A comparative study on CO_2 emissions in door-to-door combined transport

Analysis of the current CO_2 saving potentials in the transport sector

On behalf of

UIRR
UNION INTERNATIONALE POUR LE TRANSPORT COMBINE RAIL-ROUTE

d-fine

analytical. quantitative. tech.

Door-to-door combined transport has the current potential to save up to 90% of CO_2 emissions compared with transport on the road only

Management Summary

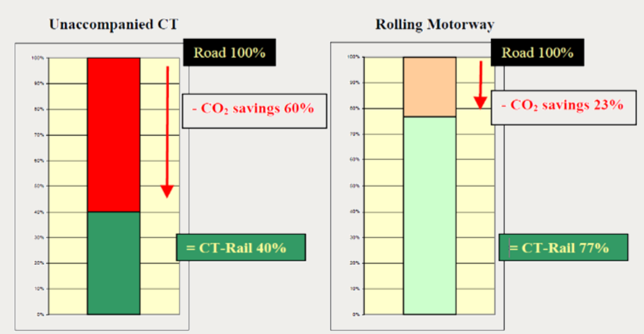
- This study analyses the **current potential to save CO_2 emission** by transporting goods door-to-door with combined transport instead of using road transport.
- Today, several CO_2 calculators are available to perform comparative studies, e.g., EcoTransIT.
- This study uses existing calculators to determine the possible CO_2 and to establish scenarios that are defined by market-ready technologies (e.g., CO_2 emissions for Euro VI trucks) as well as the current energy mix per country.
- The structure of the study is as follows:
  - **Ten relations** have been selected as calculation examples in accordance with their relevance for transporting goods within the EU.
  - **Two scenarios** have been defined w.r.t. infrastructural and regulatory requirements as well as statistical freight parameters.
  - **Eight existing calculators** have been used to determine the CO_2 emissions per relation, scenario and transport mode. Their results were used following a specified calculation methodology for the determination and benchmarking of the resulting emission values.
- The study shows that
  - door-to-door combined transport has the potential **to save between 63 % and 90 %** of the equivalent CO_2 emissions of unimodal road transport for the selected relations in the parametrised transport scenarios and
  - mainly two effects contribute to the CO_2 savings: greater energy efficiency in general and better use of zero-carbon energy.
- The study was conducted by d-fine in close cooperation with UIRR (International Union for Road-Rail Combined Transport s.c.r.l.). Financing by UIRR is gratefully acknowledged. In addition, we thank SGKV, tranporeon, IVE mbH, and KombiConsult for discussion and contribution to the study as well as the organisations providing the emission calculators.

01 Scope of the study and general approach

Combined transport allows emission savings compared to road transport – a realistic picture is obtained by updating to modern standards

PACT[01] programme

- Final report *Combined Transport (CT) CO_2 Reduction* (2003) using 2001 facts and data
  - Demonstrated advantage of door-to-door CT to pure road transport for **20 analysed relations**
  - Door-to-door CT was found to **reduce CO_2 emissions to 45 % on average** for all relations (road-only as 100% reference)



System advantage of door-to-door CT-rail compared to road (100%) [01]

2003

2021

What has changed since 2003

- **Energy input mix** for electricity production in the EU countries
- New state-of-the-art **powertrain technologies for road transport**
- **Volumes in CT (domestic and international) increased by approx. 90 %** in the period from 2009 to 2019[02]
- Increased **capabilities for the use of long (740m) rail freight trains**
- New **state-of-the-art terminals** allowing electrically powered transhipments of 740m-long electric rail freight trains
- Updated statistical distribution of **road leg distances**[02]

Objective of the 2021 Update

- **Calculation of CO_2 emissions** via the energy consumption for the door-to-door transport by truck compared to road/rail CT
- Use of **existing calculators** for energy and emissions assessment for global freight transport on road and rail as well as for terminal operations
- Use of current statistical values to achieve comparability for different relevant relations
- Demonstration and comparison of the potential of existing and widely used technologies and infrastructures for road and rail

The objective of this study is to evaluate the carbon footprint and pro rata energy consumption for door-to-door CT using advanced calculators and recent data and contrasting it with the unimodal road alternative.

Assessing the current environmental performance and the potentials of CT compared to road only in door-to-door transport

Updating existing results for cases of practical relevance following a pragmatic approach to create a realistic picture

Scope

10

Representative relations depicting CT in Europe

ILUs

Transport in intermodal loading units, i.e. swap bodies, containers, and semi-trailers

CT vs. Road

Benchmarking of door-to-door CT compared to pure door-to-door road freight transport

Approach

2 Scenarios

Heavy Weight Scenario[03]

Good practice ILUs and wagons, max. permissible laden weight

Statistical Scenario

Statistical distribution of ILUs, load factors, and empty trips

CO_2 calculation[04]

Existing CO_2 calculators

EcoTransIT[05]

SGKV SYSLOG+[06]

Further free and commercial tools for benchmarking

Most recent data

Updated emissions with data on electricity generation[07]

Aim

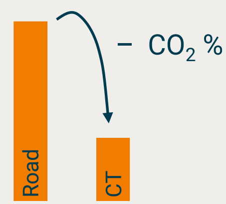
Bottom-up

CO_2 emissions based on energy consumption

Energy provision (well-to-tank, WTT) + **Vehicle efficiency** (tank-to-wheel, TTW)

= **Well-to-Wheel** (WTW)

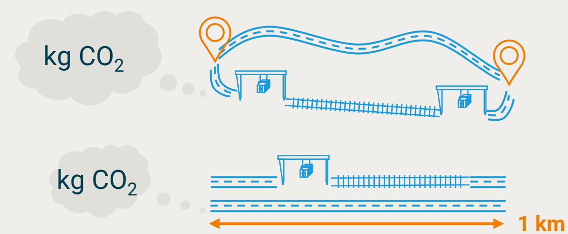
Road as a reference



CO_2 emission

Comparability

emissions per tonne and tonne-kilometre[07]



CO2 EMISSIONS IN DOOR-TO-DOOR CT

02 Details on the methodology

Selection of relations, calculation details, and scenario definition

Four consecutive steps including an comprehensive energy and emission assessment for ten relations

Structure of the study

01 Selection of relations

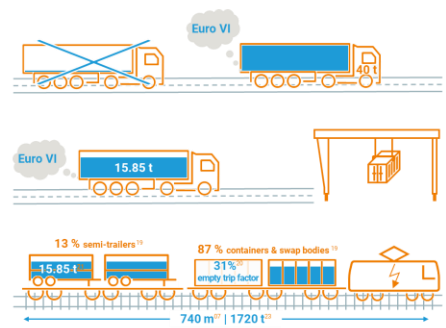
- Relevant and representative relations
- Consultation with UIRR members
- Typical start and end points in terminal catchment areas
- Representative distances in terms of statistics

02 Selection of emission calculators

Calculator	Direct access	Transport
EcoTransIT	Yes	Road, Rail, Ocean, Air
PTV	No	Road
SGKV	No	Road, Rail, Short Sea
carboncare	Yes	Road, Rail, Ocean, Air, Barge
climatecare	Yes	Road, Air, Ocean
DHL	Yes	Air Ocean, Road, Rail
Interreg	Yes	Road, Rail, Ocean, Air, Pipelines
NTMCalc	Basic Yes, Advanced for Members	Road, Rail, Ocean, Air, Custom
GEODIS	Yes	Road, Rail, Air, Ocean, Barge
GHG	Yes	Road, Rail, Air, Ocean, Barge
GreenRouter	No	Road, Rail, Ocean, Air
TK'Blue – GHG calculator	No	Road, Rail, Ocean, Air
Via Green Program (VGP)	No	Road, Rail, Ocean, Air
Kühne+Nagel	Yes	Road, Rail, Ocean
LOG-NET	Yes (not useable)	Road, Rail, Ocean
DB Schenker	Yes	Land, Ocean, Air
BigMile	No	Road, Rail, Ocean, Air
REff Assessment Tool	No	Only logistic sites
ITEC Kombiconsult	No	Only intermodal terminals

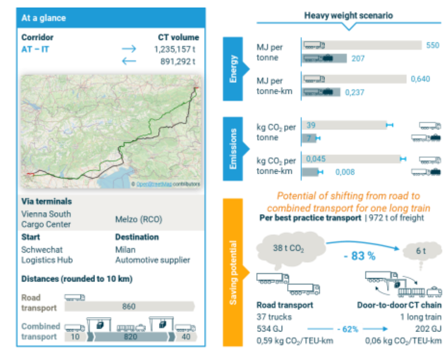
- Inspection of available modes
- Access for data provision
- Methodology and level of detail of parameterization
- Procedure for updating re-sults for most recent country specific energy mixes

03 Definition of scenarios



- Up-to-date statistics to reflect the actual transport
- Potential of current technolo-gies and infrastructures for road and rail using the best possible conditions
- Parametrisation of vehicles, payload, units, empty runs

04 Energy and emission assessment



- Energy use and emissions for door-to-door road transport and door-to-door CT
- Common metrics and projection to a particular door-to-door CT chain
- Evaluation and comparison for all relations

Relations selected in accordance with their relevance for transporting goods within the EU

01

10 relations have been selected according to the following constraints

Representative

Depicting the demand in Europe[01, 02]

TEN-T[03] Corridors

Considerable coverage of the nine corridors

Blue Banana Region

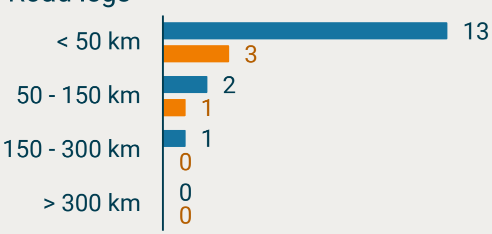
Connecting economic & metropolitan centres

Start and end points

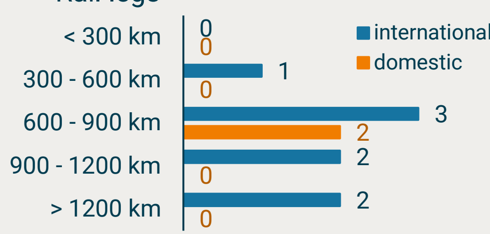
- in industrial and commercial areas in the catchment area of the terminals
- with the focus to achieve typical road leg distances

Statistical distribution of the length of road- and rail-legs

Road legs[04, 05]



Rail legs[06, 07]



The road and rail leg distances of the selected relations represent the length categories that account for significant proportions CT in Europe. Deviations from the actual percentage distribution can be explained by characteristics of the CT market and its development[05, 07].

