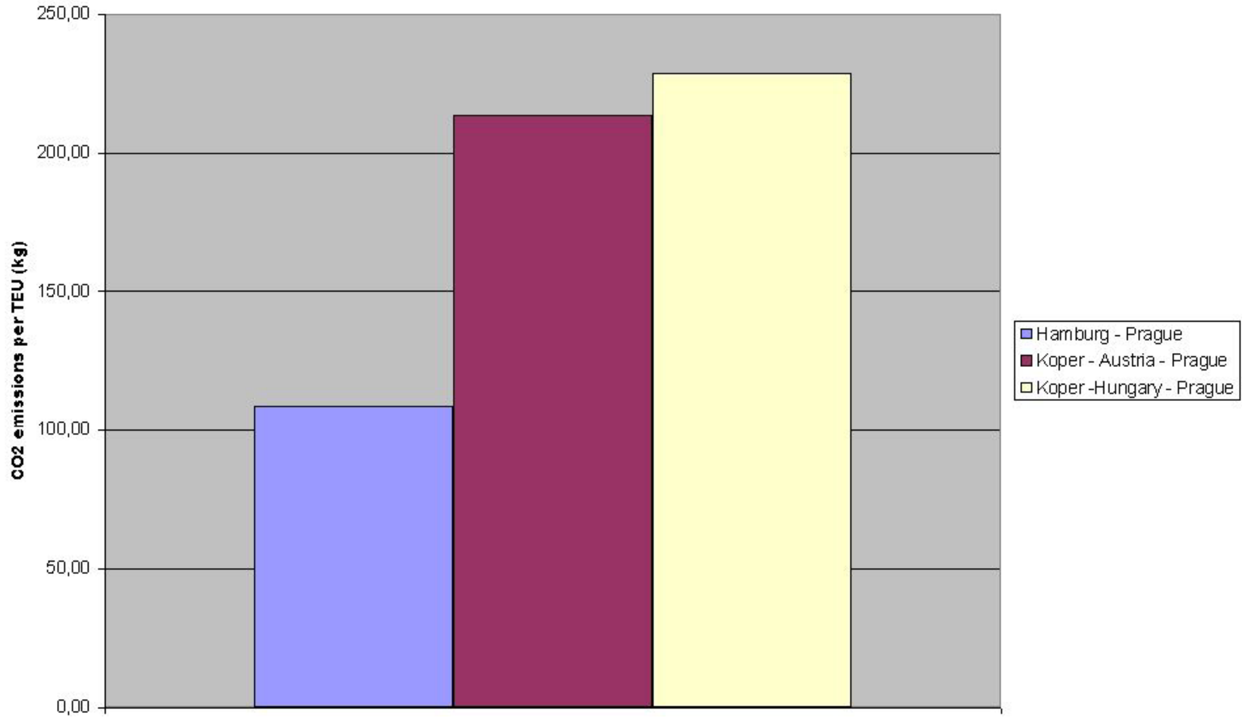
Railway traffic from Hamburg benefits from the favourable geographic conditions of the areas the main departure routes to eastern and south-eastern Europe lead through. The railway-tracks run along naturally flat gradients, partly along river courses and for the most part far away from mountain ridges. From an ecological point of view, this is of advantage as on the one hand, interventions in nature and fragile landscapes such as laying rail tracks (including the construction of tunnels, bridges and cuttings) are not necessary. On the other hand, rail routes with a slight longitudinal gradient already exist, thus enabling operators to fully utilise the system advantages the railway offers and move large volumes of freight at low energy input. Apart from the short distance to the markets, another ecological plus is that most of the railway lines are electrified.

