Towards a Global Standard for Estimating Life Cycle Greenhouse Gas Emissions from Public Transport Services

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Overview

- Motivation & Status Quo
- Scope Definition
- Calculation Methods and Data
- Way Forward

Motivation

- Effective management of GHG emissions

  Public transport operators (PTOs) are major fleet operators, and in some cases builders of extensive infrastructure systems.

- Compliance with new corporate reporting regulation

  Further new reporting obligations and standards will follow for may PTOs due to the implementation of the Corporate Sustainability Reporting Directive (CSRD).

- Impact of the energy transition

  Shift of GHG emissions from the operation phase (direct fuel combustion) to the upstream and downstream processes (energy carriers and vehicles supply chain).

- Users’ environmental consciousness

  Providing this information to the users (travelers) would enable well-founded choices when planning and making a trip.

Status Quo

Passengers & Freight

EN 16258
Standard (Europe)
All modes

ISO 14083
Standard (Global)
All modes

STREAM
Research (Europe)
All modes

GREET
Method (N. America)
Road

Objectif CO2
Method (France)
All modes

mobitool
Platform (Switzerland)
All modes

Passengers

EcoPassenger
Online tool (Europe)
Rail, Road, Air

Freight

SmartWay
Program (N. America)
All modes

EcoTransIT
Online Tool (Global)
All modes

GLEC
Framework (Global)
All modes

Non-Transport

ISO 14020/40/60
Standard (Global)

GHG Protocol
Method (Global)

SBTi
Initiative (Global)