Points of origin and destination as well as road and rail legs for the selected relations

01

	01 Vienna - Melzo	02 Malmö - Duisburg	03 Rotterdam - Vienna	04 Cologne - Busto	05 Munich - Verona	06 Hamburg - Budapest	07 Valenton - Miramas	08 Dourges - Lyon	09 Ludwigsh. - Barcelona	10 Venlo - Poznan
Locational Properties										
Start latitude	48,14	56,68	51,95	51,01	48,18	53,51	48,91	50,66	49,44	51,44
Start longitude	16,49	16,28	4,15	6,98	11,56	9,98	2,33	3,00	7,69	5,71
Terminal 1	Vienna South Cargo Center	Malmö KT	Rotterdam RSC	Köln Eiffeltor	München Riem	Hamburg Burchardkai	Valenton	Delta 3 Dourges	Ludwigs-hafen Contargo	Cabooter rail terminal Kal-denkirchen
Terminal 2	Melzo (RCO)	Samskip Mul-timod. Termi-nal Duisburg	WienCont	Busto Arsizio-Gallarate	Verona Interterminal	Budapest Metrans	Miramas	Lyon-St. Priest	Barcelona Morrot	CLIP Contai-ner Terminal Swarzędz
Destination latitude	45,50	51,38	48,18	45,64	45,42	47,42	43,61	45,69	41,37	52,40
Destination longitude	9,41	6,68	16,47	8,84	10,92	19,05	4,99	4,91	2,17	17,12
Distances[08]										
Road transport	856 km	1166 km	1197 km	832 km	403 km	1241 km	772 km	684 km	1226 km	865 km
CT road leg 1	13 km	278 km	29 km	19 km	14 km	5 km	22 km	33 km	70 km	45 km
CT road leg 2	34 km	27 km	7 km	38 km	2 km	92 km	54 km	25 km	8 km	7 km
CT rail leg	823 km	922 km	1180 km	838 km	441 km	1208 km	709 km	631 km	1342 km	847 km

EcoTransIT is a prominent calculator for CO_2 emissions in the transport sector

02

We selected the emission calculators according to the following criteria.

23 calculators have been evaluated[01], of which at least

- 13 comply with EN 16258[03]
- 7 are based on EcoTransIT
- 12 are commercial tools
- 6 perform routing
- 3 consider transhipment

8 calculators have been selected[01] considering availability, coverage of modes and facilitation of benchmarking, among these EcoTransIT and the SGKV SYSLOG[02] tool

Precise parameterization – utilising the available level of detail[04]

Some calculators use vehicle- and weight-, as well as road type- and country-specific parameters for

Routing | Driving patters | Topology | Energy efficiency | Upstream processes

Calculation methodology – definition of the procedure for determining the results

- The results given for **energy use and CO_2 emissions are WTW** values, i.e. upstream processes (WTT) are included for all modes
- CO_2 emissions determined via **EcoTransIT** are used for **road transport** and **road legs**
- The **energy consumption** is calculated using the **country-specific rail legs** and **distance-specific consumption for electric traction** from EcoTransIT[05]
- **Emissions** for **rail transport** and electrically powered **transhipments** are derived using **recent values for GHG emission intensity**[06]

Methods for establishing comparability – benchmarking our results using the set of calculators

- For calculators using coarse locational settings, road legs are replaced by EcoTransIT[07]
- Emission values per vehicle are transformed to per tonne using the scenario-specific payload[08]
- Emissions per TEU-km are derived for specific cases and their volume capacities[09]
- For calculators that do not provide routing, EcoTransIT distances are used as input[10]
- For calculators only providing TTW emissions, the WTT delta from EcoTransIT is added[11]
- Results for specific ILUs are combined representing their relative statistical share[12]

The “heavy weight scenario” represents the current potential in compliance with the infrastructural and regulatory requirements

Scenario definition and methodology for the different modes of transports

Road transport in the “heavy weight scenario”

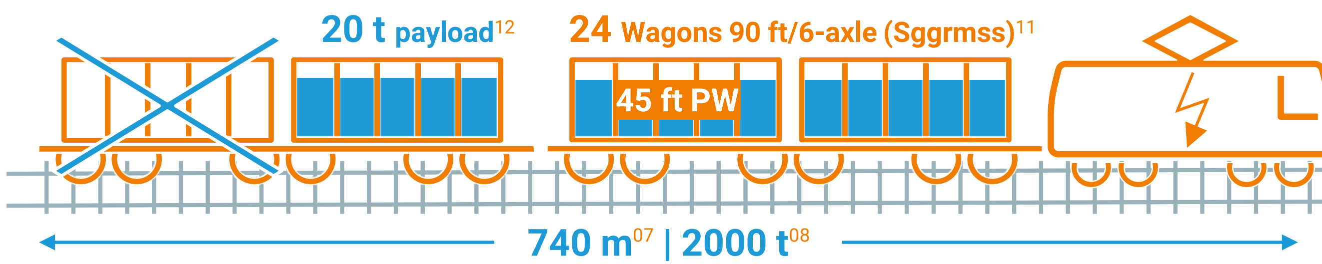
Good practice road transport and road legs in CT are performed in trucks with max. authorized weight[01-04] and state-of-the-art emission standard[05].

Empty trips are neither considered in road nor in combined transport[06].

Door-to-door combined transport in the “heavy weight scenario”

transhipment processes are accounted for in terms of an average value[13].

Good practice rail legs are performed with standard 740 m[07] long trains with contemporary electric freight locomotives[09,10] and efficient intermodal wagons[11]. Assuming a train weight of 2000 t[08], the maximum payload is obtained by efficient loading with 45 ft containers[12].

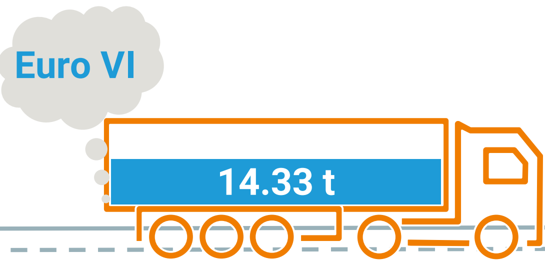


The “statistical scenario” represents current typical transport by considering recent statistics for the legs in CT as well as for road transport

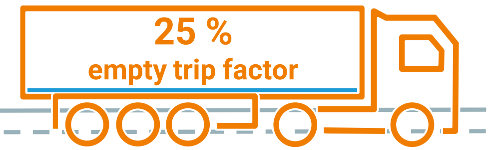
Scenario definition and methodology for the different modes of transports

Road transport in the “statistical scenario”

For **average road transport and road legs in CT**, a vehicle type reflecting the average max. laden weight of vehicles in road freight transport is adopted[14]. Euro VI was chosen as the statistically representative emission class[17].

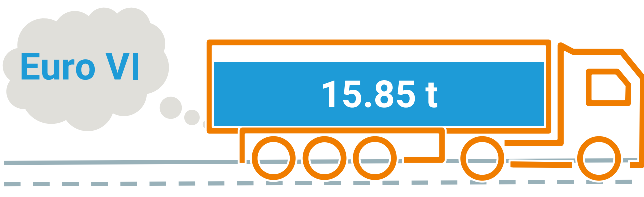


The **payload** reflects the average for load trips in road freight transport[15].

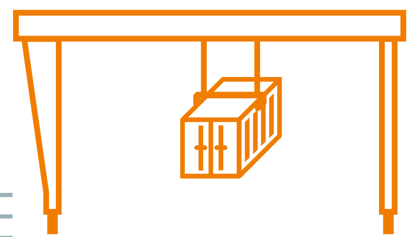


The empty trip factor for **road transport and road legs in CT** reflects the ratio of empty to loaded vehicle-km in road freight transport in Europe[16].

Door-to-door combined transport in the “statistical scenario”



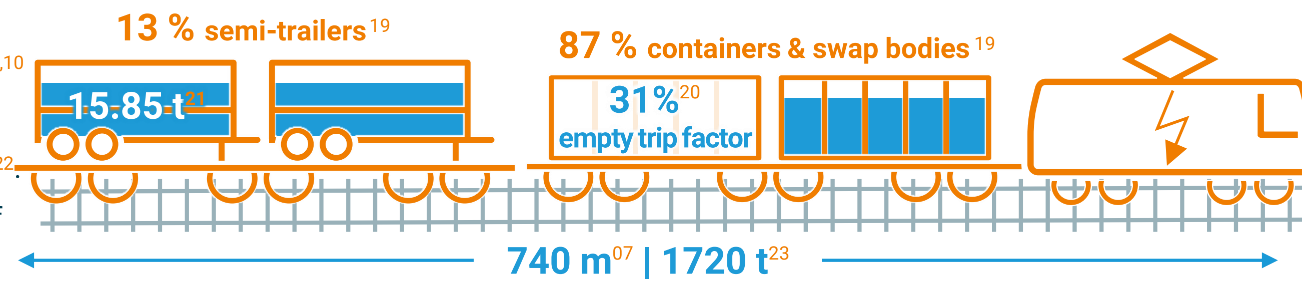
For road legs in CT, the **payload** is set according to the average weight of goods per ILU in rail freight traffic[18,21].



transhipment processes are accounted for in terms of an average value[13].

For the **average rail legs,** a standard 740 m[07] long train with contemporary electric freight locomotive[09,10] is assumed. The share of intermodal loading units (ILUs) is chosen according to the statistical share in CT[19] and typical wagons for these ILUs are selected[22].

Empty runs are considered according to the share of empty and loaded ILUs in rail freight transport[20].



