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TRANSITION TO ZERO FREIGHT EMISSIONS

METHODOLOGY

SMART FREIGHT CENTRE ACCREDITATION

as of 09/22

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INTRODUCTION

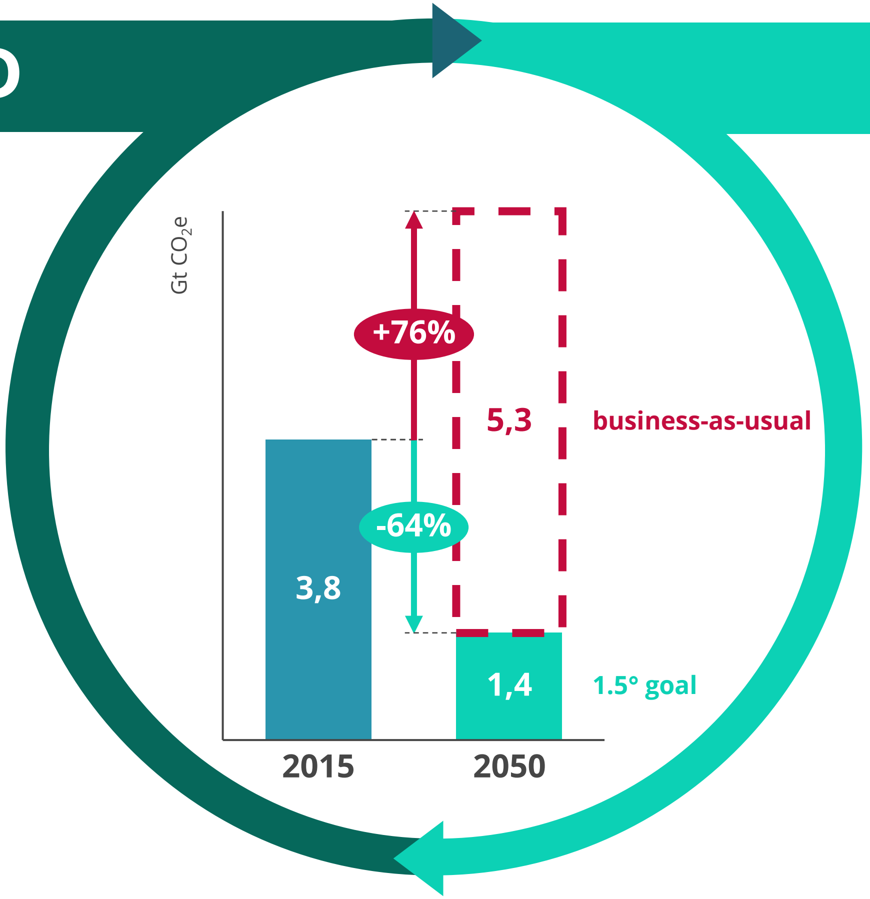
- Importance of emission transparency
- Key market drivers
- shipzero's positioning
- Primary data impact
- Emission data application areas

LOGISTICS INDUSTRY FACES MASSIVE CHALLENGE TO REACH EMISSION TARGETS

INDUSTRY TREND

- Growth in transport volume exceeds efficiency measures
- Lack of precise and reliable data blocks effective counter measures

Pressing need for action



TURNAROUND

- Professional management and reduction of CO_2-emissions
- Increase availability and transparency of emissions data
- Increasing awareness of CO_2-Impact along the value chain

Omnipresent focus topic

Source: Smart Freight Center, IEA (2018)

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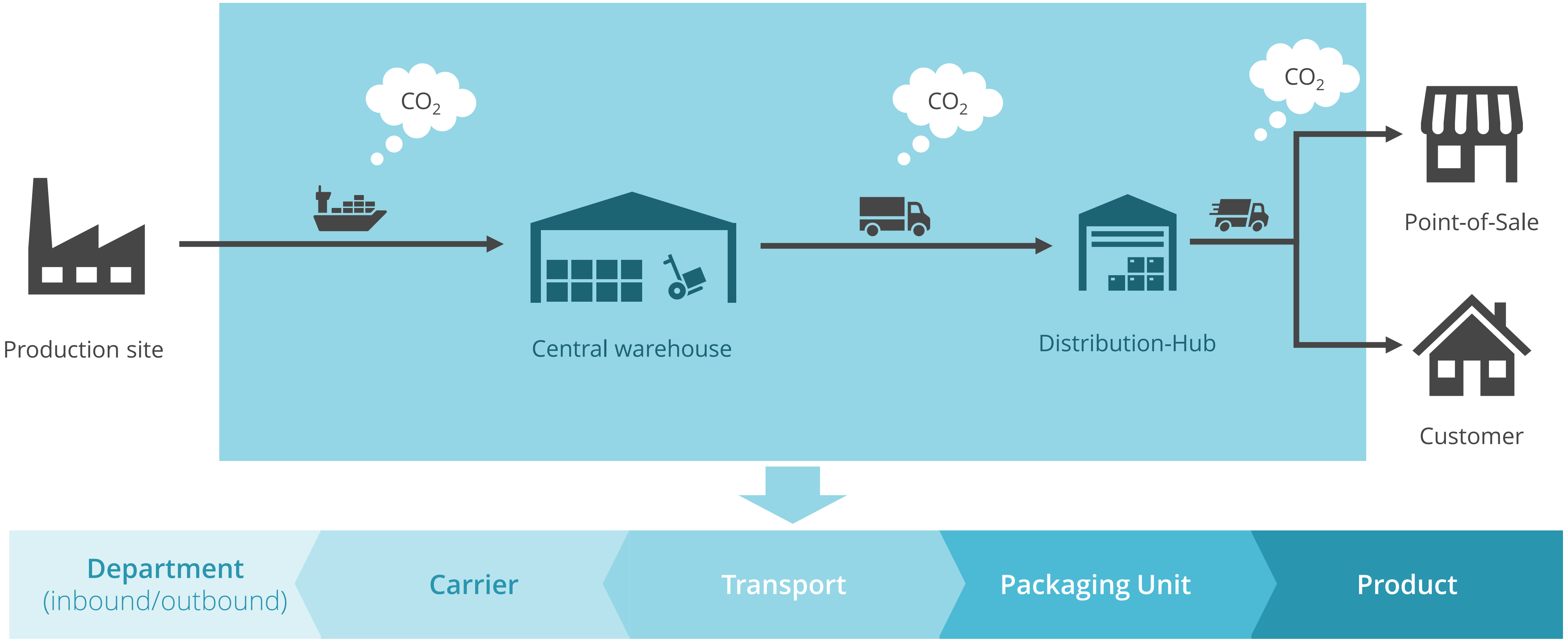
TRANSPORT BUYERS USUALLY LACK INFORMATION TO ALLOCATE EMISSIONS PRECISELY



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MULTIPLE DRIVING FORCES TO INCREASE TRANSPARENCY IN THE INDUSTRY

Emission transparency becomes key metric

Company targets
Implementation of CO_2 targets and transparent communication

Customers
Carbon footprint as important pre-qualifying criteria in buying decisions

Competition
CO_2 footprint as differentiation factor levers strategic investments.

Financial markets
CO_2-efficiency influences ratings and costs of capital.

B2B Partner
Shared responsibility.
Need for collaboration and data exchange.

Regulations
External standards regarding calculation, data exchange and reporting.

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SHIPZERO PROVIDES A UNIQUE PERSPECTIVE AND LEVEL OF DETAIL ON TRANSPORT EMISSION DATA

Category	Dimension	Transport Management System	Individual Carrier Surveys	Forwarder Reportings	Corporate Carbon Footprint Mgmt	shipzero
Emission Scope	Well-to-wheel	✓	✗	✓	✓	✓
	Multimodal	✗	✗	✓	✓	✓
	Individual transports	✓	✗	✗	✗	✓
	Split by customers / suppliers	✓	✗	(✓)	✗	✓
Reporting Standard	GLEC / EN 16258 compatible	✗	✓	✓	(✓)	✓
	Including primary consumption data	✗	✓	✗	✗	✓
	Unified approach for all transports	✓	✗	✗	✓	✓

Generalized review of multiple vendors or solution providers

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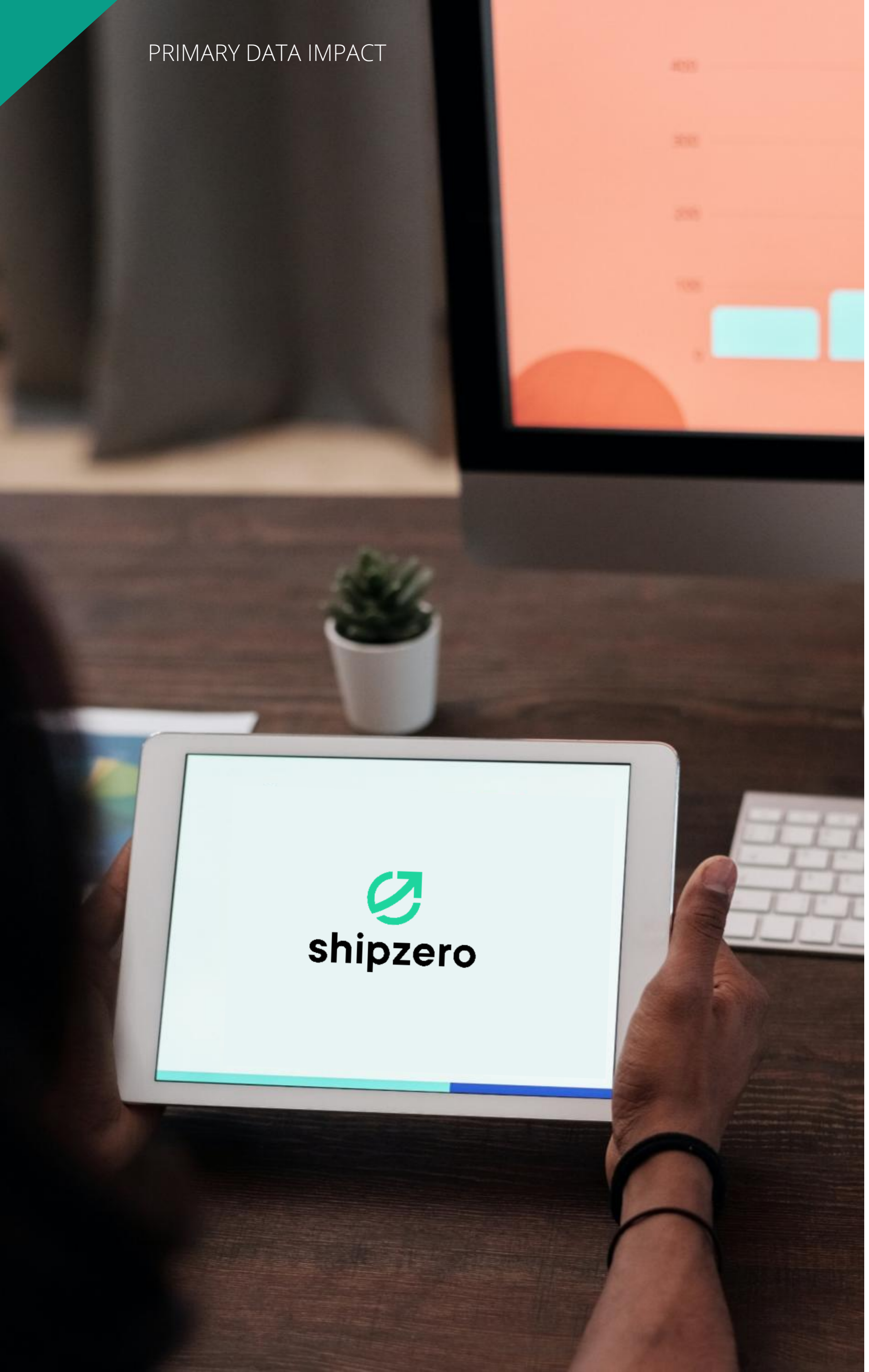


SHIPZERO: SOLVING PAINPOINTS IN CO_2 MANAGEMENT

1. Data & IT structure
- High complexity of logistics processes
- High fragmentation & heterogeneity of data and IT systems

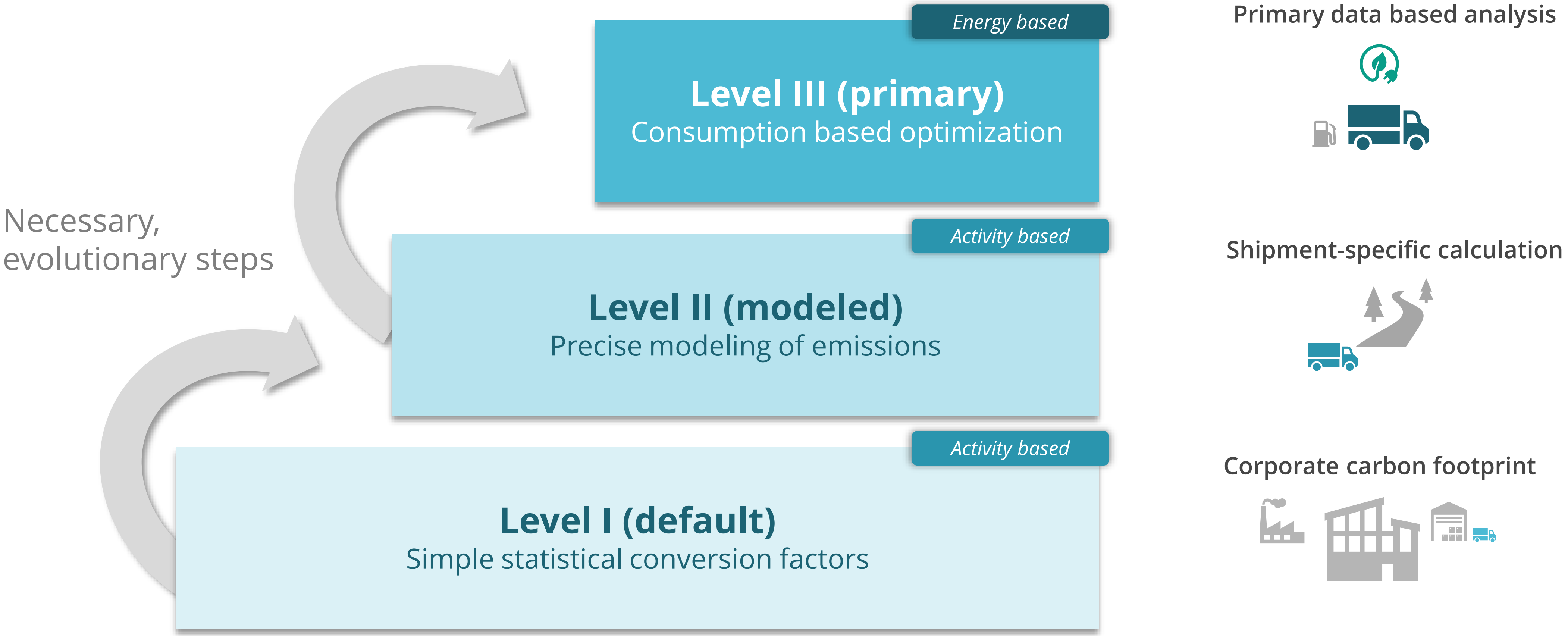
2. Calculation model
- Respond to changing standards and external requirements
- Connect available data sources, ensure quality and extend structure dynamically

3. Reporting
- Create reports for internal and external stakeholder perspectives
- Consider individual requirements for planning, management, purchasing, etc.