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Types of GHG Emissions

CO_2 CH_4 N_2O

Fuel combustion & catalytic processes

HFCs PFCs

Fugitive air-conditioning refrigerant

SF_6 NF_3

External (non-transport) industry processes

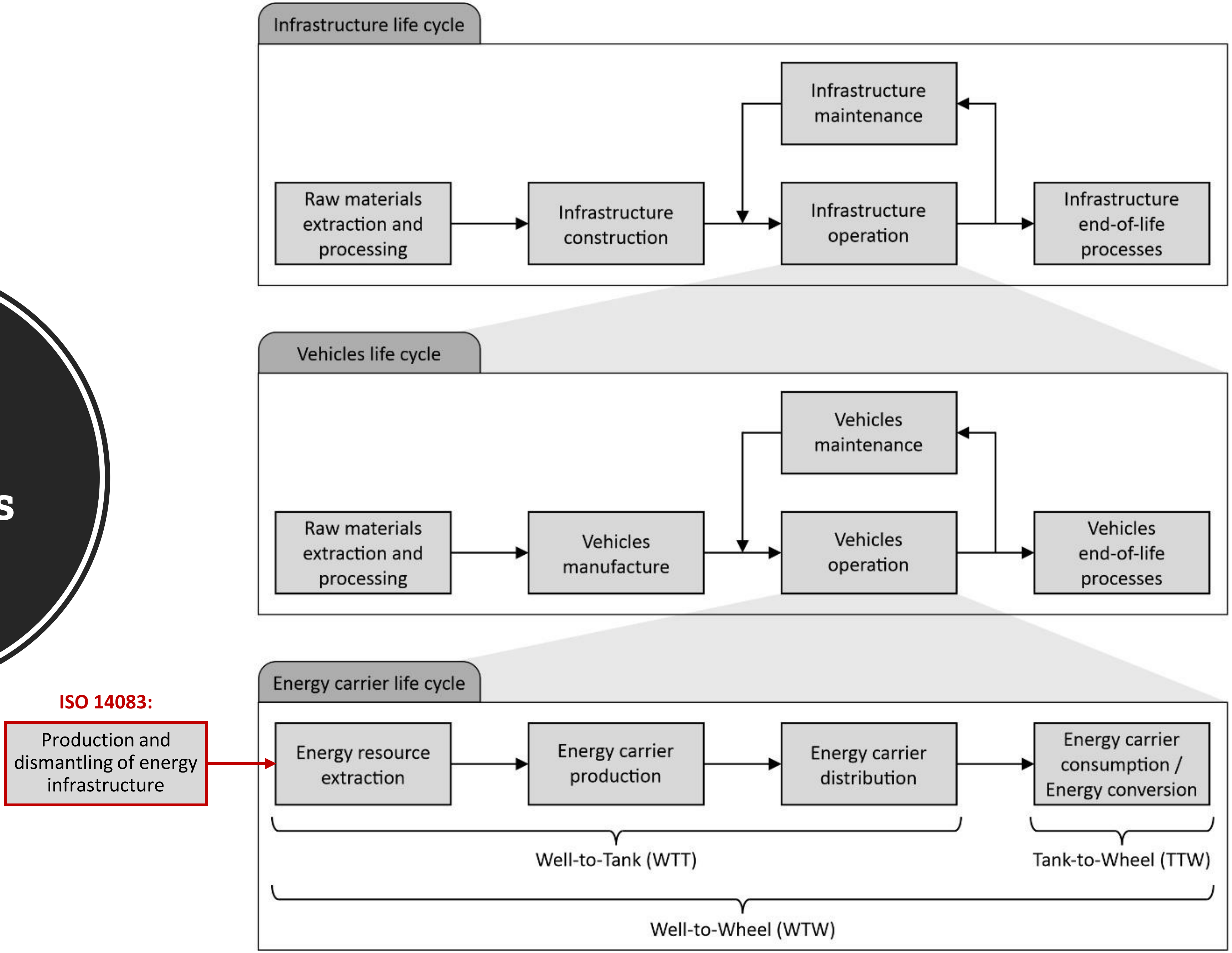
Types of GHG Emissions

GWP values for 100-year time horizon between different IPCC assessment reports

GHG	Chemical formula	Second Assessment Report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)	Sixt Assessment Report (AR6)
Carbon dioxide	CO_2	1	1	1	1
Methane	CH_4	21	25	28	29.8/27.0
Nitrous oxide	N_2O	310	298	265	273
CFC-12	CCl_2F_2	8100	10900	10200	12500
HCFC-22	$CHCLF_2$	1500	1810	1760	1960
HFC-134a	CH_2FCF_3	1300	1430	1300	1530
Sulphur hexafluoride	SF_6	23900	22800	23500	25200
Nitrogen trifluoride	NF_3	-	17200	16100	17400

Life Cycle System Boundaries
(Generic)

ISO 14083:



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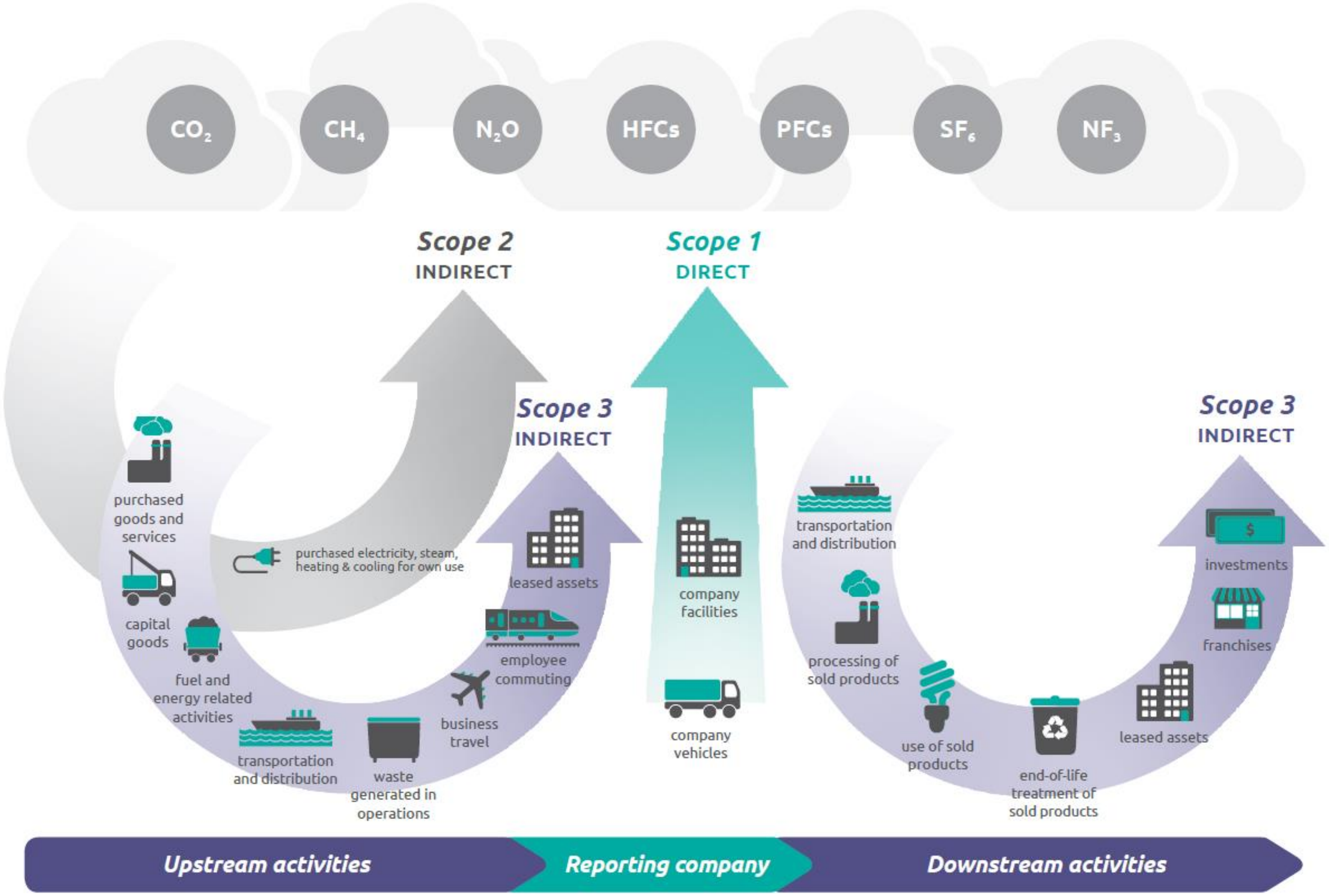
Life Cycle System Boundaries
(GHG Protocol)



Life Cycle System Boundaries | PTO Perspective

Scope 1
- Direct fuel combustion (TTW)
- Air-conditioning refrigerant leakage

Scope 2
- Production and distribution of electricity (WTT)

Scope 3
- Production and distribution of fuels (WTT)
- Production, maintenance and disposal of vehicles
- Construction, maintenance and disposal of infrastructure

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Direct Combustion Emissions

CO_2

Emissions of CO_2 | **Consumption (fuel) based approach**

$$\underset{[\text{kg } CO_2]}{Emissions\ CO_2} = \underset{[\text{l}]}{Fuel\ consumption} \times \underset{[\frac{\text{kg}}{\text{l}}]}{Fuel\ density} \times \underset{[\frac{\text{MJ}}{\text{kg}}]}{Low\ heating\ value} \times \underset{[\frac{\text{kg } CO_2}{\text{MJ}}]}{Energy-based\ emission\ factor}$$

CH_4 N_2O

Emissions of CH_4 and N_2O | **Distance (activity) based approach**

$$\underset{[\text{g } CH_4]}{Emissions\ CH_4} = \underset{[\text{km}]}{Vehicle-distance\ travelled} \times \underset{[\frac{\text{g } CH_4}{\text{km}}]}{Vehicle-specific\ distance-based\ emission\ factor}$$

GHG

Total direct combustion GHG emissions

$$\underset{[\text{kg } CO_2\text{e}]}{Total\ GHG\ emissions} = \underset{[\text{kg } CO_2]}{Emissions\ CO_2} + \underset{[\text{kg } CH_4]}{Emissions\ CH_4} \times GWP\ (CH_4) + \underset{[\text{kg } N_2O]}{Emissions\ N_2O} \times GWP\ (N_2O)$$