03 Results for the selected relations

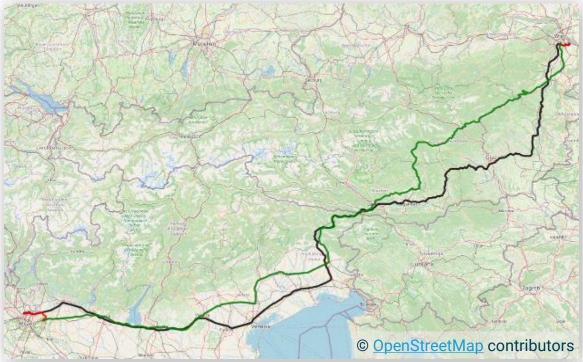
Relation details, energy consumption, CO_2 emissions and saving potential

Relation 1 | Vienna – Melzo

Crossing of the Alps followed by the Mediterranean corridor

At a glance

Corridor	CT volume
AT – IT →	1,235,157 t
←	891,292 t



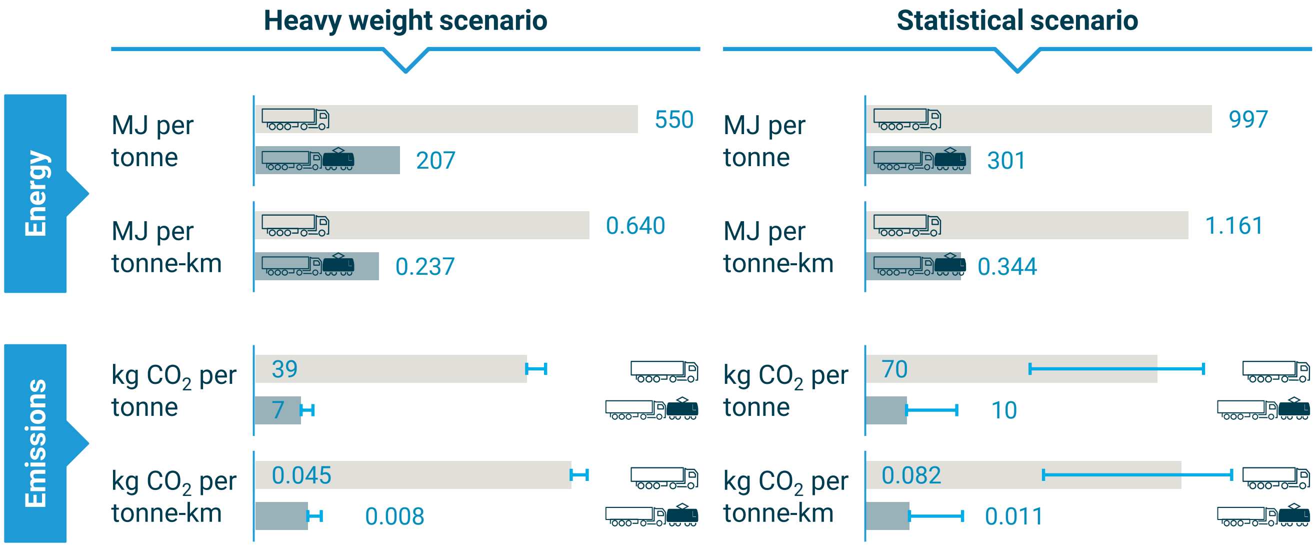
Via terminals

Vienna South Cargo Center	Melzo (RCO)

Start	Destination
Schwechat Logistics Hub	Milan Automotive supplier

Distances (rounded to 10 km)

Road transport	860		
Combined transport	10	820	30



Potential of shifting from road to combined transport for one long train

Saving potential

Per best practice transport | 972 t of freight

38 t CO_2 → - 83 % → 6 t

Road transport		Door-to-door CT chain
37 trucks		1 long train
534 GJ	- 62% →	202 GJ
0,59 kg CO_2/TEU-km		0,06 kg CO_2/TEU-km

Per average transport | 679 t of freight

48 t CO_2 → - 86 % → 7 t

Road transport		Door-to-door CT chain
47 trucks		1 long train
677 GJ	- 70% →	205 GJ
0,58 kg CO_2/TEU-km		0,08 kg CO_2/TEU-km

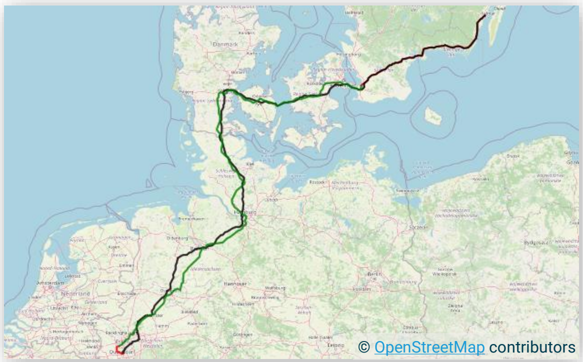
Relation 2 | Malmö – Duisburg

Freight line from the Scandinavian Baltic coast to the Ruhr area

At a glance

Corridor SE – DE

CT volume
→ 1,748,820 t
← 23,268 t



Via terminals

Malmö KT | Samskip Multimodal Rail Terminal Duisburg

Start
Kalmar Industrial area

Destination
Düsseldorf OEM

Distances (rounded to 10 km)

Road transport: 1170

Combined transport: 280 | 920 | 30

Heavy weight scenario / Statistical scenario

Energy

	Heavy weight scenario	Statistical scenario
MJ per tonne (road)	680	1369
MJ per tonne (CT)	390	625
MJ per tonne-km (road)	0.584	1.176
MJ per tonne-km (CT)	0.317	0.509

Emissions

	Heavy weight scenario	Statistical scenario
kg CO_2 per tonne (road)	47	94
kg CO_2 per tonne (CT)	18	30
kg CO_2 per tonne-km (road)	0.040	0.081
kg CO_2 per tonne-km (CT)	0.014	0.024

Saving potential

Potential of shifting from road to combined transport for one long train

Per best practice transport | 972 t of freight

46 t CO_2 → - 63 % → 17 t

Road transport	**Door-to-door CT chain**
37 trucks	1 long train
660 GJ	- 43% → 379 GJ
0,52 kg CO_2/TEU-km	0,18 kg CO_2/TEU-km

Per average transport | 679 t of freight

64 t CO_2 → - 68 % → 20 t

Road transport	**Door-to-door CT chain**
47 trucks	1 long train
930 GJ	- 54% → 424 GJ
0,58 kg CO_2/TEU-km	0,15 kg CO_2/TEU-km

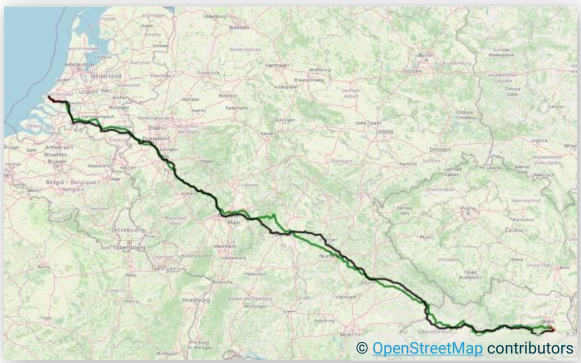
Relation 3 | Rotterdam – Vienna

Freight line from the North Sea port to the hinterland

At a glance

Corridor NL – AT

CT volume
→ 194,075 t
← 264,527 t



Via terminals
Rotterdam RSC | WienCont

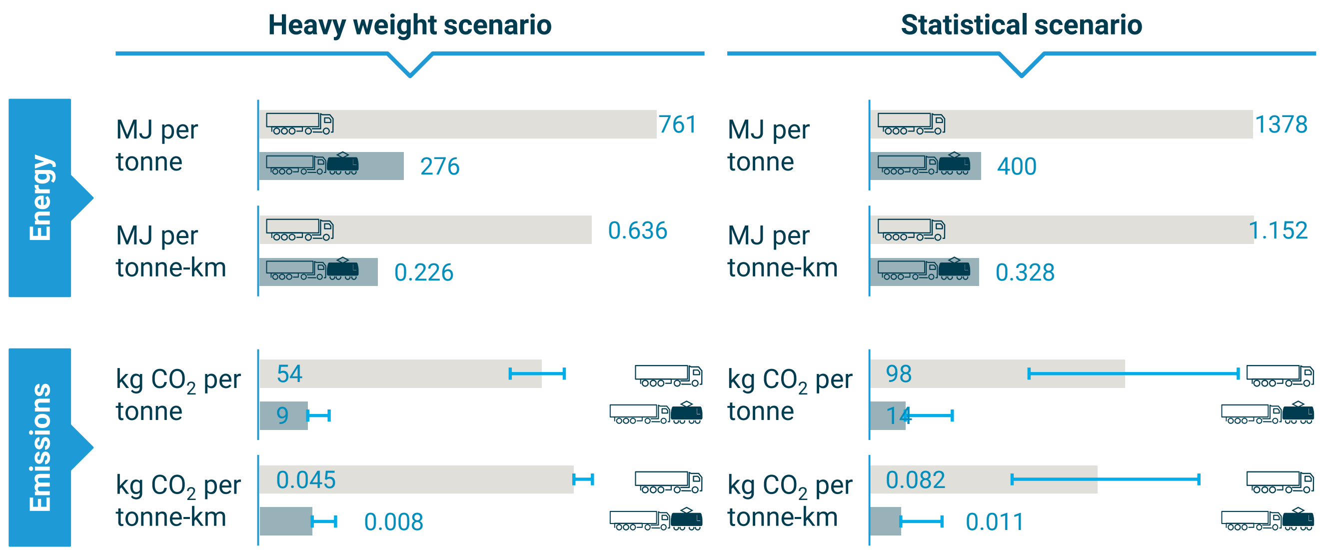
Start
Rotterdam Port Rotterdam

Destination
Schwechat Logistics Hub

Distances (rounded to 10 km)

Road transport: 1200

Combined transport: 30 | 1180 | 10



Saving potential

Potential of shifting from road to combined transport for one long train

Per best practice transport | 972 t of freight

52 t CO_2 → - 83 % → 9 t

Road transport		Door-to-door CT chain
37 trucks		1 long train
739 GJ	- 64% →	268 GJ
0,59 kg CO_2/TEU-km		0,06 kg CO_2/TEU-km

Per average transport | 679 t of freight

67 t CO_2 → - 86 % → 9 t

Road transport		Door-to-door CT chain
47 trucks		1 long train
936 GJ	- 71% →	272 GJ
0,59 kg CO_2/TEU-km		0,08 kg CO_2/TEU-km

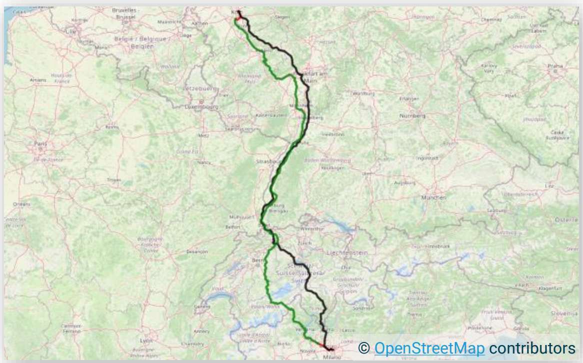
Relation 4 | Cologne – Busto

Freight line along the Rhine and across the Alps

At a glance

Corridor DE – IT

CT volume
→ 11,880,390 t
← 9,253,305 t



Via terminals

Köln Eiffeltor	Busto Arsizio-Gallarate

Start	**Destination**
Cologne Chemical industry	Milano Automotive supplier

Distances (rounded to 10 km)

Road transport: 830

Combined transport: 20 | 840 | 40

Heavy weight scenario / Statistical scenario

Energy

	Heavy weight scenario	Statistical scenario
MJ per tonne (road)	522	946
MJ per tonne (CT)	232	338
MJ per tonne-km (road)	0.622	1.127
MJ per tonne-km (CT)	0.256	0.373