4. Generate insights
- Identify concrete optimization potentials from the data
- Initiate implementation projects collaboratively on neutral, data-driven assessment

5. Partner management
- Collaboration and continuous data exchange for analysis
- Joint development of realistic goals and measures

FUNDAMENTAL IDEA OF AN INDUSTRY TRANSITION TOWARDS MORE DIFFERENTIATED EMISSIONS DATA



BY COMBINING PRIMARY AND TRANSPORT DATA SHIPZERO MAXIMIZES CALCULATION QUALITY

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Transport order data
System: TMS, ERP

- Departure and Arrival (Location & Time)
- Shipment weight
- Mode of transport
- Vehicle information
- Temperature, ADR transports
- FTL / LTL information

Primary data - routing & consumption
System: Fleet telematics, Fuel cards

- Distance per Vehicle
- Consumption / CO_2e
- Geotrace

Order data
Transport data
Freight data
Network data

collect
enrich
analyze

Routing
Energy consumption

Valid CO_2 Calculation

Communication & Risk Management

Partner Management & CO_2-reduction targets

Optimization & CO_2-reduction measures

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VARIANTS OF "PRIMARY DATA"

		impacted by				enables
Primary Data Dimensions	**Data source**	**round-trip booking** *reduce empty-running*	**utilization** *optimize load*	**dedicated propulsion** *low-carbon fuels*	**mixed fleet** carrier efficiency	**Emission allocation** customer-specific
distance	*odometer*	✗	✗	✗	✗	✗
av. fleet consumption	*fuel card averages*	✗	✗	✗	✓	✗
av. vehicle consumption	*fuel card / FMS averages*	✗	✗	✓	✓	✗
tour consumption	***vehicle (r)FMS data***	✓	✓	✓	✓	✓

Primary data is not explicitly defined - out of four levels commonly brought in context with **primary (measured) input** values to emission reporting, **only the individual tour consumption-level** allows precise analysis on measures that **transport buyers** can act on.

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TOP USE CASES FOR RELIABLE EMISSION DATA

Sustainability reporting and disclosure

Risk management for climate costs

Zero-emission products and services

Developing decarbonization strategies and targets

- Trade-lane efficiency
- Freight consolidation
- Renewable propulsion

Identifying effective CO_2 avoidance and reduction potentials

Planning of investment decisions (fleet, fuels, infrastructure)

METHODOLOGY

- Emission boundaries
- Total fuel perspective
- Modes of transport
- Data collection
- Calculation and reporting

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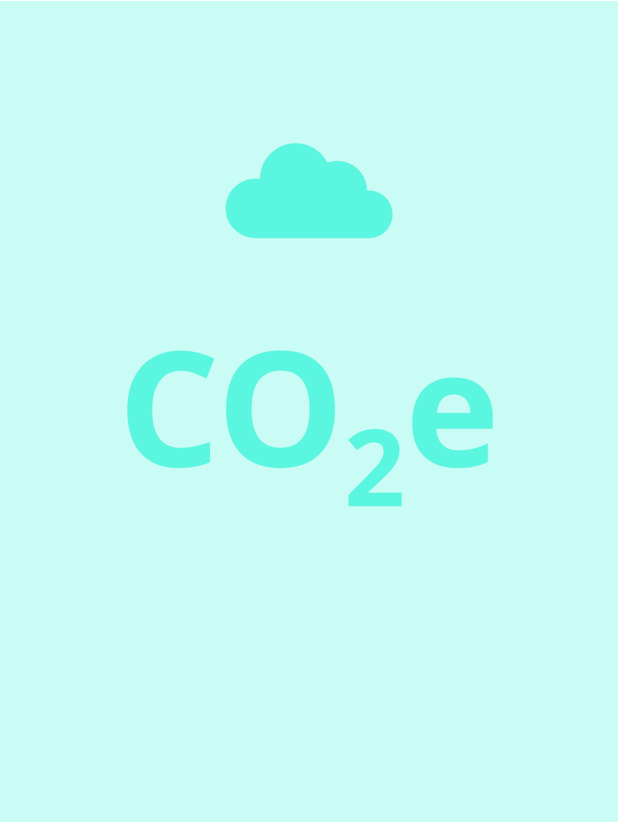
GREENHOUSE GASES & CARBON DIOXIDE EQUIVALENT



- Gases that retain heat in the atmosphere are called greenhouse gases (GHG).
- Greenhouse gases refer to a sum of seven gases that can be classified in 4 groups: carbon dioxide (CO2), methane (CH4), Nitrous oxide (N2O) and fluorinated gases.
- Carbon Dioxide (CO2) accounts for over 80% of greenhouse gases and is therefore the most referred to greenhouse gas.
- A common way to compare greenhouse gases is the carbon dioxide equivalent (CO_2e).
- This metric is based on each greenhouse gas' global-warming potential (GWP) that converts amounts of other gases to the equivalent amount of carbon dioxide with the same GWP.
- Example: methane has a GWP of 25, meaning that its GWP is 25 times as high as that of CO_2. In comparison, nitrous oxide has a GWP of 298 and sulfur oxides even of 14,800 to 22,800.
- Carbon intensity is the level of CO_2 emissions per unit of a specific activity. It is used to compare the environmental impact of different activities or of the same activity in different execution variations.
- A well-known example of a carbon intensity measure is grams of CO2 equivalents per tonne-kilometer (distance x gross cargo weight).

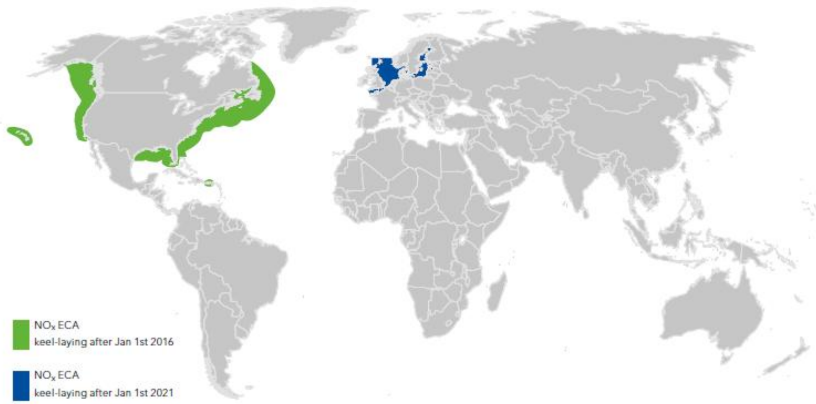
COMPREHENSIVE AND CONSISTENT COVERAGE OF GREENHOUSE GASES

Greenhouse gas coverage
shipzero covers not only the universal performance indicator of CO2-equivalents as aggregated measure for the greenhouse gas impact, but also drills down to other important emissions that underly regulations and are closely monitored by local/regional authorities or mode-specific governance bodies such as the International Maritime Organization (IMO).

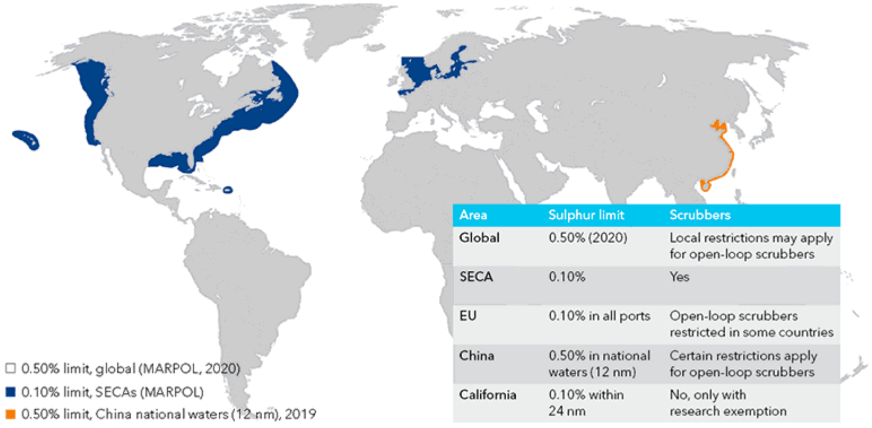
As stated on the right: NECA and SECA zones restrict maritime transport emissions on Nitrogen oxide and Sulphur oxide emissions, respectively.

Greenhouse Gas Breakdown	Abbreviation	Unit
Carbon Dioxide Equivalents	CO2e	t / kg
Carbon Dioxide	CO2	kg
Nitrogen Oxides	NOx	kg
Sulfur Dioxide	SO2	kg
Nonmethane Hydrocarbon	NMHC	kg
Particulate Matter	PM	kg

NOx Emission Control Areas (NECAs)[1]



Sulphur Emission Control Area (SECA) [1]



Area	Sulphur limit	Scrubbers
Global	0.50% (2020)	Local restrictions may apply for open-loop scrubbers
SECA	0.10%	Yes
EU	0.10% in all ports	Open-loop scrubbers restricted in some countries
China	0.50% in national waters (12 nm)	Certain restrictions apply for open-loop scrubbers
California	0.10% within 24 nm	No, only with research exemption

1) Sources: European Commission, IMO, IACCSEA

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SCOPE - SYSTEMIC AND COMPARABLE ASSESSMENT OF GREENHOUSE GAS EMISSIONS

SYSTEM BOUNDARIES

Well-to-wheel (WTW)

Energy provision, production and distribution	Operation of vehicles / vessels	Construction of infrastructure	Construction of vehicles / vessels
Well-to-tank (WTT)	Tank-to-wheel (TTW)	*out-of-scope*	

System boundaries

Transport emissions shall be fully integrated into the assessment and reporting of transport activities along the supply chain. However, in order to avoid double counting with other areas of GHG assessment as well as to keep the process of calculation viable, two segments are defined out-of-scope in all applicable guidance documents (ISO 14083, GLEC Framework, EN16258).

Those segments comprise the construction of necessary infrastructure as well as the construction of vehicles, vessels along with trailers and packaging units.

Well-to-wheel vs. well-to-tank vs. tank-to-wheel

Well-to-tank (WTT): Emissions caused by transforming primary energy (sunlight, biomass, oil, coal, nuclear etc.) to consumable energy for vessels or vehicles (diesel, kerosine, hydrogen).

Tank-to-wheel (TTW): Emissions caused by converting the vehicle or vessel fuel to propulsion, e.g., burning diesel.

Well-to-wheel (WTW): holistic approach, which considers both, well-to-tank as well as tank-to-wheel emissions, and therefore increases the comparability of fossil and renewable fuels, e.g., considering the origin of electricity for battery-electric-vehicles to reflect the share of coal or fossil gas on the local electricity-grid.

KEY METRICS FOR EMISSION TRANSPARENCY

CO_2e

Total Emissions
absolute Carbon Dioxide equivalent emissions in each time period

tkm

Freight volume
expressed as gross cargo weight (tonnage) times distance (km) calculated on a trip-level in each time period

CO_2e in g / tkm

Carbon intensity
Relative CO2e impact in gram normalized per ton-kilometer in each time period

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ADDITIONAL TRANSPORT-RELATED GREENHOUSE GAS SOURCES

Tank Cleaning for hazardous goods and chemicals
Tank cleaning for liquids and chemicals is an energy-intensive process. Related emissions can be separately reported based on default values, if transport activity data implies cleaning or it can be derived from the product. Not directly added to the transport emissions – does not directly affect the intensity value. More precise approach by integration of cleaning records or (owned) facility consumption.

Logistics sites and warehouse emissions
Emissions caused by storage, cross-dockings or terminal operation within a transport chain. Related emissions can be separately reported based on default values, if transport activity data implies it. Not directly added to the transport emissions – does not directly affect the intensity value. More precise approach by integration of owned or operated facility consumption and/or capacity.

Company carbon footprint
Scope 1 and 2 emissions that arise from heat and electricity usage in office buildings, employee commute and other directly energy-consuming activities. For a carrier or forwarding company – depending on the business model – these emissions account for roughly 5-15% of total Scope 1-3 footprint. Not added to transport emissions and therefore not affecting the intensity value. Can be assessed on-demand on an annual basis per location. Certification through external partners possible.

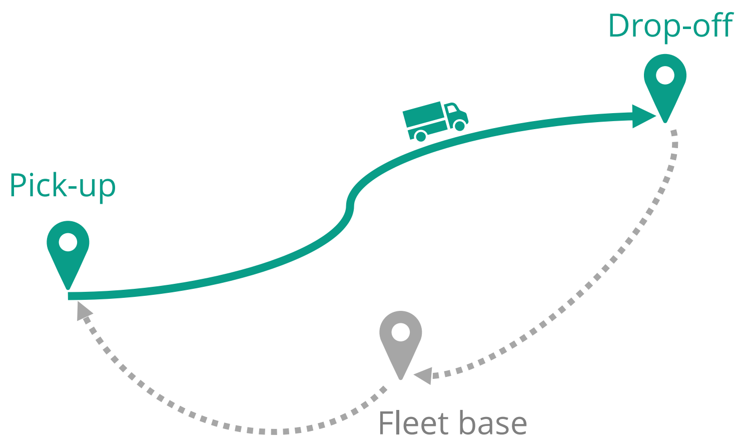
EMPTY RUNNING

Empty running
Refers to the distance traveled empty in order to pick up freight, relocate vehicles/vessels or return to a dedicated location. In a broader sense it covers also milage picked up through maintenance, cleaning or fueling events – independently of a dedicated freight order.

Empty running is applied by default GLEC recommendations to every transport as long as a dedicated round-trip with no further vehicle movement is not stated in the transport activity data. Empty running may differ by transport type and load characteristics as stated in the GLEC Framework. For primary tracked fleets, two alternative options exist:

(1) All consumption and mileage that is not falling into the category of "loaded transport" is aggregated and divided by the number of "loaded transports" executed in the same time frame. This average is then applied to every transport (vehicle or fleet level).

(2) Trip consumption is considered until the next "loaded transport" starts. After reaching the "loaded transport" drop-off point, all consumption after that and until the next tour start is assigned as empty running to the previous trip.



Distance from pick-up to drop-off is the base measure (planned or actual primary). Detours between pick-up and drop-off are added to the mileage, while additional distance-travelled empty/off-duty is not reflected in reporting. Only the consumption is added to increase emission intensity and therefore absolute emissions for the trip.

LOAD FACTOR

Load factor
The load factor determines the utilization of a vessel/vehicle with regards to the allowed maximum weight capacity. Therefore, the load factor relies on the vehicle selected as well as on local restrictions or regulations as to what maximum weight a vehicle can be loaded.

The absolute transport weight (sum of all cargo) on a vehicle or vessel is set in relation to the maximum allowed payload weight of a vehicle in the respective geography.