Fugitive Refrigerant Emissions

Mass Balance Method

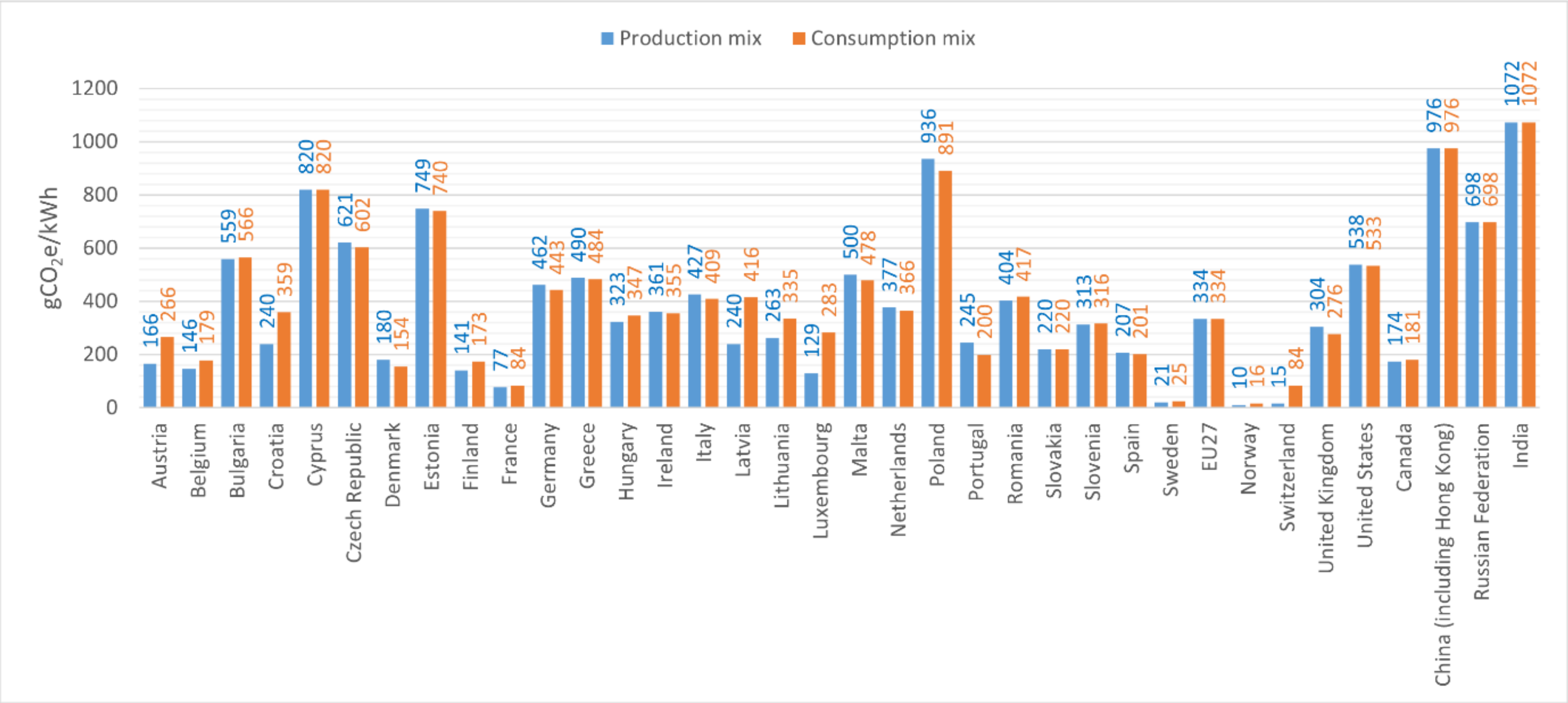
- Most accurate method.
- Accounts for the changes in refrigerant inventory in a defined time period.
- Requires data on stored refrigerant inventory, purchases, sales, returns, recycling, and disposal, for standalone reserves and for charged equipment.