Emissions

	Heavy weight scenario	Statistical scenario
kg CO_2 per tonne (road)	38	69
kg CO_2 per tonne (CT)	8	12
kg CO_2 per tonne-km (road)	0.045	0.082
kg CO_2 per tonne-km (CT)	0.008	0.013

Saving potential

Potential of shifting from road to combined transport for one long train

Per best practice transport | 972 t of freight

37 t CO_2 → - 80 % → 7 t

Road transport	Door-to-door CT chain
37 trucks	1 long train
507 GJ — - 56% →	225 GJ
0,59 kg CO_2/TEU-km	0,07 kg CO_2/TEU-km

Per average transport | 679 t of freight

47 t CO_2 → - 83 % → 8 t

Road transport	Door-to-door CT chain
47 trucks	1 long train
642 GJ — - 64% →	230 GJ
0,59 kg CO_2/TEU-km	0,08 kg CO_2/TEU-km

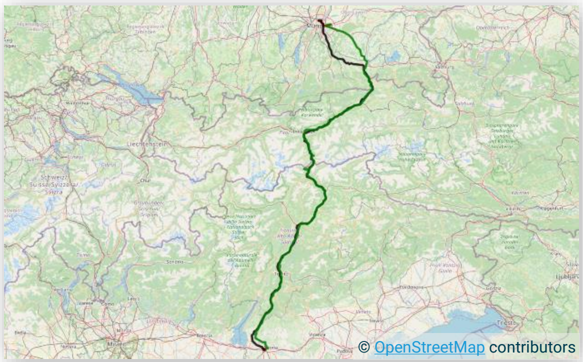
Relation 5 | Munich – Verona

The Alpine segment of the Scandinavian-Mediterranean corridor

At a glance

Corridor DE – IT

CT volume
→ 11,880,390 t
← 9,253,305 t



Via terminals
München Riem | Verona Interterminal

Start
Munich
Automotive supplier

Destination
Verona
OEM

Distances (rounded to 10 km)

Road transport: 400

Combined transport: 10 | 440 | <10

Heavy weight scenario / Statistical scenario

Energy

	Heavy weight scenario	Statistical scenario
MJ per tonne (road)	259	466
MJ per tonne (CT)	117	164
MJ per tonne-km (road)	0.595	1.069
MJ per tonne-km (CT)	0.253	0.356

Emissions

	Heavy weight scenario	Statistical scenario
kg CO_2 per tonne (road)	18	33
kg CO_2 per tonne (CT)	4	6
kg CO_2 per tonne-km (road)	0.041	0.076
kg CO_2 per tonne-km (CT)	0.008	0.012

Saving potential

Potential of shifting from road to combined transport for one long train

Per best practice transport | 972 t of freight

17 t CO_2 → - 78 % → 4 t

Road transport
37 trucks
252 GJ
0,54 kg CO_2/TEU-km

- 55% →

Door-to-door CT chain
1 long train
114 GJ
0,06 kg CO_2/TEU-km

Per average transport | 679 t of freight

22 t CO_2 → - 83 % → 4 t

Road transport
47 trucks
316 GJ
0,54 kg CO_2/TEU-km

- 65% →

Door-to-door CT chain
1 long train
112 GJ
0,08 kg CO_2/TEU-km

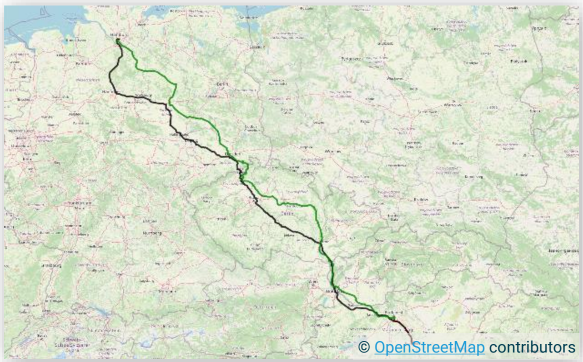
Relation 6 | Hamburg – Budapest
Freight line from the North Sea to the Danube

04

At a glance

Corridor DE – HU

CT volume
→ 1,820,038 t
← 445,840 t



Via terminals
Hamburg Burchardkai | Budapest Metrans

Start
Hamburg
Port of Hamburg

Destination
Kecskemet
OEM

Distances (rounded to 10 km)

Road transport: 1240

Combined transport: 10 | 1210 | 90

Heavy weight scenario

Energy

	Road	CT
MJ per tonne	788	377
MJ per tonne-km	0.630	0.289

Emissions

	Road	CT
kg CO_2 per tonne	56	15
kg CO_2 per tonne-km	0.045	0.011

Statistical scenario

Energy

	Road	CT
MJ per tonne	1424	552
MJ per tonne-km	1.138	0.423

Emissions

	Road	CT
kg CO_2 per tonne	102	23
kg CO_2 per tonne-km	0.082	0.017

Saving potential

Potential of shifting from road to combined transport for one long train

Per best practice transport | 972 t of freight

54 t CO_2 → - 73 % → 14 t

Road transport		Door-to-door CT chain
37 trucks		1 long train
766 GJ	- 52% →	366 GJ
0,58 kg CO_2/TEU-km		0,09 kg CO_2/TEU-km

Per average transport | 679 t of freight

69 t CO_2 → - 78 % → 15 t

Road transport		Door-to-door CT chain
47 trucks		1 long train
967 GJ	- 61% →	375 GJ
0,58 kg CO_2/TEU-km		0,12 kg CO_2/TEU-km

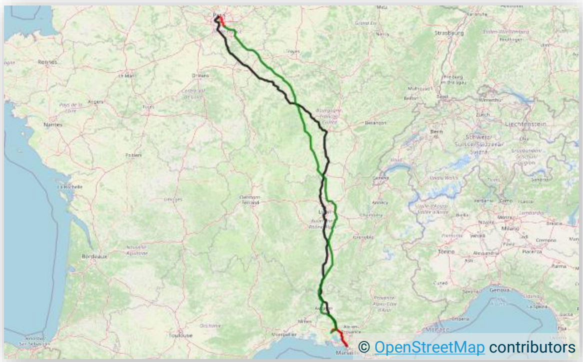
Relation 7 | Valenton – Miramas

Inner French route from Paris to the Mediterranean Sea

At a glance

Corridor
FR – FR

CT volume
456,352 t
(domestic)



Via terminals
Valenton
Miramas

Start
Paris
OEM

Destination
Marseille
Port Marseille

Distances (rounded to 10 km)

Road transport: 770

Combined transport: 20 | 710 | 50

Heavy weight scenario / Statistical scenario

Energy

	Heavy weight scenario	Statistical scenario
MJ per tonne (road)	495	814
MJ per tonne (CT)	252	368
MJ per tonne-km (road)	0.635	1.043
MJ per tonne-km (CT)	0.319	0.466

Emissions

	Heavy weight scenario	Statistical scenario
kg CO_2 per tonne (road)	35	57
kg CO_2 per tonne (CT)	4	7
kg CO_2 per tonne-km (road)	0.045	0.073
kg CO_2 per tonne-km (CT)	0.005	0.009

Saving potential

Potential of shifting from road to combined transport for one long train

Per best practice transport | 972 t of freight

34 t CO_2 → - 88 % → 4 t

Road transport	Door-to-door CT chain
37 trucks	1 long train
481 GJ	244 GJ (- 49%)
0,58 kg CO_2/TEU-km	0,05 kg CO_2/TEU-km

Per average transport | 679 t of freight

39 t CO_2 → - 87 % → 5 t

Road transport	Door-to-door CT chain
47 trucks	1 long train
553 GJ	250 GJ (- 55%)
0,52 kg CO_2/TEU-km	0,06 kg CO_2/TEU-km

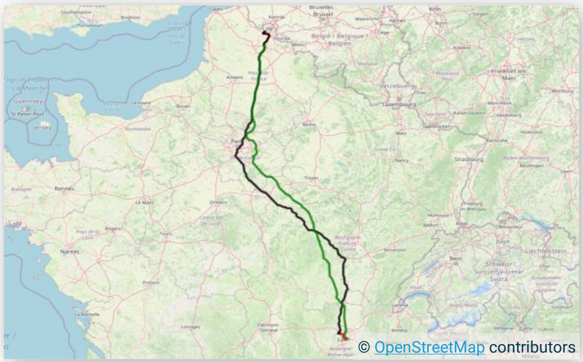
Relation 8 | Dourges – Lyon

Inner French route connecting North and South

At a glance

Corridor
FR – FR

CT volume
→ 456,352 t
← (domestic)



Via terminals

Delta 3 Dourges | Lyon-St. Priest

Start
Lille
Industrial area

Destination
Marcy-l'Étoile
Industrial area

Distances (rounded to 10 km)

Road transport: 680

Combined transport: 30 | 630 | 30

Heavy weight scenario / Statistical scenario

Energy

	Heavy weight scenario	Statistical scenario
MJ per tonne (road)	439	794
MJ per tonne (CT)	220	319
MJ per tonne-km (road)	0.638	1.154
MJ per tonne-km (CT)	0.316	0.458

Emissions

	Heavy weight scenario	Statistical scenario
kg CO_2 per tonne (road)	31	56
kg CO_2 per tonne (CT)	3	6
kg CO_2 per tonne-km (road)	0.045	0.081
kg CO_2 per tonne-km (CT)	0.005	0.008

Saving potential

Potential of shifting from road to combined transport for one long train

Per best practice transport | 972 t of freight

30 t CO_2 → - 89 % → 3 t

Road transport		Door-to-door CT chain
37 trucks		1 long train
427 GJ	- 50% →	214 GJ
0,59 kg CO_2/TEU-km		0,05 kg CO_2/TEU-km

Per average transport | 679 t of freight

38 t CO_2 → - 90 % → 4 t

Road transport		Door-to-door CT chain
47 trucks		1 long train
540 GJ	- 60% →	217 GJ
0,58 kg CO_2/TEU-km		0,05 kg CO_2/TEU-km

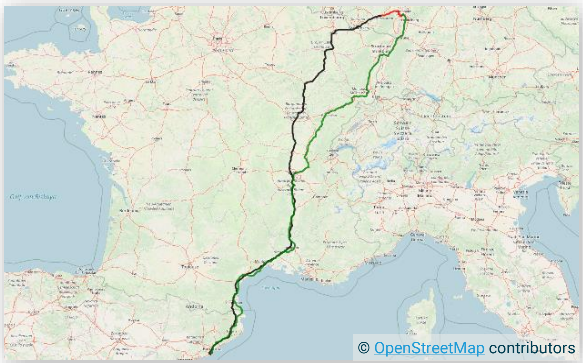
Relation 9 | Ludwigshafen – Barcelona

Along the Rhine to the Mediterranean coast

At a glance

Corridor DE – ES

CT volume
→ 2,225,341 t
← 652,250 t



Via terminals

Ludwigshafen Contargo — Barcelona Morrot

Start	**Destination**
Kaiserslautern Industrial area	Barcelona OEM

Distances (rounded to 10 km)