Default: vehicle class based on mode, geography
Modeled: vehicle class based on mode, geography, distance, travel time, packaging and further transport characteristics
Primary: vehicle master data (make/model/payload)

In order to keep it comparable, volume figures are not considered for the calculation of the load factor but can in some situations of scarce or unreliable weight data be taken as proxy to estimate an average weight, e.g., for special units like automobiles, or only data available about the packaging unit (e.g., TEU).

Road – Load factors can be precisely computed from the max. payload capacity of the vehicle (if known) or the most likely vehicle class selected. As load factors can differ a lot in different product categories, it is a significantly impacting variable for the emission calculation.

Sea - Load factors for maritime shipping are rarely available to the shipper or LSP and not openly shared from most ocean carriers on a trip level. The Clean Cargo World Initiative provides annualized averages per trade lane (or carrier), which represent the best available data at present.

Rail - Like sea transports, railway companies rarely provide exact load factors per train and trip, depending on the products and routes, educated assumptions can be taken into consideration supported by the scientific methodologies underlying.

Air - Load factor heavily depends on the trip distance or plane type (freighter vs. belly freight in passenger plane), both is reflected in an educated assumption, while airline carriers rarely provide primary data insights on their capacity.

Barge - especially bulk transports are characterized by a high utilization rate, which is necessary to be competitive. If not owned and operated, a calculation approach is applied to estimate the fuel consumption depending on the vessel class.

TEMPERATURE CONTROL

Temperature-control
Emissions also arise from diesel or electricity powered cooling or heating units during transportation. Generally, temperature-controlling units mounted to trailers or containers are powered independently of the main energy-source of the vehicle or vessel. And therefore, need to be calculated separately.

Temperature-controlled warehouses or storage places are along with general logistics site emissions not directly accounted to on single trip but in addition to the overall sum of transport emissions in order to have a complete scope 1 or 3 emission picture.

A default impact of temperature-control can be applied, if information is given in the transport activity data or directly derivable from the product (category). Those emissions increase directly the transport emissions – and therefore affect the intensity value.

A more precise approach by integration of trailer telematics or dedicated fuel card analysis is also possible and depending on the overall impact of temperature-controlled cargo – preferred in terms of reliability and compliance to the standards.

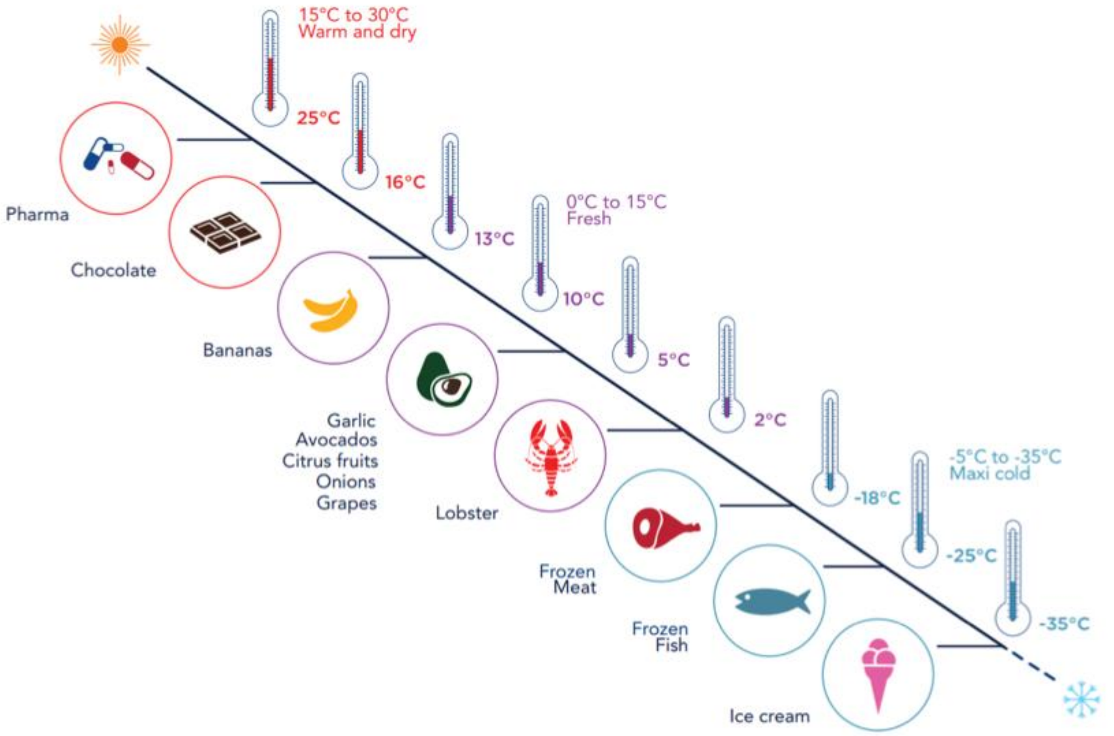


Image: CMA CGM

MARGINAL ACCOUNTING

Marginal Accounting
Marginal Accounting is an important aspect for calculating accompanying cargo – e.g., in the case of belly airfreight in passenger planes or mixed ferry transports.

In those cases, a basic utilization (e.g., passengers) is assumed and only the energy consumed through added weight of cargo is taken as baseline for the transport emissions – instead of the entire vehicle consumption as it would be in any other freight transport.

In the special cases of Ro-Ro ferries and intermodal truck/rail connections with exchangeable equipment, also the equipment weight is considered.

This is especially important for carriers operating those vessels as well as for the aspect of data sharing, where incomplete information are transmitted, and this might lead to false interpretations and accounting schemes.

DATA ENRICHMENT FOR VEHICLE CLASSES AND HOLISTIC CONSIDERATION OF ENERGY USAGE

Transport mode	Vehicles / Vessels types	Emission classes	Supported propulsion energy	Supported well-to-tank considerations
Road	15	17	Diesel, CNG, LNG, Electricity, Hydrogen	Considers country-specific energy mix and bio-fuel share
Rail	16	11	Electricity, diesel	Considers country-specific energy mix and bio-fuel share
Barge	6	5	Electricity, diesel	Considers country-specific energy mix and bio-fuel share
Maritime	49	3	HFO, MDO, MGO, LNG	Considers emission control areas
Air	263	-	Kerosene	

+1,800 individual heavy-duty vehicle make and model combinations are additionally available to precisely characterize primary-tracked road transports, once a connection to fleet master data is established through the shipzero platform.

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ROAD

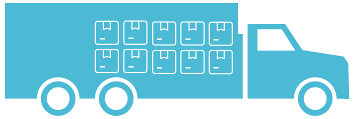
Distance and routing
Road transport distance calculation is always based on the most accurate way possible with regards to the available data. Ideally, street-level addresses can be geocoded and fed into a routing algorithm that considers network resistance (e.g., highway vs. rural vs. urban traffic) and applies the path of lowest resistance.

Additional attributes include preferences for ferry routing. For less accurate geolocations Point-of-Interest (POI) defaults for major logistics hubs (e.g., Port of Rotterdam) or geo-centroids of zip-codes and cities can be applied. Primary data is collected directly from the odometer of the truck telematics system and provides the most reliable source of distance information and routing. For LTL shipments that are usually through at least one transshipment center or move along a network of hubs, a precise routing of the shipment can be reflected, if necessary, information (e.g., bordero, loading lists) can be provided additionally.

Cargo
The cargo weight is a minimum input requirement to the shipzero calculation. As reference for any calculation the actual gross weight, incl. packaging is considered. However, in cases of missing data, gross cargo weight can be estimated, if reliable reference values are existent. For example, loading meters or volume measures and product type, or only net weight. A not reliable measure is the chargeable weight. Temperature-control of transports is also considered as additional source of energy in various product areas such as food, pharmaceuticals, or chemicals. If no direct primary data input for cool-chain energy is available a GLEC-conform refrigeration factor is applied.

Exemplary truck load calculation

Vehicle:	40t truck
Max. payload:	26t
Max. volume:	13.6 ldm
Cargo:	18 EPAL
Gross cargo weight:	18t
Cargo volume:	7.2 ldm
Load factor:	**69%**



Load factor FTL:
gross cargo weight / max. (allowed) payload of vehicle (or class)

Load factor LTL (unknown load):
gross cargo weight / max. payload of vehicle (or class) x default load factor

ROAD

exemplary

Less-than-truckload transshipments

1 – 2 Pre-haul
Collection of goods or single shipments and transport to the first cross-docking (Hub)

Truck: 26t I LF: 60% I ER: 33%

2 – 3 Main-haul
Hub-to-hub transfer over a long-haul connection, usually FTL.

Truck: 40t I LF: 100% I ER: 0%

3 – 4 Post-haul
Distribution run or last-mile to destination/receiver address

Truck: 7.5t I LF: 60% I ER: 17%

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ROAD

Transport assets and propulsion

For road transport a default (most common) vehicle class is applied for each country, if no further information can be provided as part of the transport order data, e.g., 40t truck in Germany. However, in a modeled approach an appropriate vehicle class is algorithmically selected based on parameters such as distance-traveled, cargo weight, cargo volume, LTL or FTL transport type (if applicable).

In total 15 different weight classes, each applied in accordance with the country-specific legislation of max. truck weights and payloads, are available as part of the modeled data. For primary traced transports, the truck type is not as important as for the modeled approach, as the dedicated consumption clearly indicates the emission impact, however the contextual value of the information is relevant for optimization analysis and reliable comparisons. For the European Union over 1,800 make/model information of all major European truck manufacturers can be referenced as part of a master data integration of a carrier fleet.

In terms of propulsion energies, diesel is taken as default with a country-specific bio-fuel share. This bio-fuel share can be adapted for dedicated carrier fleets, if information about the well-to-tank processing is specified to reflect zero-emission vehicles or fuels. Further supported propulsion energies include battery-electric, hydrogen, Compressed Natural Gas (CNG), Liquid Natural Gas (LNG).

Major vehicle classes

Vehicle classes	Empty weight (t)	Payload (t)	TEU capacity	Total weight (t)
<=3.5t	2.3	1.2	-	3.5
>3.5-7.5 tonnes	4	3.5	-	7.5
>7.5-12 tonnes	6	6	-	12
>-12-20 tonnes	7.5	11	-	20
>20-26 tonnes	9	17	1	26
>26-40 tonnes	14	26	2	40
>40-60 tonnes	19	41	2	60

U.S. EPA classes for North America are reflected in the calculation in a comparable classification. Emissions standards from EURO I to VI along with corresponding EPA and Japanese standards are automatically applied depending on the transport region and follow the EcoTransIT methodology guidelines.

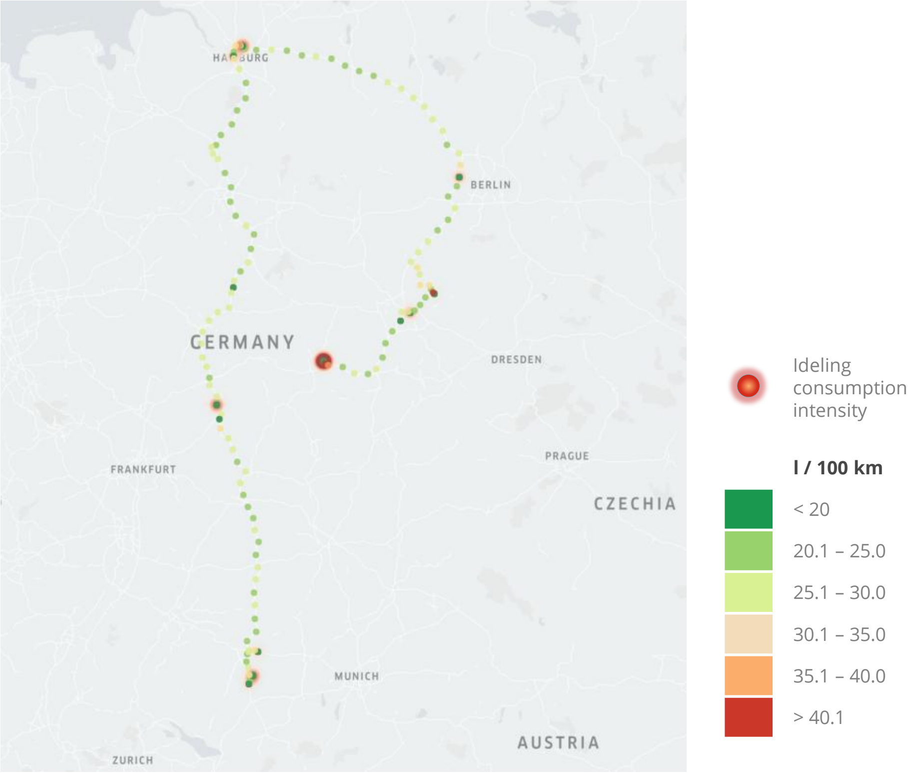
The classification of vehicles for each trip follows either direct indications from the transport order data or can be algorithmically applied based on tour characteristics and maximum payload (e.g. urban pre-haul) to reflect more realistic calculation patterns for the broad variety of different road-based transports.

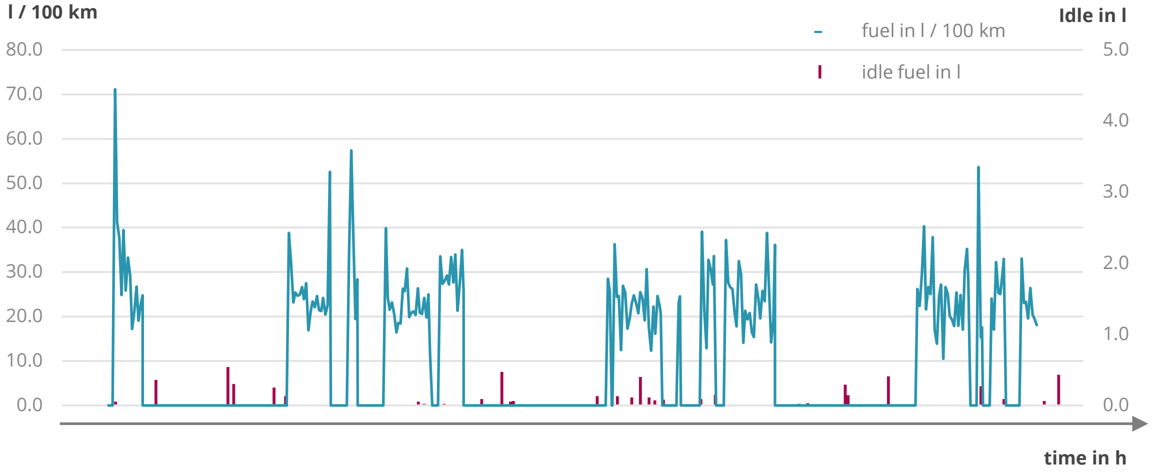
Source: EcoTransIT (2021)

ROAD

exemplary

Tour-level primary data enables a new perspective on energy-usage of vehicles





Primary fuel consumption:

Primary fuel data can be obtained directly from the FMS data provided in almost all heavy-duty tractor units built after 2017. The total fuel used in combination with the odometer based milage are the most important values to be derived. Idling emissions at loading/unloading locations have a not neglectable impact and are partly in the responsibility of a shipper.