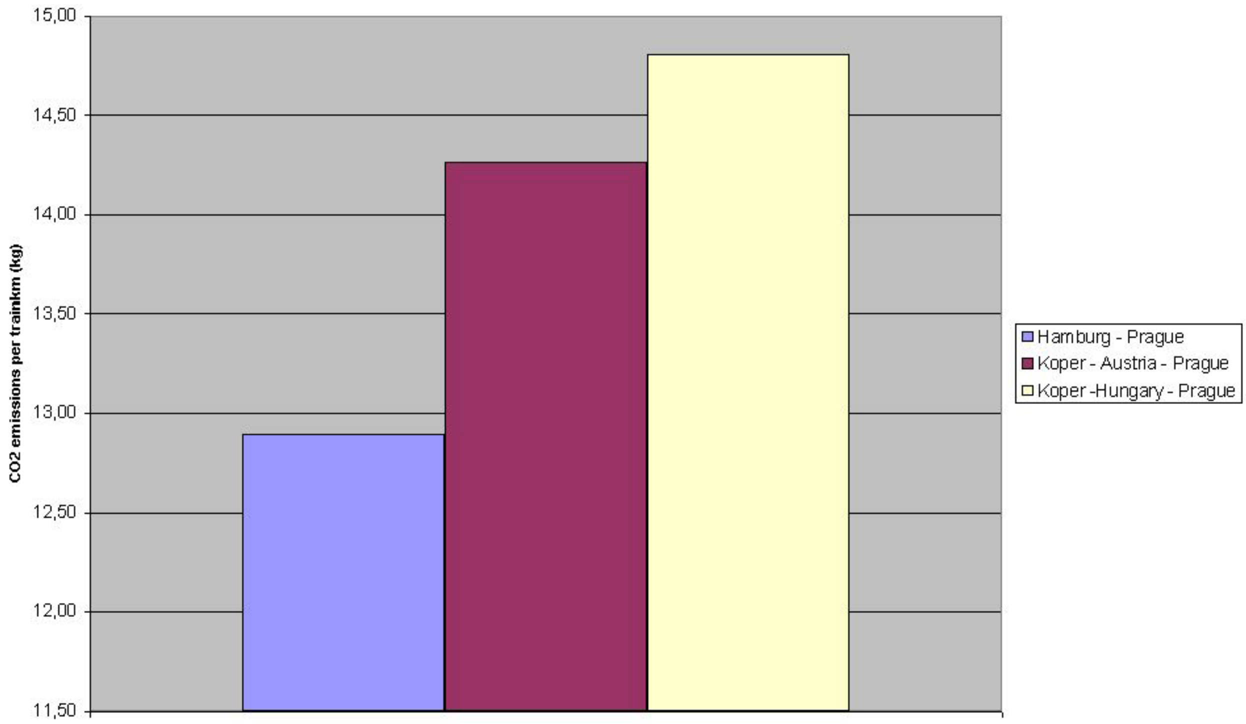
The above becomes more evident when one compares the energy consumption and pollutant emission values of the connections in Hamburg's hinterland with those of the routes that cross mountain passes.

The average container train travelling through Hamburg's hinterland is pulled by an electric locomotive, is roughly 600 m long and transports approximately 1,600 t of cargo, which is equivalent to over 90 standard containers (TEU).

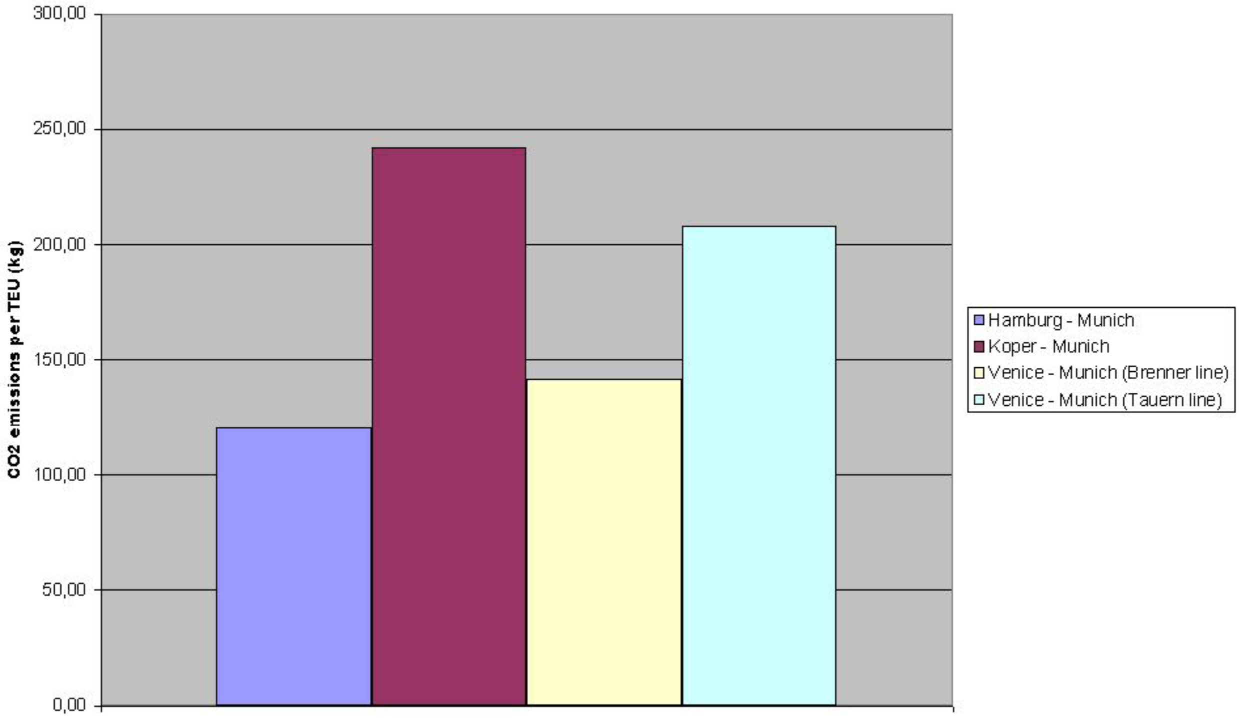
A train coming from the Mediterranean area that has to cross the mountain ranges of the Alps to get to the north, that is about 500 m long and weighs from 1,100 t to 1,300 t can move 50 to 80 TEU. Depending on how long and how steep the gradient is the train has to climb, up to three locomotives are required to pull it (sample gradients: Brenner 31‰, Tauern line 30‰, Koper line 25‰). These transports have a particularly negative impact on the environment if, due to lack of electrification or frequent change of rail systems at state borders and in part even within one country, diesel traction is used.