Road transport: 1230

Combined transport: 70 | 1340 | 10

Heavy weight scenario / Statistical scenario

Energy

	Heavy weight scenario (road)	Heavy weight scenario (CT)	Statistical scenario (road)	Statistical scenario (CT)
MJ per tonne	782	401	1418	584
MJ per tonne-km	0.635	0.280	1.150	0.408

Emissions

	Heavy weight scenario (road)	Heavy weight scenario (CT)	Statistical scenario (road)	Statistical scenario (CT)
kg CO_2 per tonne	55	7	100	11
kg CO_2 per tonne-km	0.045	0.005	0.081	0.007

Saving potential

Potential of shifting from road to combined transport for one long train

Per best practice transport | 972 t of freight

53 t CO_2 → - 88 % → 7 t

Road transport		**Door-to-door CT chain**
37 trucks		1 long train
760 GJ	- 49%	390 GJ
0,58 kg CO_2/TEU-km		0,04 kg CO_2/TEU-km

Per average transport | 679 t of freight

68 t CO_2 → - 89 % → 7 t

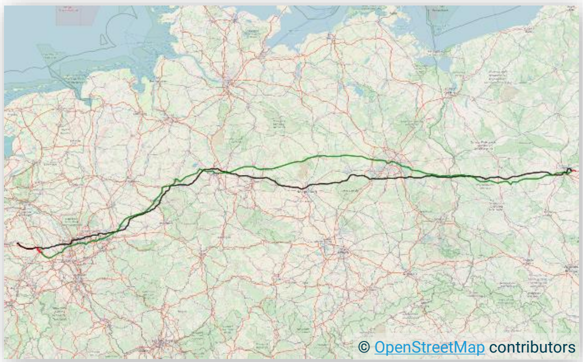
Road transport		**Door-to-door CT chain**
47 trucks		1 long train
963 GJ	- 59%	397 GJ
0,58 kg CO_2/TEU-km		0,05 kg CO_2/TEU-km

Relation 10 | Venlo – Poznań

Along the East-West corridor from the Ruhr area to Poland

At a glance

Corridor		CT volume
NL – PL	→	737,846 t
	←	362,421 t



Via terminals

Cabooter rail terminal Kaldenkirchen	CLIP Container Terminal Swarzędz
Start	**Destination**
Eindhoven area Logistics Hub	Poznań OEM

Distances (rounded to 10 km)

Road transport	870		
Combined transport	50	850	10

Heavy weight scenario / Statistical scenario

Energy

	Heavy weight scenario	Statistical scenario
MJ per tonne (road)	546	988
MJ per tonne (CT)	240	348
MJ per tonne-km (road)	0.627	1.134
MJ per tonne-km (CT)	0.267	0.386

Emissions

	Heavy weight scenario	Statistical scenario
kg CO_2 per tonne (road)	39	71
kg CO_2 per tonne (CT)	11	17
kg CO_2 per tonne-km (road)	0.045	0.082
kg CO_2 per tonne-km (CT)	0.013	0.018

Saving potential

Potential of shifting from road to combined transport for one long train

Per best practice transport | 972 t of freight

38 t CO_2 → - 71 % → 11 t

Road transport		Door-to-door CT chain
37 trucks		1 long train
530 GJ	- 56%	234 GJ
0,58 kg CO_2/TEU-km		0,10 kg CO_2/TEU-km

Per average transport | 679 t of freight

48 t CO_2 → - 77 % → 11 t

Road transport		Door-to-door CT chain
47 trucks		1 long train
671 GJ	- 65%	236 GJ
0,58 kg CO_2/TEU-km		0,12 kg CO_2/TEU-km

All ten relations show significant CO_2 savings in door-to-door CT compared with unimodal end-to-end road transport

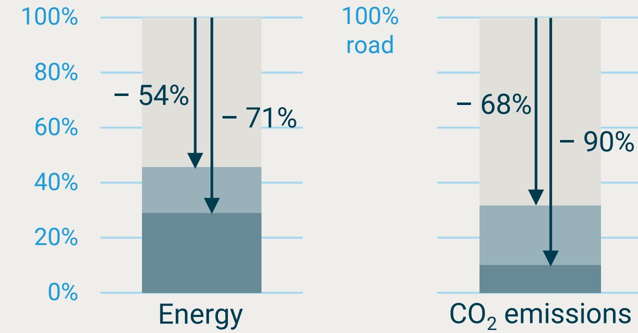
04

Overview of calculation results

	Savings per best practice transport 972 t of freight		Savings per average transport 679 t of freight	
	Energy	CO_2 emissions	Energy	CO_2 emissions
01 Vienna - Melzo	-62%	-83%	-70%	-86%
02 Malmö - Duisburg	-43%	-63%	-54%	-68%
03 Rotterdam - Vienna	-64%	-83%	-71%	-86%
04 Cologne - Busto	-56%	-80%	-64%	-83%
05 Munich - Verona	-55%	-78%	-65%	-83%
06 Hamburg - Budapest	-52%	-73%	-61%	-78%
07 Valenton - Miramas	-49%	-88%	-55%	-87%
08 Dourges - Lyon	-50%	-89%	-60%	-90%
09 Ludwigsh. - Barcelona	-49%	-88%	-59%	-89%
10 Venlo - Poznan	-56%	-71%	-65%	-77%

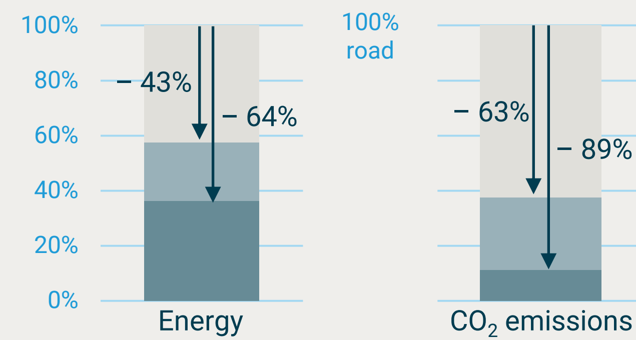
Current average door-to-door transport

Shifting to CT allows for emission savings of up to 90% in average transport



Transport of max. allowed weight (heavy cargo)

In the case of current best practice transport, CT has the potential to allow emission savings of up to 89%.



Mainly two effects contribute to the CO_2 savings – energy-efficient transport and use of sustainable energy

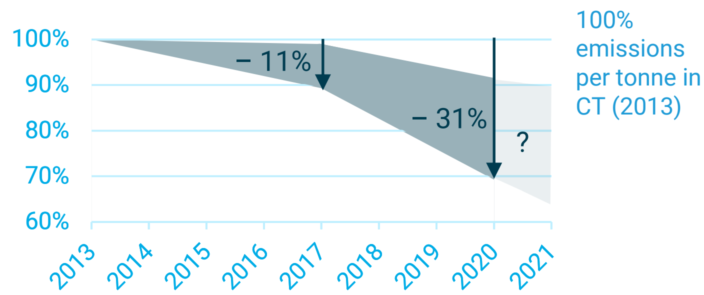
Further aspects of the evaluation

What are the main reasons for emissions savings?

High savings potential results from

- long rail legs compared to the road distance of the transport chain
- Transport through countries with a high percentage of renewable and nuclear energy production as well as the actual power mix used by rail transport companies

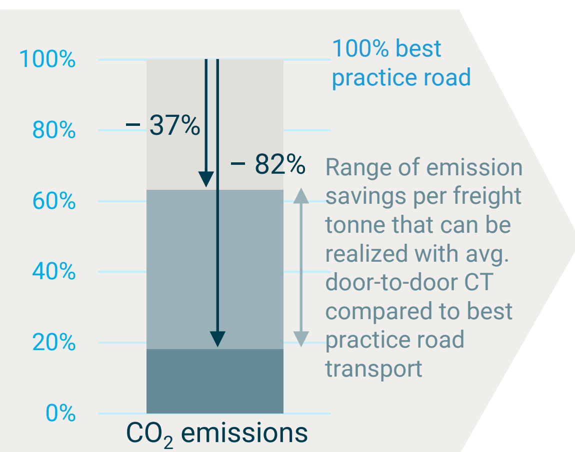
What is the effect of electricity generation?



Range of reductions in emission for the particular door-to-door CT chains for the 10 relations compared to 2013 as reference year.

Changes in the electricity generation mix allowed for CO_2 savings of up to 23% for door-to-door CT in 2020 compared to 2013 for the analysed relations.

A further shift to renewable energy generation can enable additional reductions in the coming years.

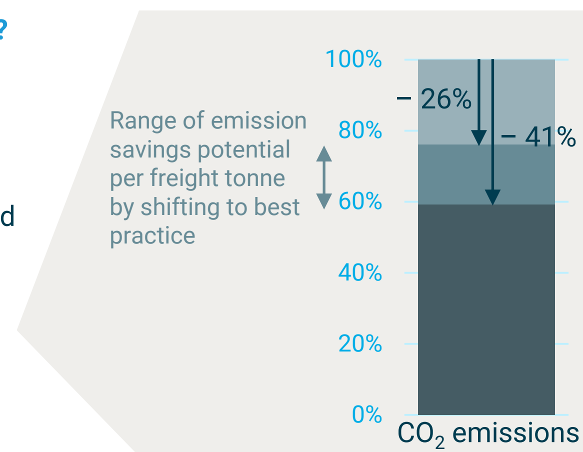


Why is the savings potential lower for best practise transport?

Currently unused potentials in road transport may result in savings in the heavy weight case.

Average door-to-door CT performs consistently better compared to the best practice door-to-door road transport.

Door-to-door CT has more potential. The shift to best practice transport can reduce emissions by up to 40%.



CO2 EMISSIONS IN DOOR-TO-DOOR CT

04 Conclusions and outlook

In summary, door-to-door combined transport is able to play a key role in reducing CO_2 emissions in the transport sector already today

Conclusions and Outlook

→ Combined transport as a key player	▪ Overall, **ten typical relations of door-to-door transport** have been considered, among them domestic and international relations with representative variations in the length of the rail and road leg.
	▪ **Eight different CO_2 emission calculators** have been considered in order to create a high level of confidence in the results, e.g. EcoTransIT and the SGKV SYSLOG.
	▪ For all presented relations and scenarios, **a considerable CO_2 saving potential** could be determined:
	  ▪ Present-day door-to-door combined transport has the ability to save between 63% and 90% of CO_2-emissions for the respective relation compared to unimodal road transport by a Euro VI trucks, while
	  ▪ two effects contribute to the CO_2 savings: energy-efficient transport and the use of carbon-free generated electricity.