Alternatively fleet or vehicle averages (l per 100 km) from fuel cards can be applied to track vehicles without FMS-supported telematics systems, which may be the case for urban last-mile transports

(r)FMS = Remote Fleet Management Standard

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RAIL

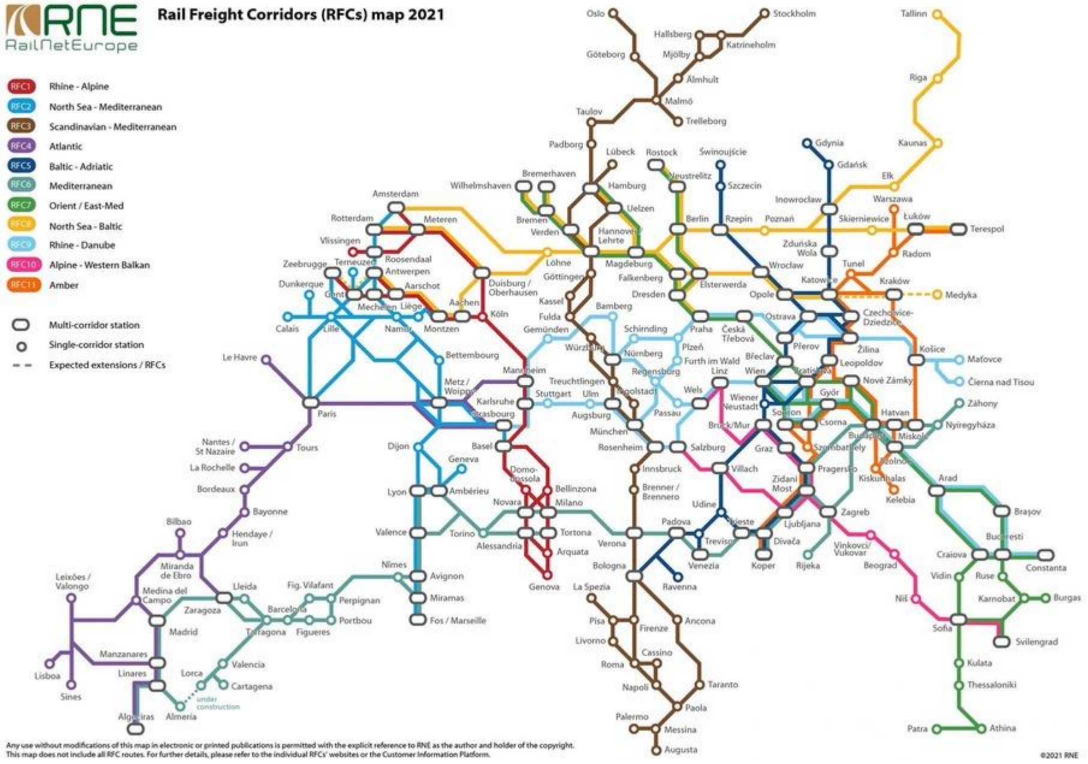
Distance and routing

Railway routing contains attributes about electrification of the track (or diesel-powered lines). In the defined Freight Corridors between major railway hubs and terminals, e.g., in the European Union are considered with lower resistance than non-freight corridor connections. Track gauges at international transition points are reflected as well as the possibility of a ferry transfer.

If start and destination point are not equivalent to a railway terminal; pre- or post-hauls on the road are imputed to the given point of arrival or destination, if not otherwise stated explicitly.

Cargo

The cargo on freight trains can be generally differentiated between standard wagons, tank cars and interchangeable trailer units or standard containers, along with special wagons for cars or special bulk products (e.g., cereals). For intermodal transports that only provide a packaging unit, e.g., number of TEUs or FEUs assumption can be applied based on the product category on that shipment. These assume 6t of net cargo weight for volume goods, 10t for average cargo and 14.5t for heavy and bulk goods. Assumptions are based on the Clean Cargo and EcoTransIT methodologies.



Source: ÖBB Infrastruktur AG

RAIL

Transport assets and propulsion

Energy-consumed from rail transports is differentiated by main source of propulsion (diesel / electricity). Well-to-tank impact on electrified tracks reflects the energy-mix of the respective country as default, if no indication of entirely renewable powered transports is available. Shunting and maneuvering of wagons in depots and terminals is reflected by a default assumption and solely powered with diesel cars.

Practically, only in rare occasions railway companies provide dedicated information about the propulsion energy type or origin for dedicated tours. General patterns for freight corridors or tracks are reflected to the best available data and can be specifically adapted, once information becomes available, e.g., due to special contracting conditions.

Major train types are differentiated based on the cargo type.

Cargo Type	Train wagon	Load factor	Empty run factor	Capacity utilization
General Cargo	Bulk	100%	80%	56%
	Average	60%	50%	40%
	Volume	30%	20%	25%
Dedi-cated Cargo	Car	85%	50%	57%
	Chemistry	100%	100%	50%
	Container	50%	20%	41%
	Coal and steel	100%	100%	50%
	Construction	100%	100%	50%
	Manufactured	75%	60%	47%
	Cereals	100%	60%	63%
int. Truck	Bulk	100%	60%	63%
	Average	60%	20%	50%
	Volume	30%	10%	27%

Source: EcoTransIT (2021)

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SEA

Distance and routing
Port-to-port connections between two seaports are routed through a network of nodes and follow typical vessel movement on major trade lanes (e.g., Northern Europe – LATAM).

Important water passages such as Suez Canal, Panama Canal, Kiel Canal put restrictions on the vessel class derived from TEU capacity or DWT (dead weight tons). Seaport locations are matched to the UN/LOCODE systematic, and only consider those ports that involve freight shipments.

Besides a modeled route, data quality can be improved by taking actual traces and distance-traveled from AIS tracking. This requires the availability of a vessel IMO number or distinct service reference along with reliable dates on the departure.

Cargo
The major distinction for global maritime trade can be made between containerized and bulk shipping (dry and liquid), a third category are roll-on/roll off ships used for the transport of vehicles. DWT (dead weight tons) for bulk as well as TEU capacity give guidance towards the maximum capacity of freight a vessel can carry. The DWT includes cargo, fuel, fresh and ballast water, passengers and crew.

Container Ship Trade Lanes

Source: EcoTransIT

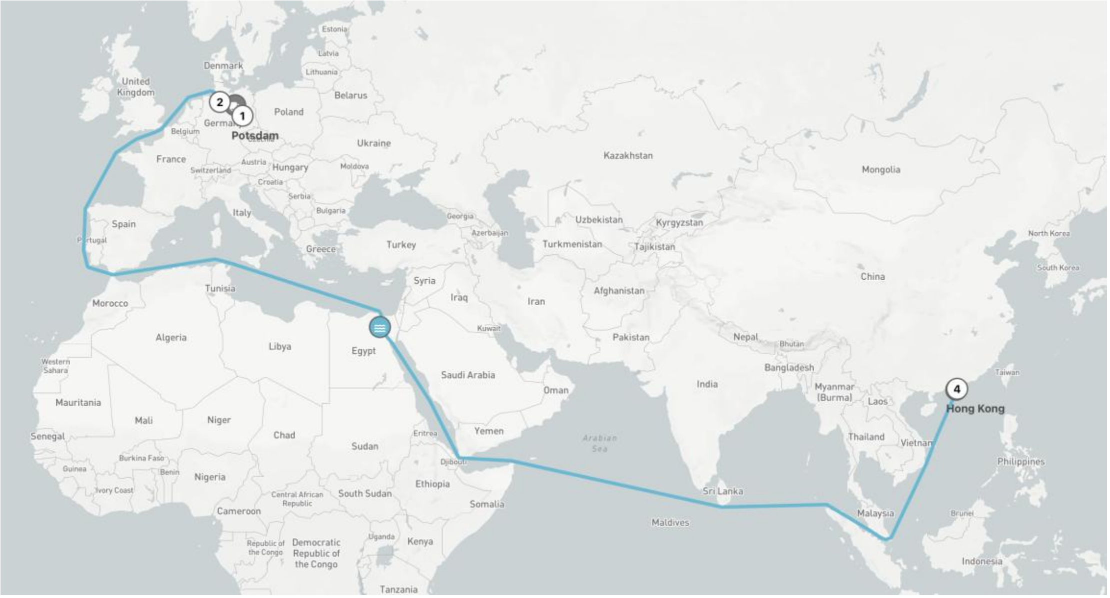
Because the cargo load by far dominates the DWT of freight vessels, fuel, fresh water and crew can be ignored. ISO standard containers of 20′ (1 TEU) or 40′ (1 FEU) are calculated by adding an empty weight of 2,250 kg (TEU) or 3,780 kg (FEU) – if the freight weight is not already containerized reflected in the order data.

SEA

Transport assets and propulsion
Fuel consumption in maritime transport is dependent on a variety of factors such as: vessel size class, sailing speed, consideration of all engines (main, auxiliary), utilization, routing, and external impacts such as weather and currents. In recent years, also the emission impact depends on regulatory zones, fuel type usage, special equipment such as sails, scrubbers and, of course, the use of renewable fuels such as bio-methane/bio-LNG, Ammonia and others.

Primary data for fuel usage is known to a limited number of parties, incl. pot. the shipowner, ocean carriers and regulatory authorities who receive an annual reporting. While noon and arrival reports provide the potential to fetch primary data on a vessel level, transparency and allocation challenges make it difficult to use the data on larger scale. The Clean Cargo Initiative focused on containerized transports provides for major container lines and trade lines annual averages of consumption and consequently emission factors as the currently best available source of primary data.

Meanwhile, AIS providers allow dedicated tracking of vessels and therefore a more precise assessment of deviations from the normal as shown in recent global blockades of ports, canals or disruptions in regular traffic (Suez, Beirut, Shanghai).



The following vessel types are differentiated: General Cargo, Dry Bulk, Liquid Bulk, Container, and Roll-on-Roll-off vessels. Vessel classes can be further specified to different capacity classes (TEU or DWT) ranging from below 5,000 DWT or >1,000 TEU to more than 200,000 DWT and container ships exceeding 14,500 TEU capacity.

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SEA

Outlook

With effect of 2021, the Clean Cargo Working Group initiated by the BSR moved under the roof of the Smart Freight Center to renew the collaborative approach of data sharing and higher transparency on the carbon emission impact followed by over 80 companies, representing over 85% of global maritime container trade.

Due to this change, methodologies along with data fetching and provisioning of emission factors will change of the course of the next months and years. Similarly, AIS providers that cover global vessel tracking move into the direction of including more environmental KPIs to their systems along with the leading freight forwarders that start to build own systems dedicated to emission monitoring and control.

All of the above mentioned happens also due to increasing regulation and international agreements by the IMO or the European Union for example by including maritime trade into the European Trading Scheme (ETS) for carbon emission certificate trade.

Becoming carbon neutral by 2050 will be a herculean task for maritime shipping with long asset lifecycles, nonetheless alternative fuels and consequently new emission factor are on the edge of implementation.

Vessel types	Trade lane / size class	Capacity utilization
Bulk (dry liquid) General Cargo	Suez trade	49%
	Transatlantic trade	55%
	Transpacific trade	53%
	Panama trade	55%
	Other global trade	56%
	Intra-continental trade	57%
	Great lake	58%
Bulk carrier (dry)	Feeder (5,000 - 15,000 dwt)	60%
	Handysize (15,000 - 35,000 dwt)	56%
	Handymax (35,000 - 60,000 dwt)	55%
	Panamax (60,000 - 80,000 dwt)	55%
	Aframax (80,000 - 120,000 dwt)	55%
	Suezmax (120,000 - 200,000 dwt)	50%
Bulk carrier (liquid)	Feeder (5,000 - 15,000 dwt)	52%
	Handysize (15,000 - 35,000 dwt)	61%
	Handymax (35,000 - 60,000 dwt)	59%
	Panamax (60,000 - 80,000 dwt)	53%
	Aframax (80,000 - 120,000 dwt)	49%
	Suezmax (120,000 - 200,000 dwt)	48%
General Cargo	All trades, all size classes	60%
Container vessels	All trades, all size classes	70%
RoRo vessels	All trades, all size classes	70%
Ferries (RoPax)	All ferry routes	64%

Source: EcoTransIT (2021)

BARGE

Distance and routing

The inland waterway routing is based on the navigable network of inland waterways for barges and takes place between inland waterway ports. The European Classification of Waterways (CEMT) determine the restrictions for large vessels – a similar global classification is not available at present.

Cargo

Barge transports are differentiated between containerized and bulk shipping. Actual cargo weights are applied. Furthermore, ambient and temperature-controlled transports can be differentiated in containerized barge shipments.

Transport assets and propulsion

For barge transports, three capacity categories are applicable on which a dedicated energy consumption is calculated based on the EcoTransIT World methodology:

up to 1500 t capacity (CEMT Classes I-IV)
1500 – 3000 t capacity (Class V)
>3000 t (Class VI and above)

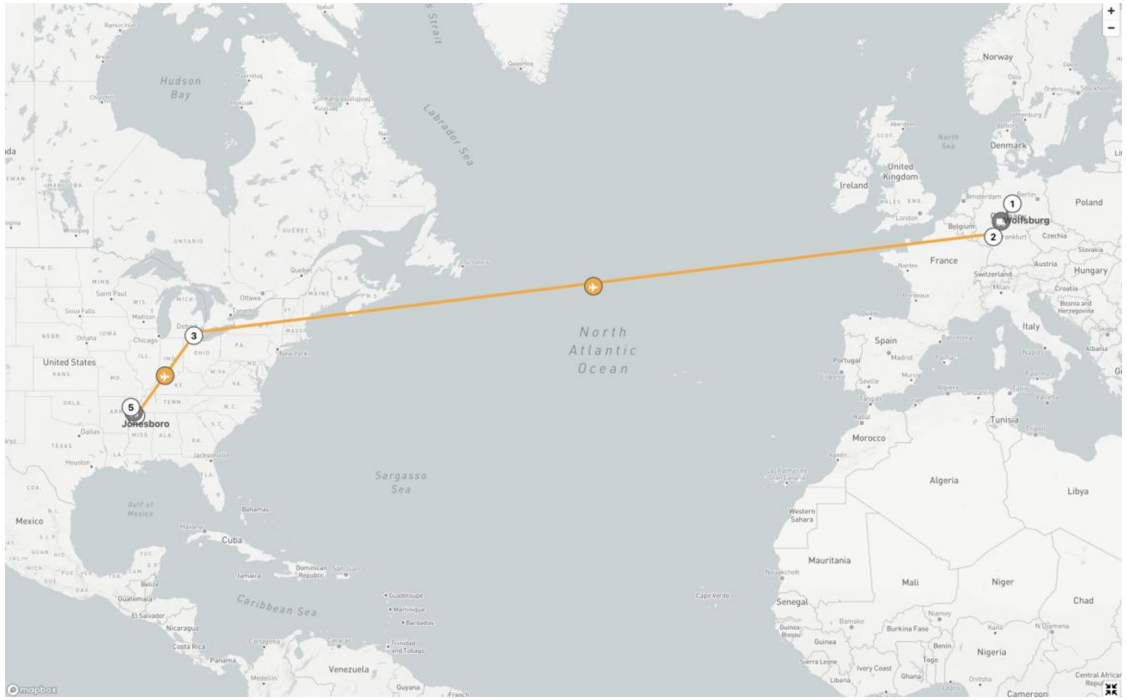
Possibilities to reflect alternatives to fossil diesel fuel such as electrification and hydrogen-powered barges will be included to modeled approaches, once a reliable reference data set becomes available.