Equipment-Based Method

- Uses default emission factors for mobile air-conditioning equipment from the IPCC, allow estimation of emissions associated with the size, installation, operation, and disposal (and refrigerant recovery) of mobile air conditioning equipment.
- Requires data on the amount of refrigerant charged into new equipment, the proportion of operating time during the year, and the quantity of refrigerant of disposed equipment.

Well-to-Wheel Emissions | Electricity

Production vs Consumption Mix

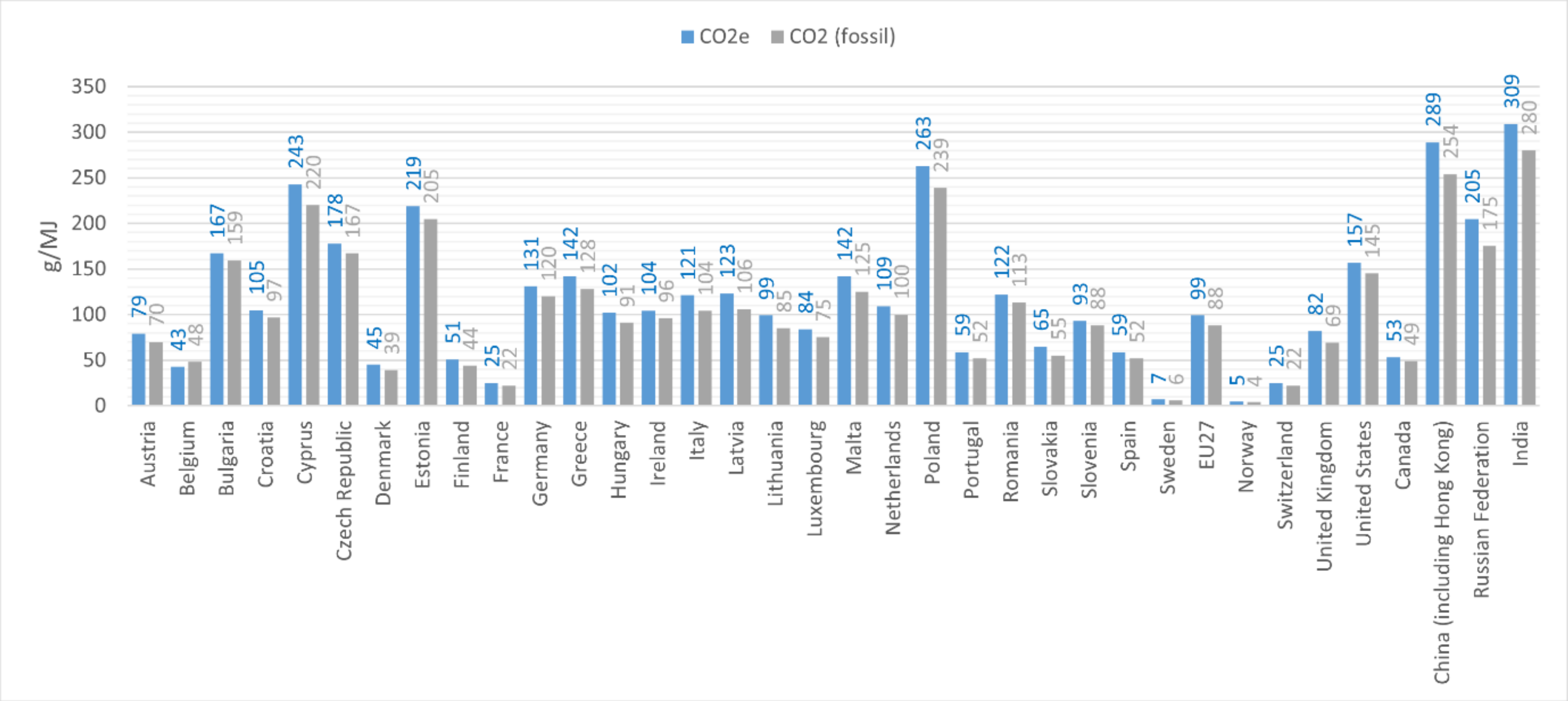


GHG emission factors (in gCO2e/kWh) of electricity at medium voltage level (including infrastructure) for production and consumption mixes in the year 2021.