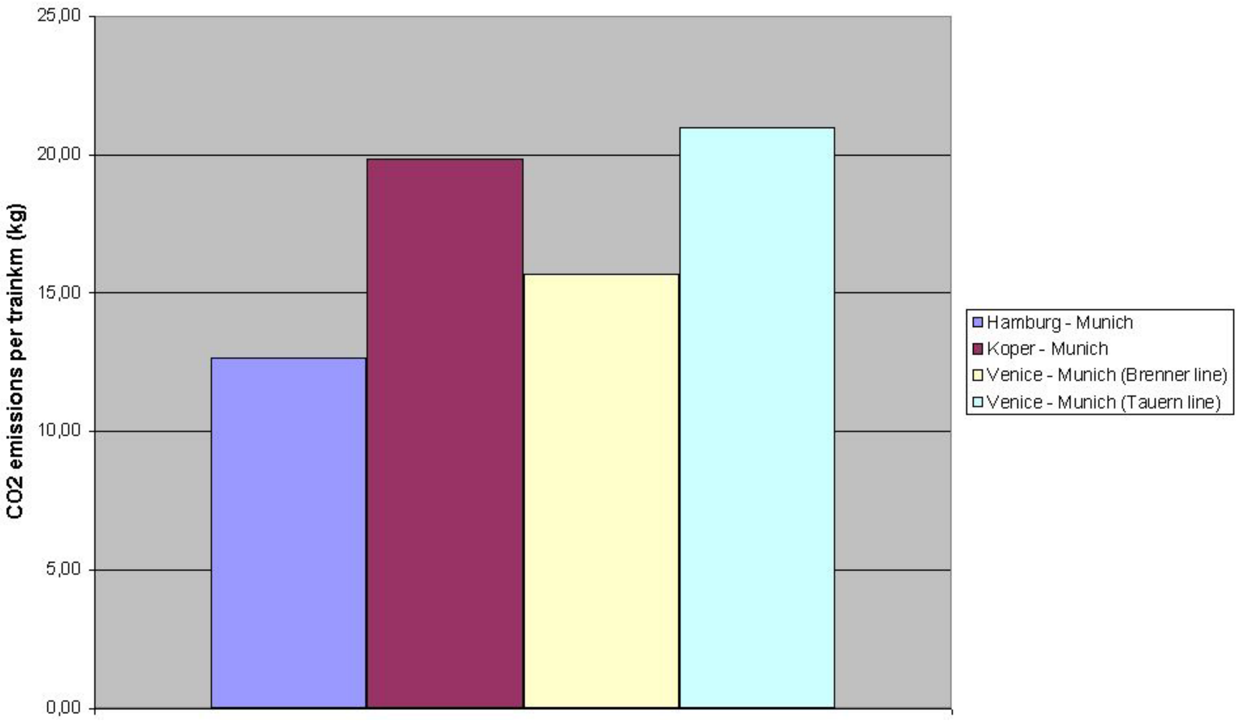
4.1. To Prague


250,00
200,00
150,00
100,00
50,00
0,00
CO2 emissions per TEU (kg)
Hamburg - Prague
Koper - Austria - Prague
Koper -Hungary - Prague