AIR

Distance and routing
The calculation of the flight distance uses the Great Circle Distance (GCD). GCD refers to the shortest distance between two airports. To account for a more realistic routing a default of on average 95km is added to the GCD for each leg of flight. This stands in accordance with the European standard EN 16258 as well as the European Emission Trading System (ETS).

Routing of air freight heavily depends on possible connections between airports to a given data. Most intercontinental connections move through the hub network of big transshipment/international airports. To reflect those intermediate flight legs correctly, actual connecting flights can be added in a modeled approach by considering dates, airports (IATA codes) as well as flight numbers.

Cargo
Air freight containers are special unit load devices (ULD) that normally require repacking and distribution of cargo units in multi-modal transport chains involving air freight. Gross cargo weight is taken as reference. Depending on the plane type (derived from flight number) a distinction between belly freight in passenger planes and cargo planes is made in order to account appropriately for the emission allocation.



Freight load factor: short haul 50%; medium and long haul 70%.
Passenger load factor: short haul 65%; medium haul 70%; long haul 80%

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AIR

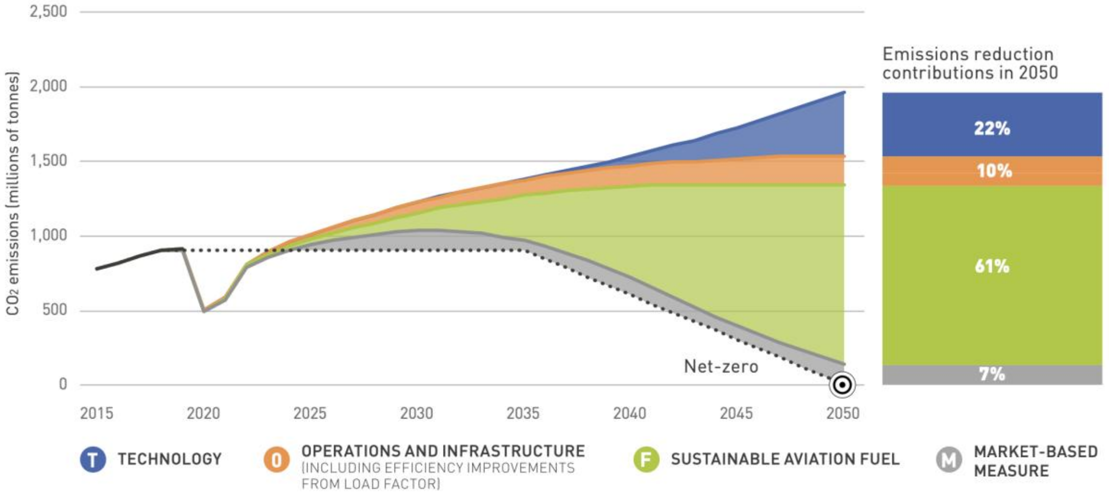
Transport assets and propulsion

For the calculation of transport emissions all operations including taxiing, take-off, cruising, landing is considered as part of the applied emission factors. The consumed energy per trip can be modeled across over 250 different plane types as available in the IPCC 2006 report and in accordance with the EcoTransIT World methodology.

The primary form of propulsion energy is jet fuel/kerosene. However, first flights using alternative forms to fossil-based jet fuel are already successfully demonstrated. Therefore, biofuels and biofuel shares are considered and will increase in significance in global air freight significantly as part of the IATA and IBAC commitments to reach net zero carbon emissions by 2050.

The Sustainable Aviation Fuel (SAF) Initiative is aiming to align among others EU's Renewable Energy Directive (RED II) and ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and more transparency and reporting obligations for airline carriers will foster primary data insights also for the airfreight industry soon.

Emission reduction scenario for aviation



Source: ATAG (09/2021)

HANDLING DIFFERENT DATA QUALITY LEVELS

Data availability and best-in-class approach
shipzero works on the principle of maximum precision. The more data available on a transport, the more factors on greenhouse gas emissions can be considered individually. At the same time, shipments with lower data availability can also be evaluated comparably by filling in data gaps via a stepwise system.

Initially, scientifically determined default values can be used to establish an auditable basis of emission values for all transports. In further steps, the model can be fine-tuned with historical data or advanced input information on vehicles, drives, cargo, routes, etc. Optimally, real consumption data of individual tours can be integrated.

The permeability of the model makes it possible, for example, to use primary data for the pre-carriage and onward carriage and model data for the main carriage even within a single transport. No data remains unused due to the use of oversimplified calculation approaches.

In the mid-term, systemic data exchange between internal systems and external partners will be inevitable to create a transparency layer that enables active and compliant emission tracking as well as the decision basis for decarbonization measures and investments into renewable fuels and renewably powered transport assets.

The shipzero approach makes it possible to calibrate models individually and to include default values for subcontractors, vehicles or own fleets without leaving the guidelines of the international GLEC framework. This enables a future-proof emission evaluation, as the use of default values with the change of propulsion energies, vehicle types and due to the fragmentation of international supply chains for a manual modeling will be an almost insurmountable challenge for reliable data and goes along with enormous maintenance efforts regarding the actuality of the reference values.

Quality and clarification management
Whenever working with data, errors from manual or systemic processes might occur and pose a challenge to the following analysis and calculation. Having this in mind, shipzero tries to algorithmically scan and improve data quality as much as possible, ranging from typos in addresses or weights to implausible loads or transport chains.

Most of these topics can be fixed automatically and autonomously by the shipzero data quality management. However, there will be cases where a clarification with responsible stakeholders can improve data quality and allows corrections directly at the source, which improves the overall data quality of supply chain information within the company. These clarification reports will be made available frequently and need to be reviewed at least annually for an audit-compliant emission management.

CARRIER & SUB-CONTRACTOR INTEGRATION

Sub-contractor integration
There is strong evidence from parties across all industries that data sharing and contextual enrichment of information enables great opportunities for data analytics and consequently better decision making.

In the case of decarbonization of transport chain, no single party, not even the largest freight forwarding companies in the world, are in the position of full data transparency and have the operational resources to combine different data sets across companies to evaluate performance and effectiveness of decarbonization progress.

shipzero aims to support extremely convenient data sharing for exactly that purpose by providing the ability to automatically connect to loyal transport partners and at the same time rely on the quality control, maintenance, security and curation of information through an independent platform, that has absolutely no conflict of interest caused by other business models such as freight brokerage, compensation or carrier listings.

Data exchange may take place through fully automated system integration by fetching telematics data directly from the provider API or semi-automated through structured information that can be uploaded or updated periodically on the shipzero platform such as certification states.

Governance principles
It is important for data collection and sharing to provide convenience, especially in terms of time efficiency, to data contributors. Sharing data must not be an additional burden coming on top of the duties of providing high-quality transport services.

shipzero embraces automation and fetching data directly from the source (raw data) or any stable analytics environment without putting the load or necessity of real-time data flows on the operative systems.

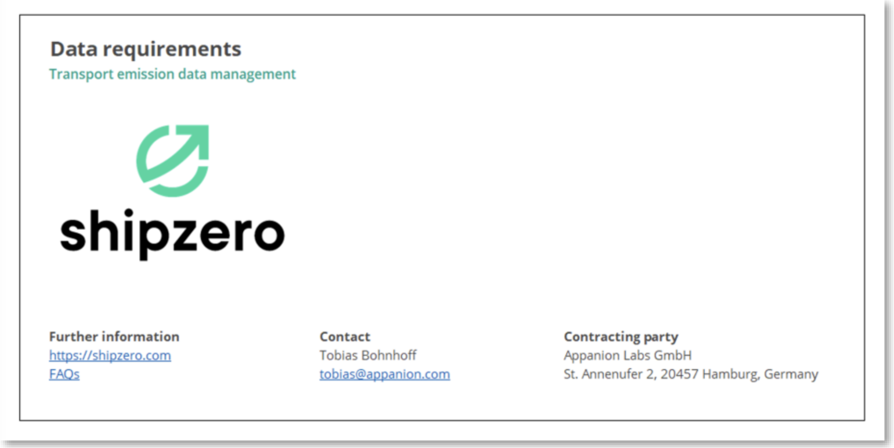
On that principles, shipzero acts as neutral exchange platform that provides infrastructure, data curation and correct allocation in a strong governance framework to avoid multiple bilateral agreements or individual reporting for each customer.

Forwarders and shippers don't have a right for in-depth operational insights into the carrier's operation but should value voluntary transparency as an additional service level and incentivize the service by fair contracting conditions. To avoid misuse of transparency or increased pressure on subcontractors, every data contributor on the shipzero platform can customer-individually opt-out of any data sharing, if an open and collaborative effort on decarbonization is no longer perceived.

ORDER DATA REQUIREMENTS

Full list available on request

Required data input	example
id_transport	101020029244
id_order	9823282
zip_departure	20457
city_departure	Hamburg
country_departure	DE
zip_arrival	3198 LK
city_arrival	Rotterdam
country_arrival	NL
date_arrival	2021-01-02T01:48:52
date_departure	2021-01-04T12:33:47
accounting_month	2021_06
transport_mode	road
cargo_weight	0.71
cargo_weight_unit	t



Data requirements

Transport emission data management

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Further information
https://shipzero.com
FAQs

Contact
Tobias Bohnhoff
tobias@appanion.com

Contracting party
Appanion Labs GmbH
St. Annenufer 2, 20457 Hamburg, Germany

fields (column header)	information relevance	category	example	comment
id_transport	minimum input requirement	identifiers	101020029244	identifier for the transport or tour physically realized by one vehicle/vessel
id_order	minimum input requirement	identifiers	9823282	unique identifier for a shipment / shipping unit - multiple orders can be grouped to one transports in LTL/LCL cases
zip_departure	minimum input requirement	Transport information	20457	zip-code
city_departure	minimum input requirement	Transport information	Hamburg	city name
country_departure	minimum input requirement	Transport information	DE	ideally iso2 country code
zip_arrival	minimum input requirement	Transport information	3198 LK	zip-code
city_arrival	minimum input requirement	Transport information	Rotterdam	city name
country_arrival	minimum input requirement	Transport information	NL	ideally iso2 country code
date_arrival	minimum input requirement	Transport information	2021-01-02T01:48:52	full datetime, if applicable (ideally with timezone information, if relevant)
date_departure	minimum input requirement	Transport information	2021-01-04T12:33:47	full datetime, if applicable (ideally with timezone information, if relevant)
accounting_month	minimum input requirement	Transport information	2021_06	month that the transport should be accounted to
transport_mode	minimum input requirement	Transport information	road	ideally provided on a transport leg basis or for the main mode of transport (road, rail, sea, air, barge)
cargo_weight	minimum input requirement	Cargo information	0.71	numeric variable
cargo_weight_unit	minimum input requirement	Cargo information	t	standard mass units: kilogram, metric ton, pound
id_leg	advanced input	identifiers	101020029244-1	unique identifier for a transport chain element (e.g. pre-haul, main-haul, post-haul) - not necessary for direct connections
id_sort	advanced input	identifiers	1	sorting id to order the transport legs in multi-stopp transports or pre-haul/main-haul/post-haul transports - not necessary for direct connections
street_departure	advanced input	Transport information	St. Annenufer 2	street-level address
poi_departure	advanced input	Transport information	DEHAM	e.g. UN/LOCODE for ports, IATA/ICAO for airports UIC for rail terminals, or plant/company related address string
latitude_departure	advanced input	Transport information	53.54	geocode in decimal degrees
longitude_departure	advanced input	Transport information	10.00	geocode in decimal degrees
street_arrival	advanced input	Transport information	Rijndvarsweg 3035	street-level address
poi_arrival	advanced input	Transport information	NLRTM	e.g. UN/LOCODE for ports, IATA/ICAO for airports UIC for rail terminals, or plant/company related address string
latitude_arrival	advanced input	Transport information	51.94764	geocode in decimal degrees
longitude_arrival	advanced input	Transport information	4.15546	geocode in decimal degrees
status_id	advanced input	Transport information	1	status id to indicate if tranport order is confirmed and processed to avoid counting cancelled tours
cargo_volume	advanced input	Cargo information	3.24	numeric variable
cargo_volume_unit	advanced input	Cargo information	CBM	standard volume units: cubic meters

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ALLOCATION OF EMISSIONS BY MODE AND CATEGORY

exemplary

Category	KPI	Sea	Road	Rail	Air	Barge	Total
Category A	CO_2e in t	30,108	54,913	6,354	12,514	10,804	114,693
	Volume in m tkm	3,811	707	409	19	399	5,345
	Intensity in g/tkm	7.9	77.7	15.5	658.6	27.1	26.4
Category B	CO_2e in t	25,182	117,533	573	3,942	679	147,909
	Volume in m tkm	2,258	1,452	36	6	25	3,777
	Intensity in g/tkm	11.2	80.9	15.9	657.0	27.2	63.6
Category C	CO_2e in t	4,259	1,109	460	22	0	5,850
	Volume in m tkm	390	12	19	0	0	421
	Intensity in g/tkm	10.9	92.42	24.2	687.5	0.0	11.6
Total	**CO_2e in t**	59,549	173,555	7,387	16,478	11,483	268,452
Total	**Volume in m tkm**	6,459	2,171	464	25	424	9,543
Total	**Intensity in g/tkm**	9.2	79.9	15.9	658.3	27.1	44.3

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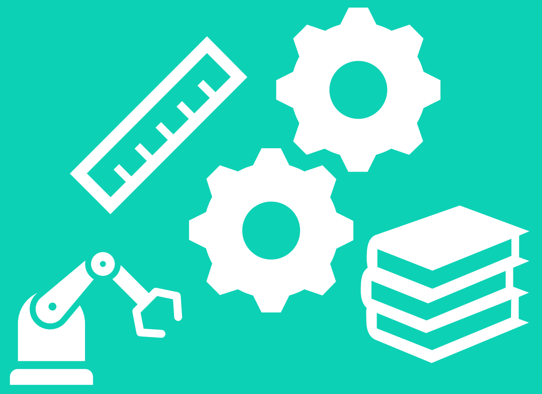
HOW IT WORKS