→ A zero carbon future is ahead	▪ **Further improvements** in CO_2 emission savings can be expected in door-to-door combined transport over the next years:
	  ▪ Sustainable energy from renewable sources will contribute to an improved energy mix,
	  ▪ transhipment terminals have already started to establish emission-free operations, e.g., Samskip's Duisburg Terminal, and
	  ▪ assuming that electricity comes from renewable sources, battery-electric trucks enable emission-free road legs when performing in a CT transport-chain with typically short road distances.
	▪ While this study shows a impressive CO_2 emission savings potential of current CT, **decarbonized transport offerings** are also already underway, e.g.:
	  ▪ Some operators begin to offer emission free transport, e.g., Metrans[01], DB Cargo[02]

01 Website information: METRANS Trains Get 100 % CO2 Free, https://metrans.eu/metrans-trains-get-100-co2-free/ 02 Website information: Products DBeco plus und DBeco neutral, https://www.dbcargo.com/rail-de-de/leistungen/co2-freie-transporte

Footnotes

01 | Scope of the study and general approach

01 Pilot Actions For Combined Transport
PACT Study Combined Transport CO_2 Reduction p. 62, Final Report, March 2003

02 CT volumes (domestic and international): 2009: 6.70 Mio. TEU; 2019: 12.8 Mio. TEU
UIC-UIRR 2020 Report on Combined Transport in Europe.

03 Heavy weight scenario, assuming that cargo is transported in

- 45 ft ILUs on articulated flat waggons for rail legs,
- 44 t trucks (or 60 t for Sweden) as it is allowed for road legs in CT, and
- 40 t trucks as it is the permissible total weight for international road transport,

with all transport vehicles loaded to their maximum capacity and empty runs for re-distribution of loading units are neglected.
Regulation on maximum authorized weights: Council Directive 96/53/EC of 25 July 1996, laying down for certain road vehicles circulating within the Community the maximum authorized dimensions in national and international traffic and the maximum authorized weights in international traffic, Official Journal L 235 , 17/09/1996 P. 0059 – 0075 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31996L0053

04 The evaluation of explicit energy consumption data of specific individual transport operations is beyond the scope of this study. In order to analyse the energy consumption and emissions for the two scenarios for door-to-door road transport and door-to-door CT, we employ existing emission calculators.

05 The calculator provided by EcoTransIT is conformal with the framework provided by the Global Logistics Emissions Council (GLEC).
https://www.smartfreightcentre.org/en/how-to-implement-items/what-is-glec-framework/58/
https://www.ecotransit.org/de/

06 https://sgkv.de/portfolio/kv-tools/syslog/

07 Determination of emissions from electric energy consumption based on the electricity consumption as calculated by EcoTransIT and the most recent data on the greenhouse gas emission intensity of electricity generation from EEA
European Environment Agency, Greenhouse gas emission intensity of electricity generation (Created 29 Jul 2021. Published 25 Oct 2021, Last modified 25 Oct 2021)
https://www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity-9

08 Emissions per TEU-kilometre are also indicated for reporting purposes. The vehicle capacities were used to determine the volumes transported. This results in different values for the volume utilisation in tonnes per TEU for the different legs. The emissions per TEU-kilometre are calculated as the sum of the individual legs.

02 | Step 01 – Selection of relations

01

01 The relations were selected in cooperation with the UIRR member companies in order to represent relevant relations in Europe. With more than 40 UIRR member companies from 17 European countries, the market of intermodal transport can be adequately represented. (*2020-21 UIRR Report, European Road-Rail Combined Transport*). Freight volumes of the connected corridors are reported in *UIC-UIRR 2020 Report on Combined Transport in Europe, UIC freight department, 11/2020.*

02 Transport volumes for 2020 are used as an indicator of demand (*UIC-UIRR 2020 Report on Combined Transport in Europe, UIC freight department, 11/2020).*

03 Trans-European Transport Network (TEN-T)
https://ec.europa.eu/transport/themes/infrastructure/ten-t_en *(accessed: 17.10.2021) and Regulation (EU) No 1315/2013 of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU*

04 The start and end points of the transport routes were selected in industrial and commercial areas in the respective catchment area of the start and end terminals in such a way that typical transport routes are created and at the same time the statistical distribution of road leg distances in CT is represented. The international relations cover the single road leg length classes <50 km, 50-150 km, and 150-300 km, which cover 74% of road leg distances of door-to-door CT in Europe. The domestic relations belong to the length classes <50 km and 50-150 km, representing 58% of door-to-door CT in Europe.
Statistical distribution for single road legs: International door-to-door CT: <50 km: 42%, 50-150 km: 23%, 150-300 km: 9%, >300 km: 26%;
Domestic door-to-door CT: <50 km: 20%, 50-150 km: 38%, 150-300 km: 16%, >300 km : 26%;
Source: UIC-UIRR 2020 Report on Combined Transport in Europe, UIC freight department, 11/2020

05 The selected relations do not reflect the statistical distribution of single road legs exactly, but shorter road legs are overrepresented. This can be justified by the fact that longer road legs are mainly due to the use of company trains, which are out of the scope of this study. (*Contract No FV355/2012/MOVE/D1/ETU/SI2.659386, Analysis of the EU Combined, Transport Final Report*)

06 In the selection of the relations, it was ensured to cover different length classes of the rail legs to represent the typical rail distances in door-to-door CT in Europe. The international relations cover the rail leg length classes <600 km, 600-900 km, 900-1200 km, and >1200 km, which cover all typical rail length distances in European door-to-door CT. The domestic relations belong to the length class 600-900 km, representing 13% of door-to-door CT in Europe.
Statistical distribution of total rail legs: International door-to-door CT: <600 km: 45%, 600-900 km: 19%, 900-1200 km: 21%, >1200 km: 14%;
Domestic door-to-door CT: <300 km: 28%, 300-600 km: 56%, 600-900 km: 13%, 900-1200 km: 3%, >1200 km: 1%;
Source: UIC-UIRR 2020 Report on Combined Transport in Europe, UIC freight department, 11/2020

07 The selected relations do not reflect the statistical distribution of rail legs exactly, but the longer rail legs are overrepresented. This can be justified by the fact that door-to-door CT is gradually losing competitiveness on the shorter routes compared to road transport. (*Contract No FV355/2012/MOVE/D1/ETU/SI2.659386, Analysis of the EU Combined, Transport Final Report*)

08 Distances are determined based on the emission calculators. The table shows the values of the EcoTransIT calculator.

02 | Step 02 – Selection of emission calculators (1/2)

02

01 See the Appendix for a full list of all calculators evaluated in the scope of this study. Criteria such as free availability and coverage of the relevant transport modes were decisive for the selection - whereby care was also taken to use calculators that were independent of EcoTransIT if possible for comparison.

02 We thank IVE mbH and SGKV for supporting the study by swiftly providing the calculations for the selected relations.

03 *CSN EN 16258 – Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers), released 2012*

04 Further information on the level of detail for the specific calculator is provided in the Appendix or in the respective methodology of the calculator. Links are provided in the Appendix.

05 It can happen that the intrinsic EcoTransIT routing integrates short sections with diesel traction into the rail legs for some relations. As we assume completely electrified traction for rail transport, the following adjustments have been applied to the energy values of EcoTransIT. Based on several electric-only rail sections per country, the energy consumption per kilometre was determined for both scenarios ("heavy weight" and “statistical”) for every country. Using these factors, the TTW energy consumption for electric traction was calculated on the basis of the rail leg distances per country. WTW energy consumption for rail legs and electrically powered transhipment is derived using the upstream energy factors for 2017 provided in the 2020 methodology of EcoTransIT (their Table 53) following equation 4.3.4 in the EcoTransIT methodology.
EcoTransIT World, Environmental Methodology and Data Update 2020, EcoTransIT World Initiative

06 The online version of the EcoTransIT calculator uses the GHG emission intensity factors for the year 2013 according to Table 52 of the Methodology Update 2019. In order to obtain values that are as recent as possible, emission values were calculated according to the formulas in chapter 3.4.3 of the methodology using the more recent emission intensity factors for 2017 from the methodology update for 2020. As changes in emission factors of up to 30% (e.g. for Spain) have occurred for the countries of the respective relations between the years 2017 and 2020 (s. EEA), the calculated emissions for 2017 were propagated to 2020 using the ratios of the factors given by the EEA and the Federal Office for the Environment of Switzerland. 2019 was selected because this represents the most recent year with reported values. This procedure assumes that the upstream energy factors have not changed over the 2-year period.
EcoTransIT World, Environmental Methodology and Data Update 2019, EcoTransIT World Initiative
EcoTransIT World, Environmental Methodology and Data Update 2020, EcoTransIT World Initiative
European Environment Agency (EEA), Greenhouse gas emission intensity of electricity generation https://www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity-9 (accessed: 02.11.2021)
Kenngrössen zur Entwicklung der Treibhausgasemissionen in der Schweiz 1990–2019, Aktualisiert im April 2021, Eidgenössisches Departement für Umwelt, Verkehr, Energie und Kommunikation UVEK, Bundesamt für Umwelt BAFU, Abteilung Klima

02 | Step 02 – Selection of emission calculators (2/2)

02

07 The exact calculation for the shorter distances of the road legs is not possible with calculators not allowing a location selection on address or coordinate level but only on city (district) level. This would result in large relative errors. For these calculators, the emissions for the door-to-door CT chain were determined by adding the EcoTransIT values for road legs and transhipment to the rail leg.

08 For the calculators that determine emission values per vehicle, the values per tonne of freight transported are determined by dividing the vehicle emission value by the scenario-specific weight of the payload. In case the parametrisation of a 44t truck was not possible within the calculator for the CT road legs in the heavy scenario, a 40t truck was used and the lower payload of the 40 t truck was also considered for the "heavy weight" scenario for the emission calculation per tonne.

09 Emissions per TEU-km cannot be determined directly, as there is no constraint regarding a constant volume. For both scenarios, a distance-weighted average is determined for door-to-door CT based on the calculation for one door-to-door CT chain and the volume capacities of the required vehicles for the legs. The values for road transport are also derived from the volume capacity of the vehicles used.

10 Some calculators depend on the input of distances (e.g. ClimateCare, Interreg), in this case the values of EcoTransIT rounded to the nearest kilometre were used as input.

11 Some calculators only report TTW emissions for road transport (e.g. Interreg). In this case, a delta for emissions from upstream processes was determined using the EcoTransIT WTW and TTW values, which was added to the calculated emissions of the respective calculator.