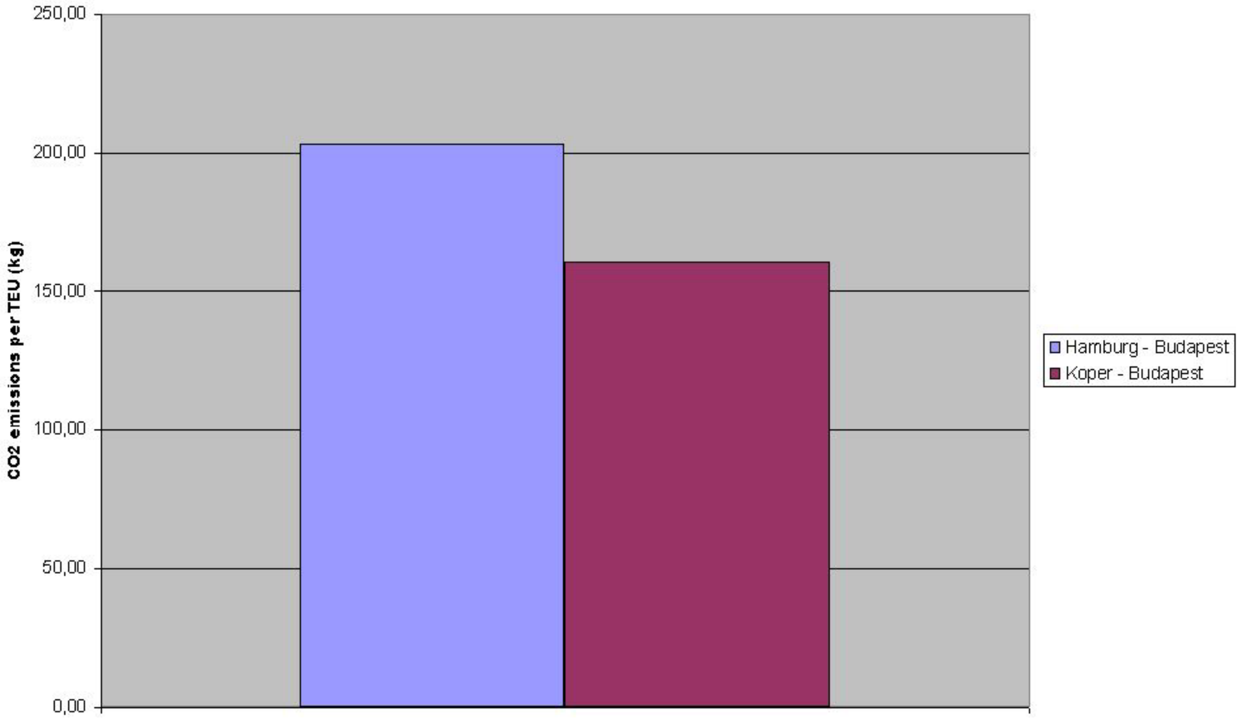

15,00
14,50
14,00
13,50
13,00
12,50
12,00
11,50
CO2 emissions per trainkm (kg)
Hamburg - Prague
Koper - Austria - Prague
Koper -Hungary - Prague