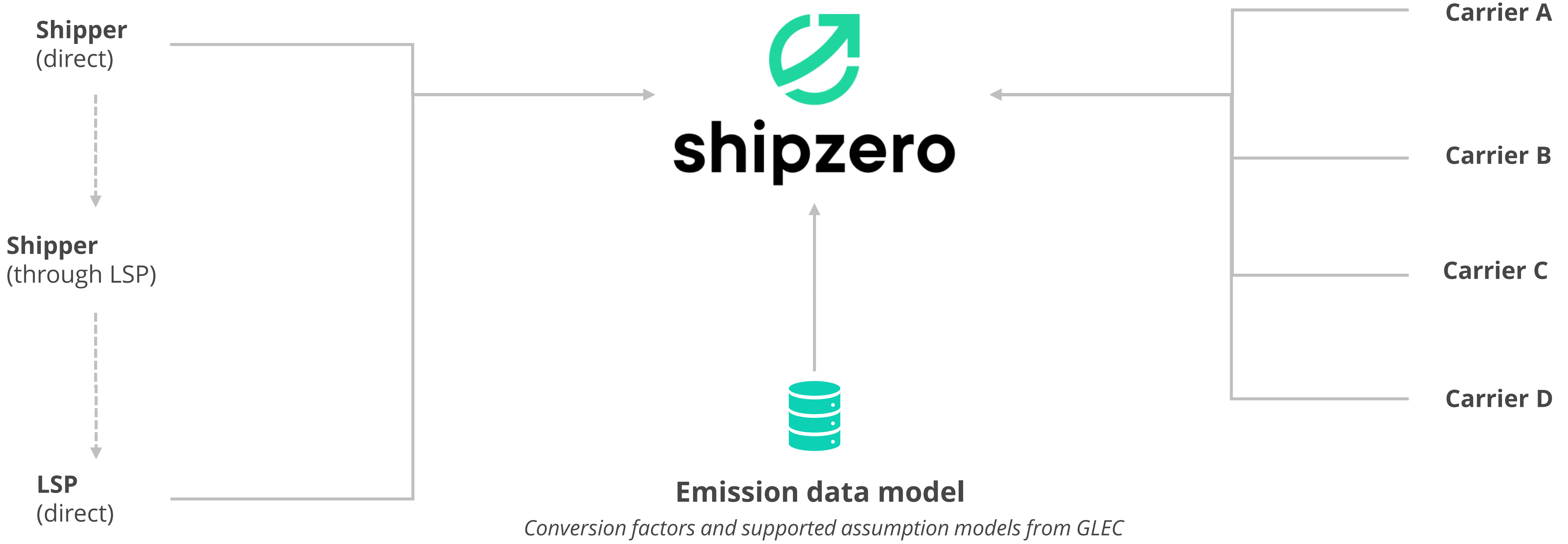
- Technical integration
- Processes and data flows
- Governance and data exchange



INDEPENDENT DATA CURATION, QUALITY CONTROL & CALCULATION

Order data integration from TMS
Processing and harmonization

Data integration of sub-contractors
consolidation and harmonization



HOW IT WORKS

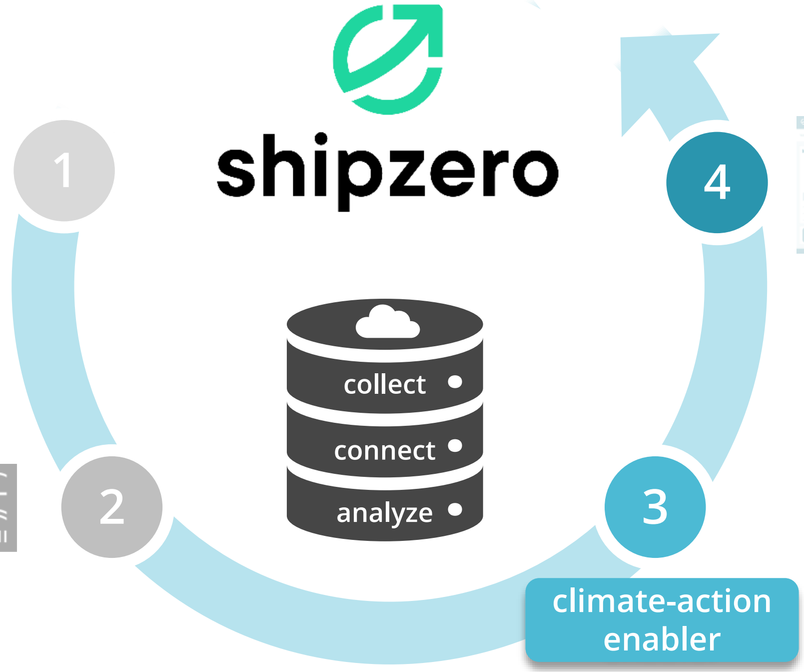
DATA SOURCES

Shipment order data

Start, destination, payload, mode, date

Calculation model

Multimodal, global, and compliant results



DATA CONSUMERS

Tangible insights

Continuous and precise reporting, identification of reduction potentials

Smart enrichment

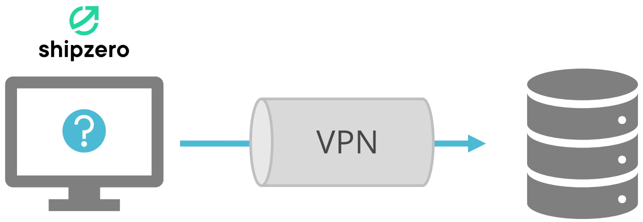
External and primary telematics data from vessels/vehicles

FLEXIBLE CONNECTION OPTIONS FOR TRANSPORT ORDER DATA TRANSFER

File transfer

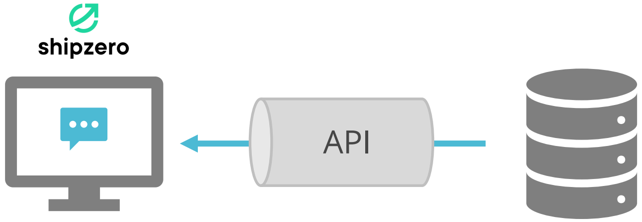
- Easy setup – directly accessible
- Semi-automated
- Sub-optimal for data quality loops

Remote VPN / private tunnel database access



- Fully automated – data pull
- Relatively easy setup for any SQL-supp. DB
- Access only for pre-defined tables

TMS / ERP API against shipzero endpoint



- Pot. built-in API/ supported protocol
- Low maintenance
- Initial setup requires some coordination

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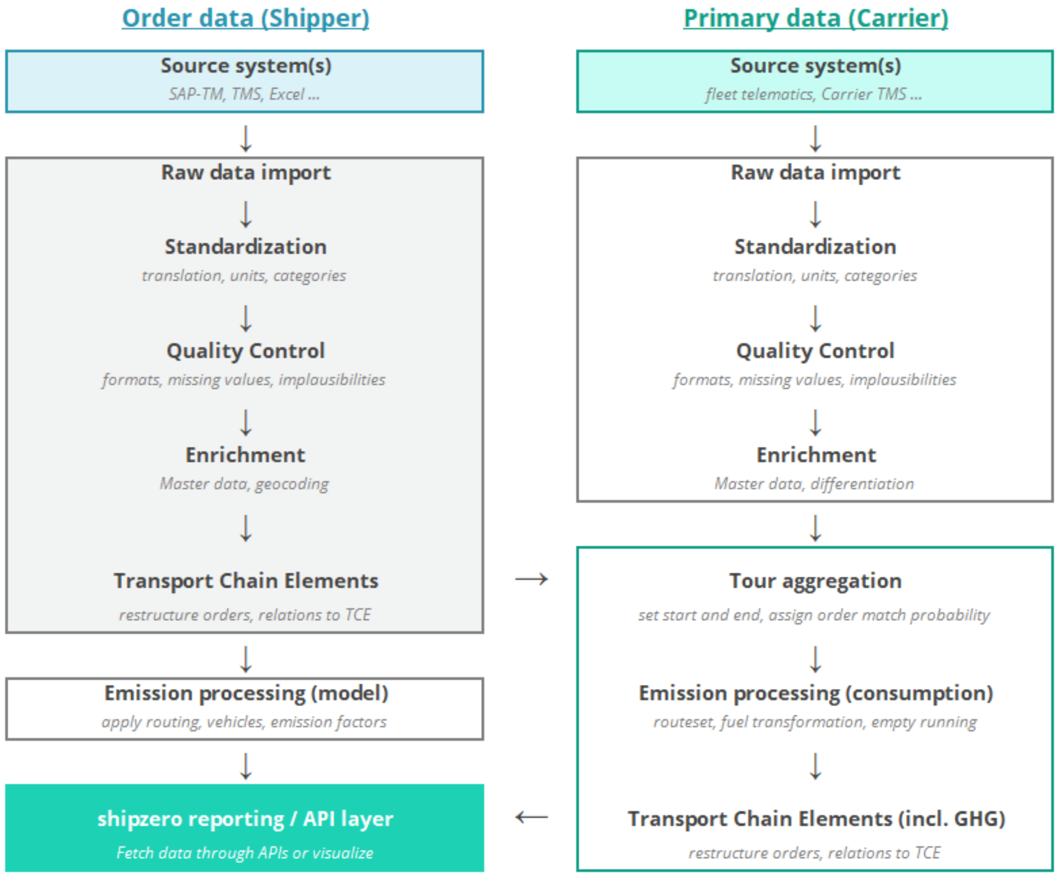
PROCESS OF DATA INTEGRATION



Challenge

- No consistent standard or structure of transport order data at shipper/LSP side
- Data quality is highly impacted by manual inputs and multiple management systems at one shipper/LSP entity
- FMS/rFMS data from telematics systems provides analogous content but in different formats, units or scopes

Solution

- Integrated data pipeline concept standardizes transport order data, while algorithmic plausibility checks identify and resolve input errors
- Data structures of order and operations (telematics) become aligned and can be system-independently merged or enriched
- Reporting and API layer enables dynamic data exchange

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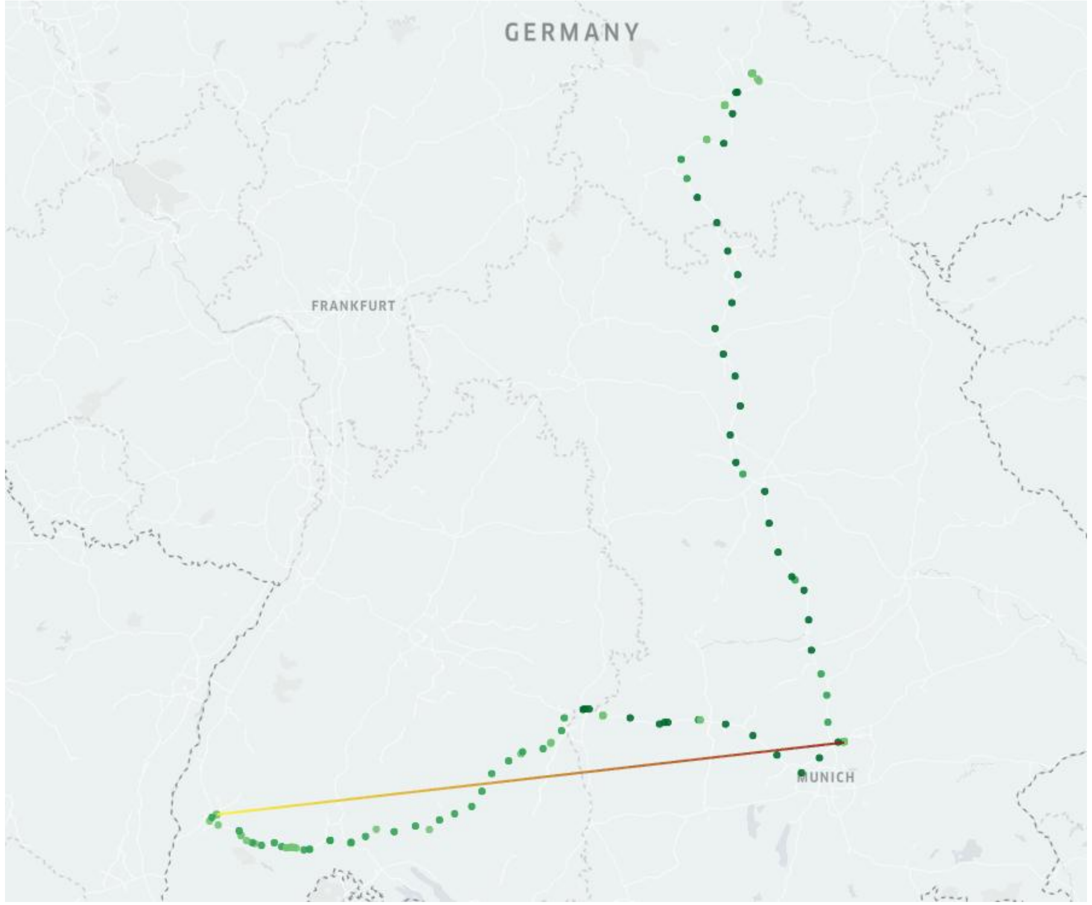
PROCESS OF TRANSPORT MATCHING (ROAD)



Challenge

- No consistent way to connect order data (shipper) to telematics data (carrier)
- Dispatchment changes dynamically, plate numbers / identifiers often unknown
- Even information, if owned or sub-contracted fleet is used, is not provided

Solution

- Disaggregation and sorting of orders to individual transport chain elements
- Geocoding of all waypoints and algorithmic prequalification of matches (time-distance-matching)
- Dynamically learning decision-engine picks the correct vehicle

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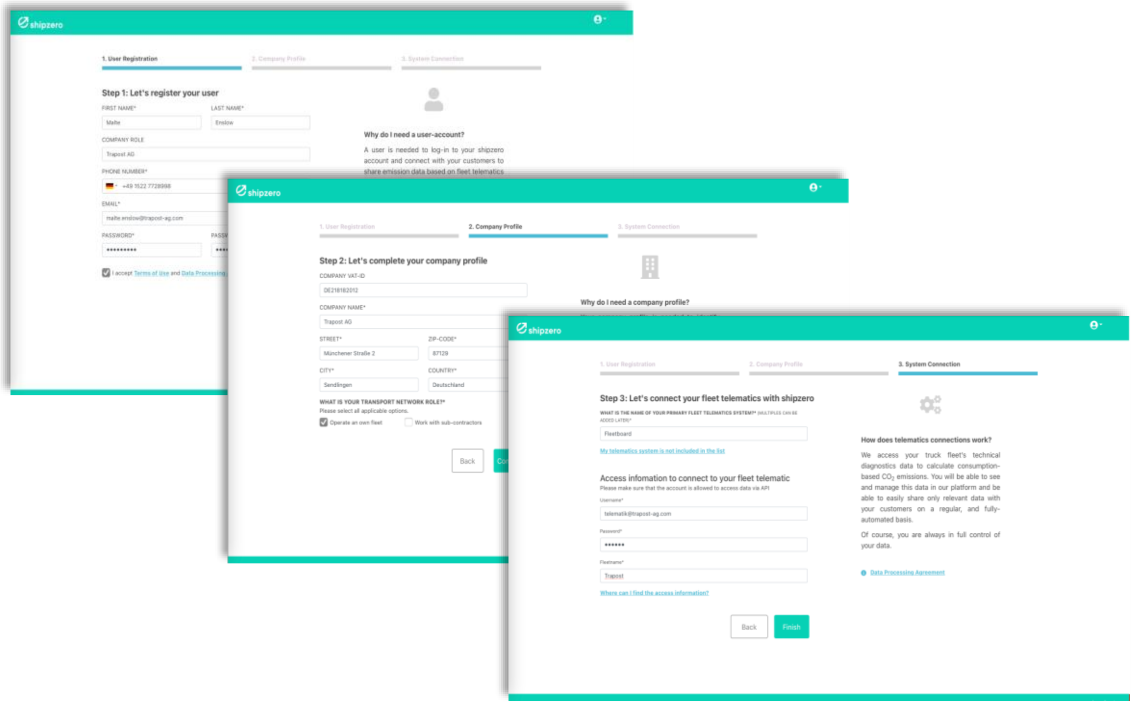
DATA ACQUISITION AND CARRIER OPT-IN