12 The SGKV SYSLOG calculator requires the selection of a specific ILU type. Since the SYSLOG tool assumes a default average load factor, this tool is used for benchmarking in the “statistical” scenario. To represent the statistical share of ILUs defined for this scenario, we performed the calculation for 40 ft containers which is identical also for semi-trailers and for 20 ft containers which is identical also for swap bodies. These two results were combined in the following way: Using the average volume of 1.53 TEU per container and swap body (derivation s. footnote 21 chapter “scenario definition and methodology”), this translates into 47% 20 ft containers and 53% 40 ft containers. Containers comprise 87% of ILUs in CT, semi-trailers make up the remaining 13% (derivation s. footnote 19 chapter “scenario definition and methodology”). Hence, the combination of results is calculated for 41% of 20 ft containers and 59 % of 40 ft containers.

02 | Step 03 – Scenario definition and methodology (1/6)

03

01 The authorized maximum weight for road trains or articulated vehicles is 40 t for transport in Europe and 44 t for articulated vehicles carrying one or more containers or swap bodies, up to a total maximum length of 45 feet in intermodal transport operations.
Council Directive 96/53/EC of 25 July 1996 as amended by Directive 2015/719 laying down for certain road vehicles circulating within the Community the maximum authorized dimensions in national and international traffic and the maximum authorized weights in international traffic, Official Journal L 235 , 17/09/1996 p. 59
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01996L0053-20190814

02 The calculation is performed for a fully loaded 40 t truck, wherever the calculator allows for the selection.
For the EcoTransIT calculator, the parametrisation is: vehicle type 26-40 t (intrinsic parameters: empty weight = 14 t; payload capacity = 26 t; vessel capacity = 2 TEU; maximum total weight = 40 t; *Source: EcoTransIT World, Environmental Methodology and Data Update 2019, EcoTransIT World Initiative*); load factor = 100%.
Using the vehicle parameters, the further parameters translate into: payload = 26 t; TEU load = 2 TEU; freight weight per TEU = 13 t/TEU

03 For Sweden, the allowed maximum gross combination weight for articulated vehicles is higher (64 t since 2016, formerly 60 t).
Legal loading: Weight and dimension regulations for heavy vehicles, Swedish transport agency
https://www.transportstyrelsen.se/globalassets/global/publikationer/vag/yrkestrafik/lasta-lagligt/tran045-lasta-lagligt-eng-low.pdf

04 The calculation is performed for a fully loaded 44 t truck or a 60 t truck for Sweden, respectively, wherever the calculator allows for the selection.
Parametrisation for a 44t truck for the EcoTransIT calculator: the weight of 44 t indicates the vehicle type 44-60 t. With its intrinsic parameters 44-60 t (empty weight = 19 t; payload capacity = 41 t; vessel capacity = 2 TEU; maximum total weight = 60 t; *Source: EcoTransIT World, Environmental Methodology and Data Update 2019, EcoTransIT World Initiative*), the payload for the 44 t total weight case is 44 t - 19 t = 25 t, which is one tonne less than for a fully loaded 40 t truck. In order to reflect the potential of using 44 t trucks and at the same time take into account a possibly higher empty weight, we map the payload-to-empty-weight ratio of the new vehicle class 40-50t truck (empty weight = 15 t; payload capacity = 35 t; vessel capacity = 2 TEU; maximum total weight = 50 t; *Source: EcoTransIT World, Environmental Methodology and Data Update 2020, EcoTransIT World Initiative*), which was introduced with the 2020 update but does not seem to be available in the online version, to the existing vehicle type 44-60 t truck. For the 44 t case, we get a payload to empty weight ratio of 29 t / 15 t for the 40-50 t truck type. To reflect the same ratio, the 44-60 t truck would need to be loaded with 36.73 t payload. This results in a load factor of 36.73 t / 41 t = 90%, which is used for the calculation.
Parametrisation for a 60 t truck for the EcoTransIT calculator: vehicle type 44-60 t (intrinsic parameters: empty weight = 19 t; payload capacity = 41 t; vessel capacity = 2 TEU; maximum total weight = 60 t; *Source: EcoTransIT World, Environmental Methodology and Data Update 2019, EcoTransIT World Initiative*); load factor = 100%.

02 | Step 03 – Scenario definition and methodology (2/6)

03

05 The transport is assumed to be conducted by diesel trucks compliant with the Euro VI emission standard.
Wherever the calculator allows for parametrisation of the fuel type and emission standard of the selected vehicle, diesel and Euro VI is chosen.

06 Wherever the calculator allows for parametrisation of empty trips related to the transport, the empty trip factor is chosen to be 0.

07 The standard length of freight trains required by the TEN-T regulation is 740 m.
Regulation (EU) No 1315/2013 of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU Text with EEA relevance https://eur-lex.europa.eu/legal-content/DE/ALL/?uri=celex:32013R1315
This length is feasible in many European countries; some countries, which the selected relations pass through, would even allow for longer train lengths or are testing them in pilot projects.
Longer trains Facts & Experiences in Europe, Results of the CER working group on longer and heavier trains, Community of European Railway and Infrastructure Companies, 2016 https://cer.be/sites/default/files/publication/160525_Longer%20Trains_Facts%20and%20Experiences%20in%20Europe_final_0.pdf

08 The standard total weight of a 740 m long freight train is 2000 t.
UIRR Position Paper, Guidelines revision: key to a competitive infrastructure, 19. April 2021, https://www.uirr.com/en/media-centre/press-releases-and-position-papers/2021/mediacentre/1830-position-paper-ten-t-guidelines-revision-key-to-a-competitive-infrastructure.html

09 With a typical length of 20 m for a freight locomotive, we adopt a load length of 720 m.
For the heavy weight scenario, we adopt a mass of 1910 t for wagons and load, assuming a typical weight of 90 t for a typical freight locomotive.
Typical lengths and total weights of electric freight locomotives are e.g. 18.98 m and max. 90 t for the Siemens Vectron (Siemens Mobility, Vectron. Die Lok, die neue Wege schafft, https://assets.new.siemens.com/siemens/assets/api/uuid:187443e1-48ca-449e-9542-31b8c449f454/mo-vectron-technikbroschuere-de.pdf) and 18.90 m and 84 t for the Bombardier Traxx Series (https://www.alphatrains.eu/downloads/fleet/loco/alpha_data_sheet_loco_traxx_br186.pdf)

10 The transport is assumed to be conducted by electric locomotives. Wherever the calculator allows for parametrisation of the traction, electrified is chosen.

11 We adopt an efficient intermodal wagon (90 ft/6-axle, Sggmrss, Technical data: No of axles = 6; max. permissible axle load = 22.5 t; tara = 29.5 t; payload = 105.5 t; total length = 29.59 m; loading length = 27.64 m)
COSMOS Project, Good Practice Manual, 2013, KombiConsult GmbH, http://www.intermodal-cosmos.eu/content/e4/e251/e259/e270/COSMOS_WP1_Good-Practice-Manual_12_Efficient-Intermodal-Wagons_KC-HC_20130430_eng.pdf
With a total length of 29.59 m per wagon, 24 wagons can be joined to form a train of a length of 710.16 m. Considering the tare weight of 29.5 t per wagon, the loading weight of the freight train is determined to 1202 t or 50.08 t per wagon which is well below the maximum permissible payload of 105.5 t and corresponds to a load factor of 47.5% for the wagon.

02 | Step 03 – Scenario definition and methodology (3/6)

03

12 We assume that each wagon carries two 45 ft PW containers: length = 13.76 m; tara = 4.8 t; payload = 25.68 t
ISO 668:2013-08, Series 1 freight containers - Classification, dimensions and ratings
This results in a total weight of 25.04 t per container or a payload of 25.04 t – 4.8 t = 20.24 t per container resulting in 7.53 t/TEU. This payload is well below the maximum permissible payload of 25.68 t for a 45 ft PW container and corresponds to a load factor of 78.8 % for each container. For the calculation, the parametrisation of the calculator is chosen to reflect the parameters derived above in the closest possible way.
For the EcoTransIT calculator, the parametrisation is: train type = extra large train (2000t); train weight = 1910 t; load factor = 64 %. The load factor is calculated as the ratio of payload and payload capacity of the wagon. The values for the EcoTransIT standard wagon (empty weight = 23 t; payload capacity = 61 t) do not correspond to the values of the good practice wagon assumed in this study.[11] To reflect the load-to-wagon-weight ratio of 50.08 t / 29.5 t as for the parameters of this study, the EcoTransIT standard wagon would need to be loaded with 39.05 t. The ratio of this value and the payload capacity of the standard wagon is 64 %, which is the load factor to be used for the calculation.

13 Within the scope of the study, it is not possible to consider the emissions for the specific terminals on the basis of real consumption values. Furthermore, no terminal-specific calculations as they would be possible with the help of a custom parametrised ITEC calculation tool are carried out. EcoTransIT reports transhipment-related energy consumption and emissions. Based on the composition, it can be concluded that electrically powered transhipments are assumed. However, some terminals may use diesel technology. For the EcoTransIT calculator, the parametrisation is: handling = “other”

14 For the EU, an average maximum permissible laden weight for vehicles in road freight transport of 29.74 t is obtained based Eurostat data for 2019.
Eurostat, Annual road freight transport by maximum permissible laden weight of vehicle (Mio Tkm, Mio Veh-km, 1 000 Jrnys), online data code: ROAD_GO_TA_MPLW, last update: 05/10/2021 23:00 https://ec.europa.eu/eurostat/databrowser/product/page/ROAD_GO_TA_MPLW; own calculations
For the emission assessment, the parametrisation of the calculator is chosen to reflect the vehicle type in the closest possible way, allowing the weight to be considered for routing, energy and emission calculations (if applicable).
EcoTransIT parametrisation: vehicle type 26-40t (intrinsic parameters: empty weight = 14 t; payload capacity = 26 t; vessel capacity = 2 TEU; maximum total weight = 40 t; *Source: EcoTransIT World, Environmental Methodology and Data Update 2019, EcoTransIT World Initiative*).