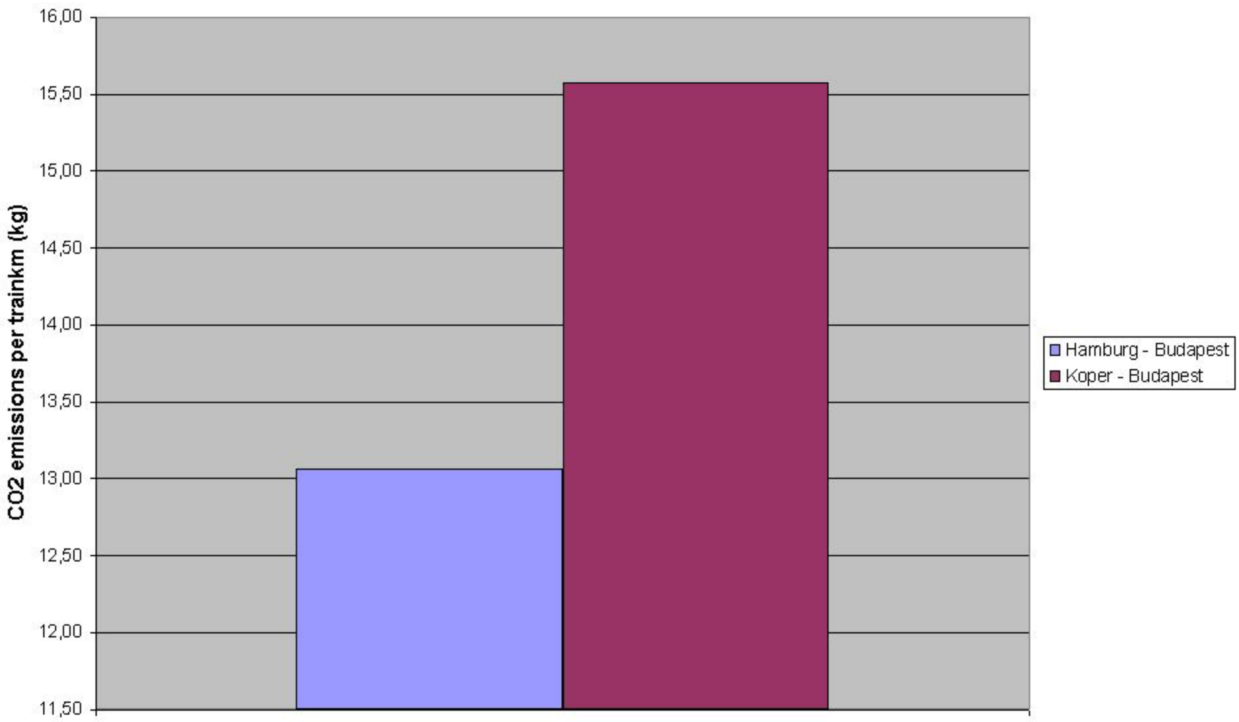
4.2. To Munich


300,00
250,00
200,00
150,00
100,00
50,00
0,00
CO2 emissions per TEU (kg)
Hamburg - Munich
Koper - Munich
Venice - Munich (Brenner line)
Venice - Munich (Tauern line)


25,00
20,00
15,00
10,00
5,00
0,00
CO2 emissions per trainkm (kg)
Hamburg - Munich
Koper - Munich
Venice - Munich (Brenner line)
Venice - Munich (Tauern line)

4.3. To Budapest





5. Notices to the Benchmark

- The distance was gathered from Railneteurope.com. For the segments which do not belong to the Corridor, the distance was calculated from the train path price system EICIS.
- The Corridor "Koper – Prague via Hungary" currently used by some trains is not the best way, although it is used by railway undertakings because of lower pricing than the corridor via Austria. On the Austria corridor the diesel track can be avoided and the locomotive changeover time can be reduced. Railistics believes that the alternative corridor is more eligible for a benchmark comparison.
- The maximal length of train was calculated according to the information on Railneteurope.com and information from railway operators.
- The maximal gross train tonnage was calculated according to the information on Railneteurope.com.
- The maximal loading capacity was calculated according to the values of maximal length of train.
- The maximal quantity of TEU was calculated according to the maximal length of train and maximal loading capacity.
- Codification for combined traffic: Gathered from the profile map of technical commission of Interunit.
- Theoretical energy demand: simulated with software FBS under following assumptions:
    - Locomotive: TRAXX for electrified tracks, diesel-electric locomotive (power 1325 kW) for diesel tracks
    - Wagons: Container Wagon with four axles
    - Train length: 500 m
    - Average Loading quote: 2/3
    - Mean running speed: 60 km/h
    - Gradient for normal tracks: 2‰
    - Mean gradient for steep tracks: Mean value of the maximal gradient
- The energy produced from the power plant was calculated in sections according to the different tractions systems with following assumptions:
    - Efficiency factor of modern E-Loco: 85% (Experience value of Railistics, indicated from manufacturer and railway undertakings)
    - Efficiency factor of diesel locomotive: 40% (Experience value of Railistics, indicated from manufacturer and railway undertakings)

- Fuel consumption of D-loco: 200 g /kWh (Experience value of Railistics, indicated from manufacturer and railway undertakings)
- Loss of energy in power line of 15 kV AC: 8% (interview experts)
- Loss of energy in power line of 25 kV AC: 6% (interview experts)
- Loss of energy in power line of 3 kV DC: 16% (interview experts)

- CO_2 emission:
  - For energy plants the mean value of EU of 2007 (0,39 kg/kWh) is used (Source: Austria Press Agency)
  - For diesel locomotives 0,263 kg/kWh is used (Source: Presentation from International Conference on CLEAN ELECTRICAL POWER, 2007)

6. References

- FBS http://www.irfp.de/english/fbs/index.html
- Railneteurope http://www.railneteurope.com/
- EICIS http://www.railneteurope.com/index.php/eicis.html
- Interunit http://www.uirr.com/?action=page&page=61&title=INTERUNIT
- Austria Press Agency http://www.apa.co.at/
- International Conference on CLEAN ELECTRICAL POWER 2007, Capri (Italy)