Challenge

- Shippers and LSPs work with hundreds or thousands of different road carriers
- Carrier IT infrastructure and capacity for regularly providing information to a variety of customers is not in place
- Data needs to be curated to each requesting party before sharing and fear of additional efficiency pressure in contracting by the carrier

Solution

- 3-step registration process to directly connect own telematics services (completed once in under 10 minutes)
- Comprehensive data processing agreement allows compliant curation of data for each individual requesting party
- No data transfer through carrier IT, no manual effort on a regular basis

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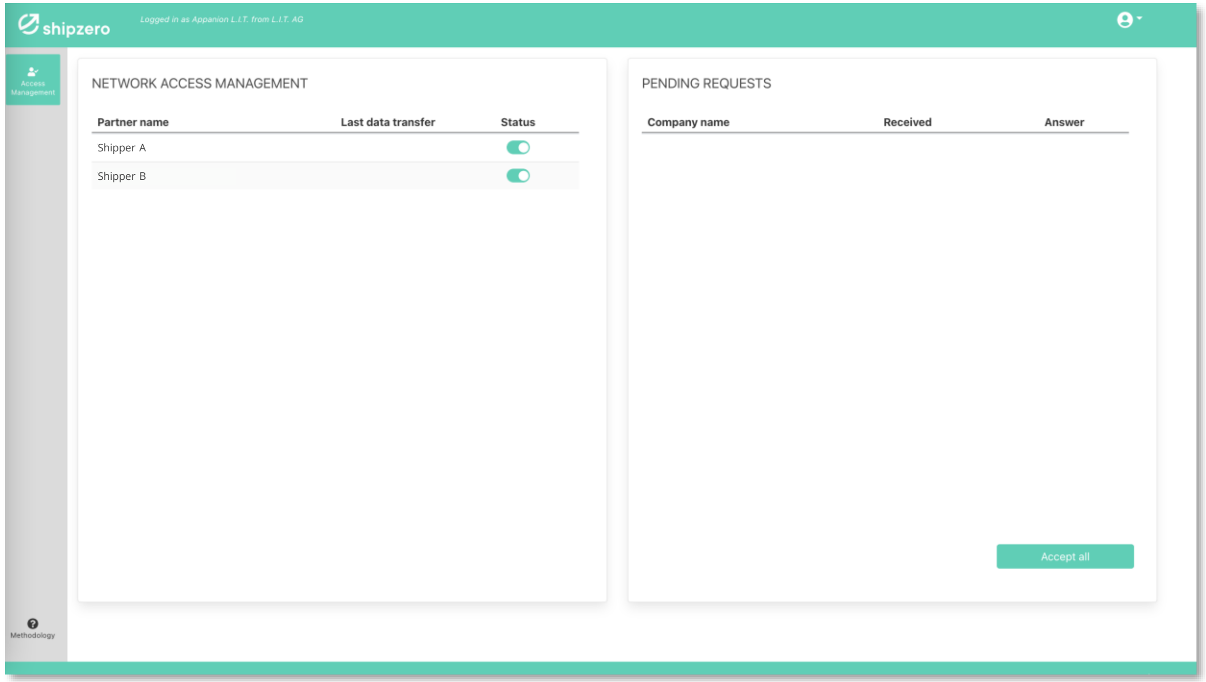
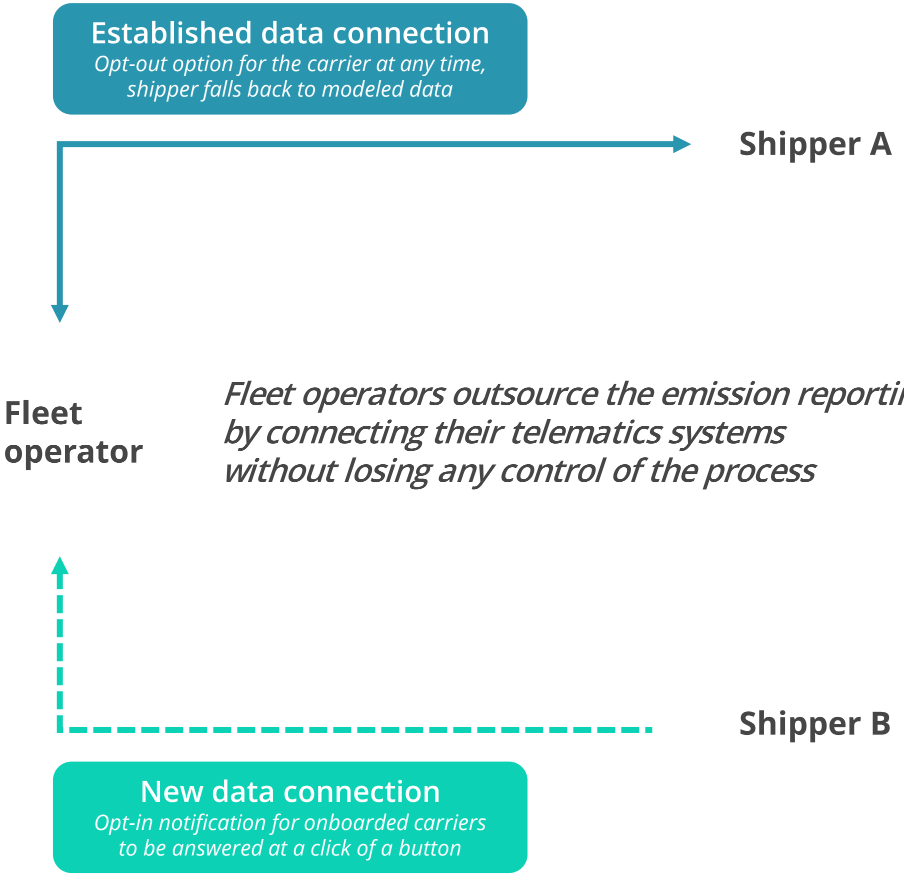
DATA CONTRIBUTION AND SOVEREIGNTY FOR FLEET OPERATORS





Fleet operators outsource the emission reporting by connecting their telematics systems without losing any control of the process

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DATA PROCESSING AGREEMENT

Data processing agreement

- Shipzero's data processing agreement is a key part for establishing compliant data exchange between all parties and establish curated and easy to manage data sharing agreements on top
- Important is the specification of:
    - Which kind of data is processed for which purpose
    - Where and how the data is sourced and processed
    - Safety, Security and access management related measures
- Exclusion of any analysis around personal data (GDPR compliance)
- Exclusion of critical information such as contractual details or sensitive financial data
- Establishing full data sovereignty to any data contributor on the shipzero platform at any time
- Restricting potential misuse of data and guaranteeing structured procedures how to handle data that is removed from the platform

RELIABILITY

- Privacy and security
- Compliance
- Partners and sources
- Analytics
- FAQs, contacts and references

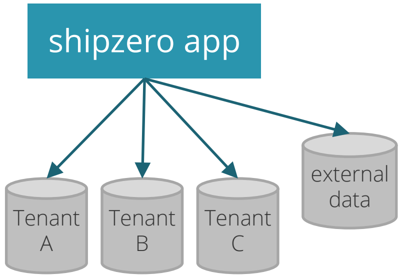
DATA PRIVACY AND SOVEREIGNTY

Secure data storage

Microsoft Azure

- Non-financial, historical data
- No personal data (GDPR)
- All databases located in Europe West (AMS or FRA)
- Built-in Microsoft Azure Cloud Security

Multi-tenant data mgmt



- Individually managed tenants
- No unauthorized data sharing
- Transferability of results for self-service analytics

Encrypted data transfer

- Secure API management (TLS encrypted)
- Direct database connections via VPN
- Dedicated user rights management and authentication

Data sharing consent

- Self-sovereign data management as carrier:
- Opt-in to share the data with transport partners
- Opt-out at anytime, if commercial agreements change

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COMPLIANCE AND REPORTING STANDARDS

In accordance with:

- European Committee for Standardization — EN 16258:2012
- Greenhouse Gas Protocol — Greenhouse Gas Protocol
- Smart Freight Centre — GLEC Framework
- Clean Cargo Sustainable Transportation — Clean Cargo Working Group

Usable for disclosure, offsetting and audits:

- CDP — Carbon Disclosure Project
- Science Based Targets: Driving Ambitious Corporate Climate Action — Science-based Targets Initiative
- ClimatePartner — Compensation
- ISO 14083:2022 — ISO standard 14083:2022 (upcoming)

CERTIFICATION AND SUPPLIER ASSESSMENTS

Certification
shipzero is not a certification organization. However, the use of shipzero as a tool for emissions data management allows to be compliant with applicable standards of emissions determination. These standards include the Greenhouse Gas Protocol, the European Regulation EN16258 and the GLEC Framework. In addition, ISO standard 14083 is expected to come into force in 2022 and will make the methodological approach and the scope of the transport emissions survey certifiable.

The GLEC Framework, on the other hand, provides guidelines within which companies should set up their greenhouse gas calculations, but does not represent certification in the sense of a commercial external verification of compliance with the regulations.

The methodology of shipzero and referenced guidelines can be used in audit procedures and for the purpose of greenhouse gas offsetting without restrictions. A detailed examination of the methodological procedure can be carried out by the certification organization upon request. The use of shipzero is in line with the guidelines of the GLEC Framework and will be aligned with any upcoming future requirements as well as the the ISO 14083.

Supportive role towards sustainable supplier assessments
shipzero is a data service that provides reliable insights on carbon emissions that are generated from global freight movement. Therefore, it does not cover all aspects of a sustainability assessment but contributes to a positive assessment due to standard conformity, sound data management, involving of primary data use, as well as having structured processes to work on and improve data quality and identify gaps for a continuous improvement process.

All those aspects help to accomplish a positive assessment in the industry-leading assessment frameworks, but also for individually carried out survey by key stakeholders.

SQAS Assessed Company

drive sustainability

ecovadis

shipzero

PARTNERS AND SOURCES

Calculation model with strong scientific background

Calculation and methodology partner

EcoTransIT World

Smart Freight Centre *accredited calculation*

Compensation partner

ClimatePartner

Scientific methodology partners of the EcoTransIT World Initiative

Methodology

ifeu INSTITUT FÜR ENERGIE- UND UMWELTFORSCHUNG HEIDELBERG

INFRAS

Fraunhofer IML

MAJOR CATEGORIES OF DECARBONIZATION IN FREIGHT TRANSPORTATION

Reduce Freight Transport	Optimize Transport Modes	Improve Fleet Energy Efficiency	Reduce Carbon Content of Propulsion Energy
Demand forecasting to avoid express / air freight	Modal shift simulation	Zero-emission vehicles	Fuel management
Improved load consolidation	Multi-modal optimization	Driving behaviour	Low carbon fuels
Decrease empty running	Synchromodality	Fleet maintenance	Electrification

Lacking one **silver bullet**, only **combination** of measures leads to a **full decarbonization** of freight transport – **data analytics** can outline an effective pathway in terms of **€ or $ spent per saved ton of CO_2.**

Source: refence to Smart Freight Center / Alan McKinnon (2021)

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PRIMARY VS. MODELED EMISSION DATA TRADE LANE LEVEL

Trade lane comparison – road freight
Below is shown a like for like comparison of the exact same transports for one carrier and month on two dedicated trade lanes. Assumptions made for the modeled data were based on the same information available for both analysis aside from the primary fuel measurement and actual distance.

Lane A – aggregated impact.

Contractor	Method	CO_2e in t	Volume in tkm	Intensity in CO_2e g/tkm
Carrier A	Modeled[1]	7.04	35,822	196.6
Carrier A	Primary	6.52	39,306	165.9
Carrier A	% deviation	-7%	10%	-16%

Lane B – aggregated impact

Contractor	Method	CO_2e in t	Volume in tkm	Intensity in CO_2e g/tkm
Carrier B	Modeled[1]	4.45	34,537	129.0
Carrier B	Primary	3.79	38,954	97.3
Carrier B	% deviation	-15%	13%	-25%

Both data sets show significant deviation to the average calculation on both actual distance and total emissions due to efficient and modernized fleets and real-world driving behaviour, which outlines the importance to rely on tracking data for optimization purposes.

1) Identical parameter selection to ensure like for like comparison, modelled GLEC-conform

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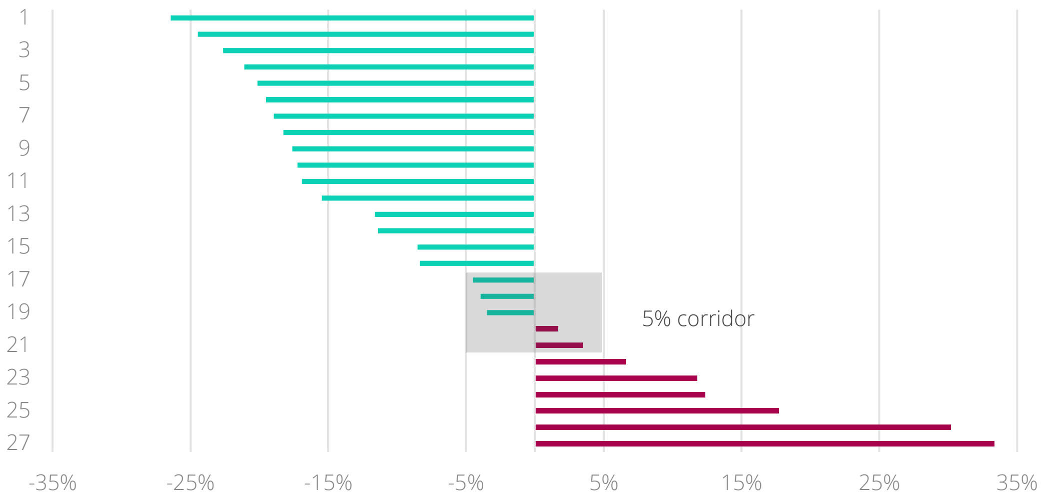
PRIMARY VS. MODELED EMISSION DATA TRIP LANE LEVEL

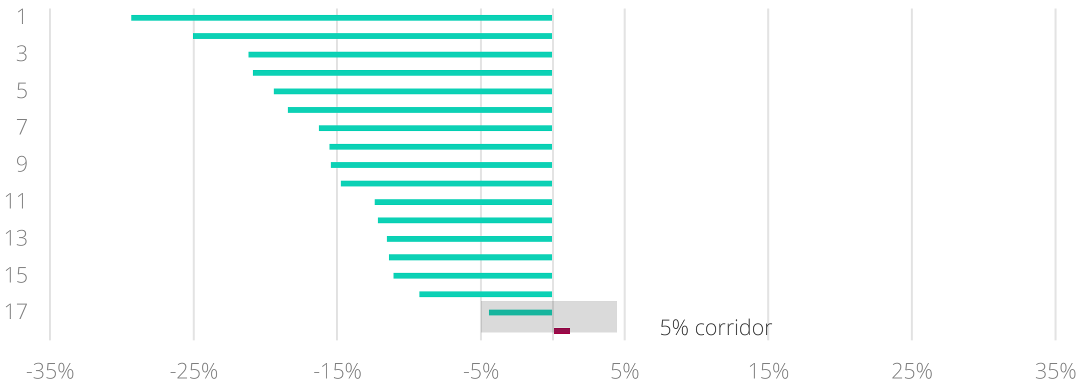
Trade lane comparison – road freight
On an individual tour level, two findings are important:

- Only very few cases fall into the category of an acceptable 5% deviation corridor compared to the modeled averages.
- Most trips deviated more than 15%, in total emissions which indicates high impact of actual reduction measures, if other trips can follow this example (scheduling, dispatchment, fleet equipment), but it is impossible to recognize solely based on modeled or default data.