15 In 2019, the average freight weight per vehicle in road freight transport for load trips (loading status: loaded) in the EU was 14.33 t.
Summary of annual road freight transport by type of operation and type of transport (1 000 t, Mio Tkm, Mio Veh-km), online data code: ROAD_GO_TA_TOTT, last update: 29/09/2021 23:00 https://ec.europa.eu/eurostat/databrowser/product/page/ROAD_GO_TA_TOTT; own calculations
If possible, this value is taken into account my means of the load factor (payload / payload capacity) in the parameterization of the calculators.
For the EcoTransIT calculator, the parametrisation is: load factor = 14.33t / 26t = 55%

02 | Step 03 – Scenario definition and methodology (4/6)

03

16 Empty runs are considered reflecting the relation of vehicle kilometres running empty (loading status: empty) and loaded in road freight transport. For the EU, the value for 2019 is 24.82%.
Summary of annual road freight transport by type of operation and type of transport (1 000 t, Mio Tkm, Mio Veh-km), online data code: ROAD_GO_TA_TOTT, last update: 29/09/2021 23:00 https://ec.europa.eu/eurostat/databrowser/product/page/ROAD_GO_TA_TOTT; own calculations
Also for rail legs in CT, empty runs are considered using this average empty trip factor of 24.82% for road freight transport in general, since the Eurostat dataset for road freight transport that allows for differentiation by cargo types (i.e. large containers and swap bodies and other containers) does not provide separate reporting of empty runs.
Annual road freight transport by type of cargo and distance class (1 000 t, Mio tkm, Mio Veh-km, 1 000 BTO), online data code: ROAD_GO_TA_TCRG, last update: 09/10/2021 23:00 https://ec.europa.eu/eurostat/databrowser/view/ROAD_GO_TA_TCRG/;
Wherever the calculator allows for parametrisation of empty trips related to the transport, the empty trip factor is chosen to be 25%.

17 A representative emission class is to be adopted. Statistics on the number of trucks by environmental characteristics are available for Germany published by the German Federal Motor Transport Authority (Kraftfahrbundesamt). As of 1.1.2021, more than half of the registered trucks over 12 t in Germany had emission class Euro VI.
Fahrzeugzulassungen (FZ) – Bestand an Kraftfahrzeugen nach Umwelt-Merkmalen, FZ 13, 1.Januar 2021, Kraftfahrbundesamt
Wherever the calculator allows for parametrisation of the fuel type and emission standard of the selected vehicle, diesel and Euro VI is chosen.

18 The load factor for the road legs is determined from the average weight of goods of 15.85 t per ILU for rail freight traffic in ILUs (derivation see footnote 21). Depending on the configuration options, this value is used to determine the load factor for the parametrisation of the calculators. For the EcoTransIT calculator, the parametrisation is: load factor = 15.85t / 26t = 61%.

19 According to European statistics on rail freight transport in intermodal loading units (ILUs), in 2019, the shares of ILUs in terms of number were: 85.8% containers and swap bodies, 12.7% semi-trailers (unaccompanied), 1.5% accompanied road-vehicles. The latter are neglected in the following due to their low share and a relative share of 87% containers and swap bodes and 13% semi-trailers is adopted.
Empty and loaded intermodal transport units, online data code: RAIL_GO_ITU last update: 21/09/2021 23:00
https://ec.europa.eu/eurostat/databrowser/view/RAIL_GO_ITU, own calculations
Volume of containers transported, online data code: RAIL_GO_CONTNBR, last update: 21/09/2021 23:00
https://ec.europa.eu/eurostat/databrowser/view/RAIL_GO_CONTNBR; own calculations

02 | Step 03 – Scenario definition and methodology (5/6)

03

20 The Eurostat datasets for rail freight transport in ILUs do not report on tonne- and vehicle-kilometres, for transport using the different ILUs with the distinction of loaded and empty runs. Thus, the empty trip factor is calculated as fraction of empty and loaded ILUs by number. For 2019, the empty trip factor for the current EU member states with available data was: 35.4% for containers and swap bodies and 8.4% for semi-trailers (unaccompanied). Using the shares of the different types of ILUs determined above, the total number-weighted factor is 31.1%.
Empty and loaded intermodal transport units, online data code: RAIL_GO_ITU   last update: 21/09/2021 23:00
https://ec.europa.eu/eurostat/databrowser/view/RAIL_GO_ITU, own calculations
Volume of containers transported, online data code: RAIL_GO_CONTNBR, last update: 21/09/2021 23:00
https://ec.europa.eu/eurostat/databrowser/view/RAIL_GO_CONTNBR; own calculations
Goods transported in intermodal transport units, online data code: RAIL_GO_CONTWGT, last update: 21/09/2021 23:00
https://ec.europa.eu/eurostat/databrowser/view/RAIL_GO_CONTWGT; own calculations
Wherever the calculator allows for parametrisation of empty trips related to the transport, the empty trip factor is chosen to be 31%.

21 For the calculation of the payload per ILU and the gross weights (ILU + goods), we rely on the values of the Federal Statistical Office for Germany for rail freight transport in ILUs, since they report the weight of goods and empty ILUs individually in addition to the gross weight, which is also available via Eurostat. For 2018, the average gross weight (goods, packaging, containers and loading equipment) on load trips was 18.27 t for containers and swap bodies and 26.68 t for semi-trailers. The payload (goods and packaging without containers and loading equipment) amounted to 15.13 t for containers and swap bodies and 20.68 t for semi-trailers. Using the share of ILUs by number determined above, the average gross weight amounts to 19.37 t and the average payload to 15.85 t for load trips in rail freight transport. Considering load and empty trips, the average gross weight was 14.96 t for containers and swap bodies and 24.63 t for semi-trailers. For containers and swap bodies, this translates to 9.21 t/TEU. The payload amounted to 11.38 t for containers and swap bodies and 18.78 t for semi-trailers. For containers and swap bodies, this translates to 7.00 t/TEU. Further parameters derived from the German dataset for 2018 are an average volume of 1.53 TEU per container and swap body used in rail freight transport and an average weight of freight of 9.15 t/TEU for containers and swap bodies for load trips. For containers and swap bodies, the average gross weight on load trips was 11.05 t/TEU and the average gross weight (containers and loading equipment) on empty runs was 3.17 t/TEU. For semi-trailers, the average gross weight (ILU and loading equipment) on empty runs was 4.44 t.
Verkehr - kombinierter Verkehr, Fachserie 8 Reihe 1.3, Statistisches Bundesamt (Destatis), 03.Feb.2021; https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Transport-Verkehr/Publikationen/Downloads-Querschnitt/kombinierter-verkehr-2080130187004.pdf;jsessionid=DC28EE5E870945E6A4201EF0320925AA.live731?__blob=publicationFile; own calculations
46131-0017: Beförderte Güter, Beförderungsleistung, Ladeeinheiten, Container (Eisenbahngüterverkehr): Deutschland, Jahre, Hauptverkehrsbeziehungen, Art der Ladeeinheit, Ladezustand, https://www-genesis.destatis.de/genesis//online?operation=table&code=46131-0017; own calculations

02 | Step 03 – Scenario definition and methodology (6/6)

03

22 Regarding the wagons used for container and semi-trailer transport, we rely on the type specific values for empty weight, payload capacity, vessel capacity and maximum total weight for container and truck wagons derived within the 2020 update of the EcoTransIT methodology from transport statistics from railway companies.
Container wagon: empty weight = 21 t; payload capacity = 65 t; vessel capacity = 2.6 TEU; maximum total weight = 86 t;
Rolling Road – Trailer wagon: empty weight = 34.3 t; payload capacity = 100 t; vessel capacity = 4 TEU; maximum total weight = 134.3 t.
Source: EcoTransIT World, Environmental Methodology and Data Update 2020, EcoTransIT World Initiative
We assume a the length for the wagons according to the parameters for common wagons of 20 m for the container wagon and 34 m for the trailer wagon, which can carry two semi-trailers.
COSMOS Project, Good Practice Manual, 2013, KombiConsult GmbH, http://www.intermodal-cosmos.eu/content/e4/e251/e259/e270/COSMOS_WP1_Good-Practice-Manual_12_Efficient-Intermodal-Wagons_KC-HC_20130430_eng.pdf

23 To reflect the share of ILU and compose a train of up to a maximum load length of 720m, we assume a train composed of 27 container wagons and 5 trailer wagons with at total length of 710 m. The wagons are assumed to be loaded with ILUs reflecting the statistical average total weight derived above of 9.21 t/TEU for containers and swap bodies and 24.63 t for semi-trailers. This sums up to a train weight of 1631 t. Detailed Calculation:
Total train weight (without locomotive): 27 wagons * (21 t + 2.6 TEU * 9.21 t/TEU) + 5 wagons * (34.3 t + 2 Trailer * 24.63 t/ Trailer) = 1631 t;
Total train weight (with locomotive): 1631 t + 90 t locomotive = 1720 t;
Weight of wagons: 27 wagons * 21 t + 5 wagons * 34.3 t = 738.5 t;
Load weight = 27 wagons * (2.6 TEU * 9.21 t/TEU) + 5 wagons * (2 Trailer * 24.63 t/ Trailer) = 892.5 t;
Freight weight = 27 wagons * (2.6 TEU * 7.00 t/TEU) + 5 wagons * (2 Trailer * 18.78 t/Trailer) = 679.2 t;
For the calculation, the parametrisation is chosen to reflect the parameters derived above in the closest possible way. For the EcoTransIT calculator, the parametrisation is: train type = extra large train (2000t); train weight = 1631 t; load factor = 46 %. The load factor is calculated as the ratio of payload and payload capacity of the wagon. The values for the intrinsic standard wagon (empty weight = 23 t; payload capacity = 61 t) do not correspond to the values of the type specific wagons assumed in this study. To reflect the load / wagon weight ratio of 892.5 t / 738.5 t as for the parameters of this study, the EcoTransIT intrinsic standard wagon would need to be loaded with 27.80 t. The ratio of this value and the payload capacity of the standard wagon is 46 %, which is the load factor to be used for the calculation.

Contact

d-fine GmbH
An der Hauptwache 7
D-60313 Frankfurt/Main
Germany
info@d-fine.de

UIRR s.c.r.l.
31, rue Montoyer - bte 11
B-1000 Brussels
Belgium
headoffice.brussels@uirr.com

Berlin
d-fine GmbH
Friedrichstraße 68
D-10117 Berlin
Deutschland
info@d-fine.de

Hamburg
d-fine GmbH
Rödingsmarkt 9
D-20459 Hamburg
Deutschland
info@d-fine.de

Düsseldorf
d-fine GmbH
Dreischeibenhaus
D-40221 Düsseldorf
Deutschland
info@d-fine.de

London
d-fine Ltd
6-7 Queen Street
London, EC4N 1SP
United Kingdom
info@d-fine.co.uk

Wien
d-fine Austria GmbH
Riemergasse 14 Top 12
A-1010 Wien
Österreich
info@d-fine.at

Frankfurt
d-fine GmbH
An der Hauptwache 7
D-60313 Frankfurt/Main
Deutschland
info@d-fine.de

München
d-fine GmbH
Bavariafilmplatz 8
D-82031 Grünwald
Deutschland
info@d-fine.de

Zürich
d-fine AG
Brandschenkestrasse 150
CH-8002 Zürich
Schweiz
info@d-fine.ch

d-fine

analytical. quantitative. tech.