Lane A - .Total emission deviation primary-modeled by trip



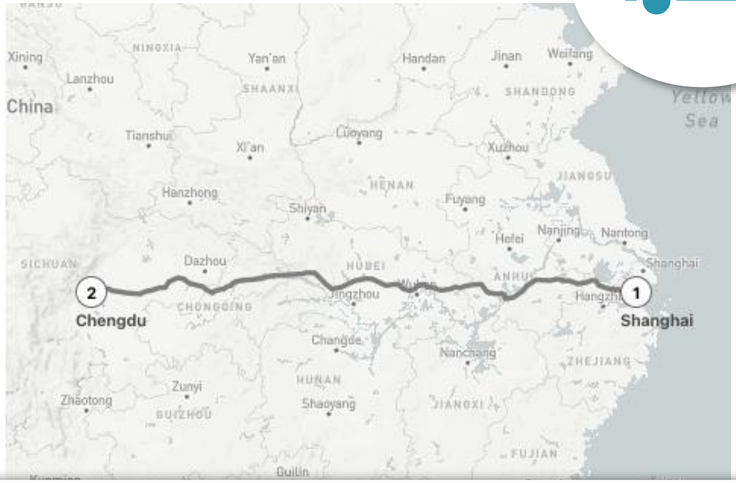
Lane B.- Total emission deviation primary-modeled by trip



1) Identical parameter selection to ensure like for like comparison, modelled GLEC-conform

MODE SHIFT ANALYSIS

CN-Shanghai - CN-Chengdu



- av. Intensity: 88.3 g/tkm
- Distance: 1,946 km
- 228 transports

Road-to-rail shift
189t CO_2e
savings potential[1]

CN-Shanghai - CN-Chengdu

- av. Intensity: 26.4 g/tkm
- Distance: 2,238 km
- 124 transports

Exemplary case for a long-distance connection with one year of transport data

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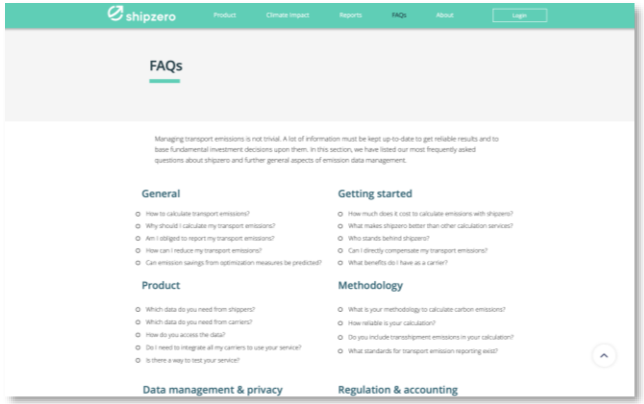
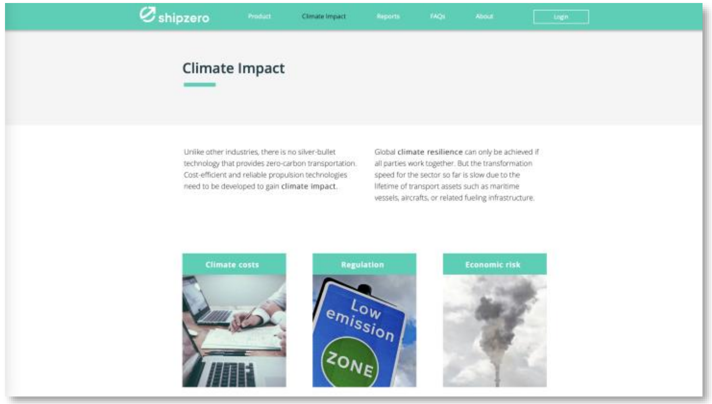
FAQS AND FURTHER READINGS



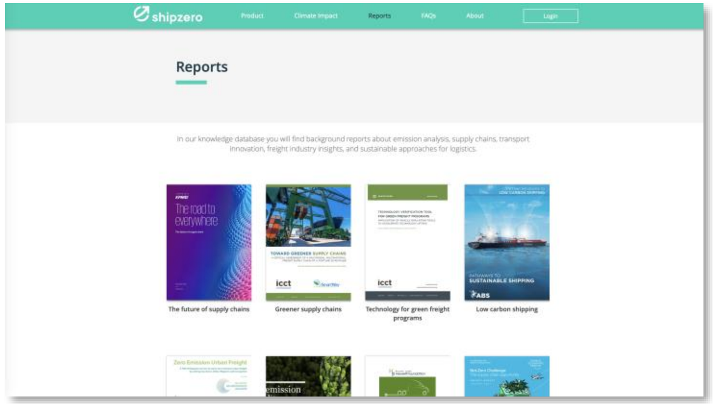
You have a product-related question?

shipzero.com/faq



You have a general question about emission management in freight transportation?

shipzero.com/climate-impact



You want to dig deeper into latest research about transport decarbonization?

shipzero.com/reports

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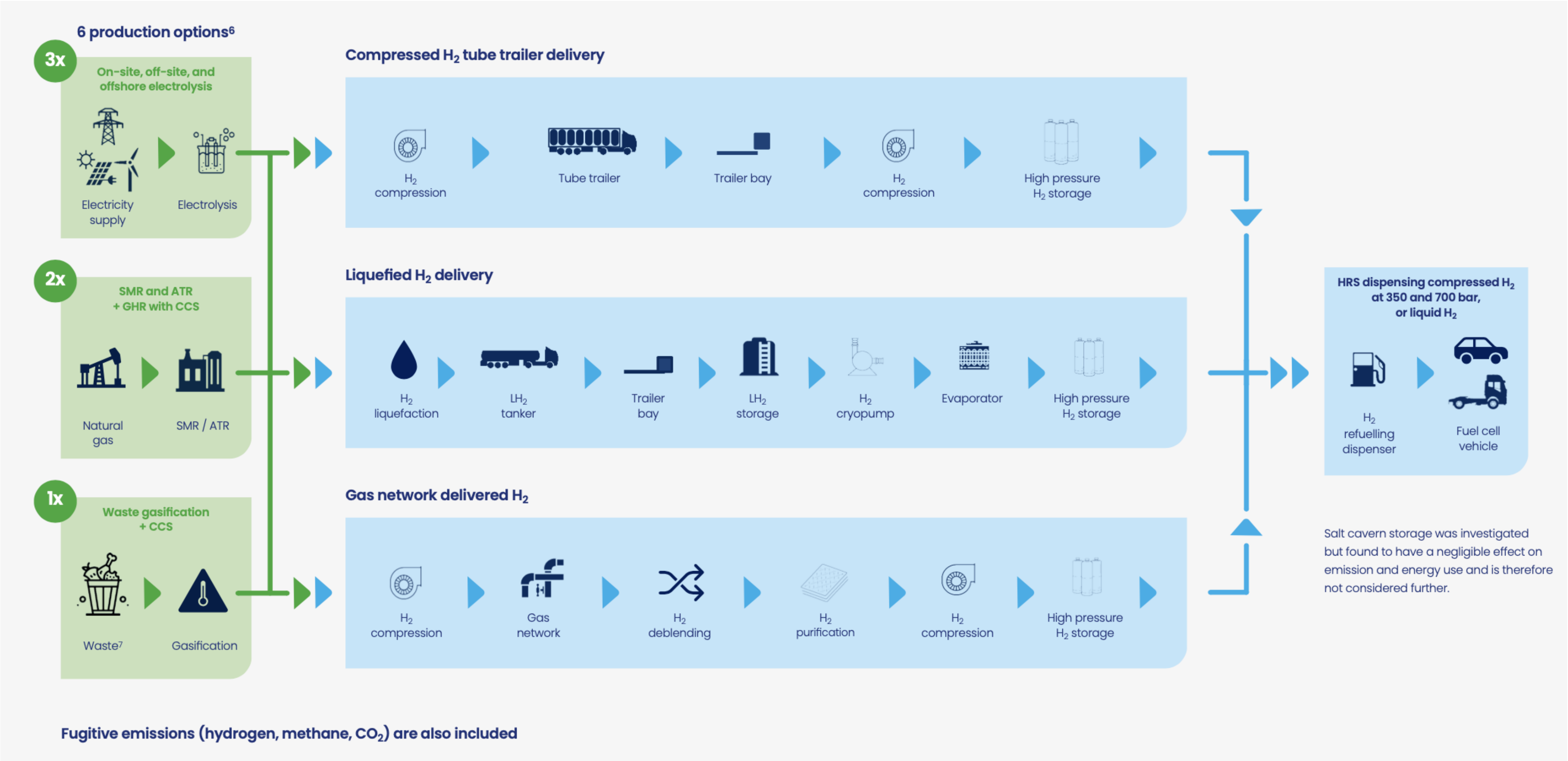
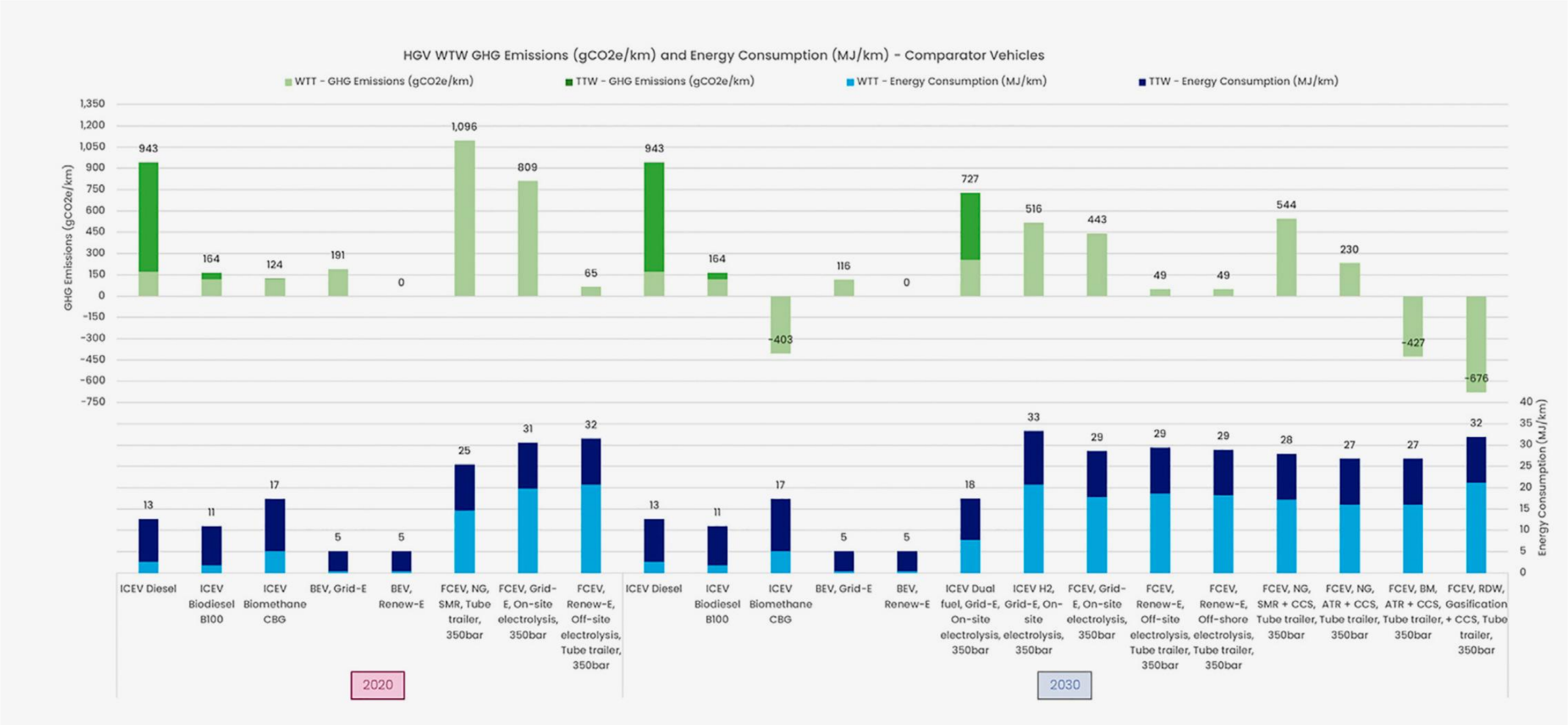
REFERENCES – HYDROGEN WELL-TO-TANK SUPPLY PATHWAYS



Source: Zemo (2021): Hydrogen Vehicle Well-to-Wheel GHG and Energy Study

REFERENCES – HYDROGEN EMISSION IMPACT AND FACTORS FOR HEAVY DUTY VEHICLES



Source: Zemo (2021): Hydrogen Vehicle Well-to-Wheel GHG and Energy Study
Not considering negative emission impact at present for calculation purposes

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- EFTCO (2021): Safe Cleaning – CO2 Reduction
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- European Organisation for the Safety of Air Navigation (2017): EUROCONTROL - Small Emitters Tool
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- Smart Freight Center (2022): GLEC Framework
- Smart Freight Center, CEFIC (2021): Calculating GHG transport and logistics emissions for the European Chemical Industry
- STC-NESTRA (2018): GHG emission factors for IWT
- United States Environmental Protection Agency (2018): Smart Way Technical Documentation
- WBCSD & World Resources Institute (2014): Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard
- Zemo Partnership (2021): Hydrogen Vehicle Well-to-Wheel GHG and Energy Study

REFERENCES

Data services & logistics network sources

- ACEA
- AzureMaps
- Bilans GES (ADEME)
- ecoinvent
- EcoTransIT World
- EPA - MOVES
- European Commission
- European Environmental Agency
- Eurostat
- Gibgas/NGVA
- GoogleMaps
- HERE Technologies
- IATA
- ICAO
- International Energy Agency
- International Maritime Organization
- LBST
- Mapbox
- MarineTraffic
- NREL
- OAG
- OpenStreetMap
- UBA
- UIC

Paid services, studies or data sets may not be fully accessible and can not made available to any 3rd party

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13 CLIMATE ACTION

17 PARTNERSHIPS FOR THE GOALS