Source: EcoTransit World (EWI, 2024)

Well-to-Wheel Emissions | Electricity

High-Voltage Railway Power Supply



GHG emission factors of the electricity supply for railway transport (WTT at pantograph, country-based production mix, including infrastructure) in the year 2021

Source: EcoTransit World (EWI, 2024)

Well-to-Wheel Emissions | Electricity

Emission Factors Databases

IEA (2021)

- Commercial database;
- Emission factors based on IPCC AR4 values;
- Information on electricity trades and losses;
- Not ISO 14083-compliant (limited to combustion emissions of the power plant only)

ecoinvent (2018)

- Commercial database;
- Production and consumption mixes;
- Full energy life cycle

EcoTransIT (2021)

- Production and consumption mixes;
- Full energy life cycle;
- Based on own modelling using Eurostat and IEA background data in mixes

EPA eGRID (2022)

- Production mix only;
- US data only;
- Transmission and distribution losses omitted;
- Data is limited to combustion emissions of the power plant only

Well-to-Wheel Emissions | Fuels

Default TTW and WTW GHG emission factors for liquid and gaseous fuels (in $kgCO_2e/MJ$)

Fuel	EN 16258		ISO 14083				GLEC V3			
	Europe		Europe		North America		Europe		North America	
	TTW	WTW	TTW	WTW	TTW	WTW	TTW	WTW	TTW	WTW
Gasoline	75.2	89.4	75.1	90.1	73.0	90.2	75.1	99.1	73.0	90.5
Ethanol	0	58.1	0.3	48.2	0.3	55.6	0.02	47.9	0.3	51.5
Diesel	74.5	90.4	74.1	87.3	75.0	90.5	74.1	96.6	75.7	91.4
Biodiesel	0	58.8	4.1	38.3	4.1	20.6	0.05	34.3	0.8	22.0
LPG	67.3	75.3	67.1	81.6	64.8	78.5	67.1	90.3	64.8	78.7
CNG	59.4	68.1	56.6	72.7	56.8	73.7	55.2	77.8	57.4	74.6
LNG	-	-	57.9	75.5	57.0	76.7	56.5	81.1	57.6	76.9
HVO	-	-	0.1	28.6	0.05	17.7	0.05	28.6	0.8	18.6
Hydrogen	-	-	0	114.4	-	-	0	160.7	-	-

Well-to-Wheel Emissions | Fuels

Default TTW and WTW GHG emission factors for liquid and gaseous fuels (in kgCO_2e/MJ)

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	Europe		Europe		North America		Europe		North America	
	TTW	WTW	TTW	WTW	TTW	WTW	TTW	WTW	TTW	WTW
Gasoline	75.2	[illegible]	75.1	90.1	73.0	90.2	75.1	[illegible]	73.0	90.5
Ethanol	[illegible]	58.1	[illegible]	48.2	[illegible]	55.6	[illegible]	[illegible]	0.3	51.5
Diesel	74.5	90.4	74.1	87.3	75.0	90.5	74.1	96.6	75.7	91.4
Biodiesel	0	58.8	[illegible]	[illegible]	[illegible]	[illegible]	0.05	34.3	0.8	22.0
LPG	67.3	75.3	67.1	81.6	64.8	78.5	67.1	90.3	64.8	78.7
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HVO	-	-	0.1	28.6	0.05	17.7	0.05	28.6	0.8	18.6
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- Mainly based on JRC WTW v3 report

- Gaseous fuels for Europe based on JRC WTW v5 report
- Liquid fuels for Europe based on ecoinvent v3
- Fuels for North America based on GREET
- Biofuels based on RED II
- Included non-CO_2 direct emissions

- GWP values update to the latest IPCC AR6
- Included methane slip

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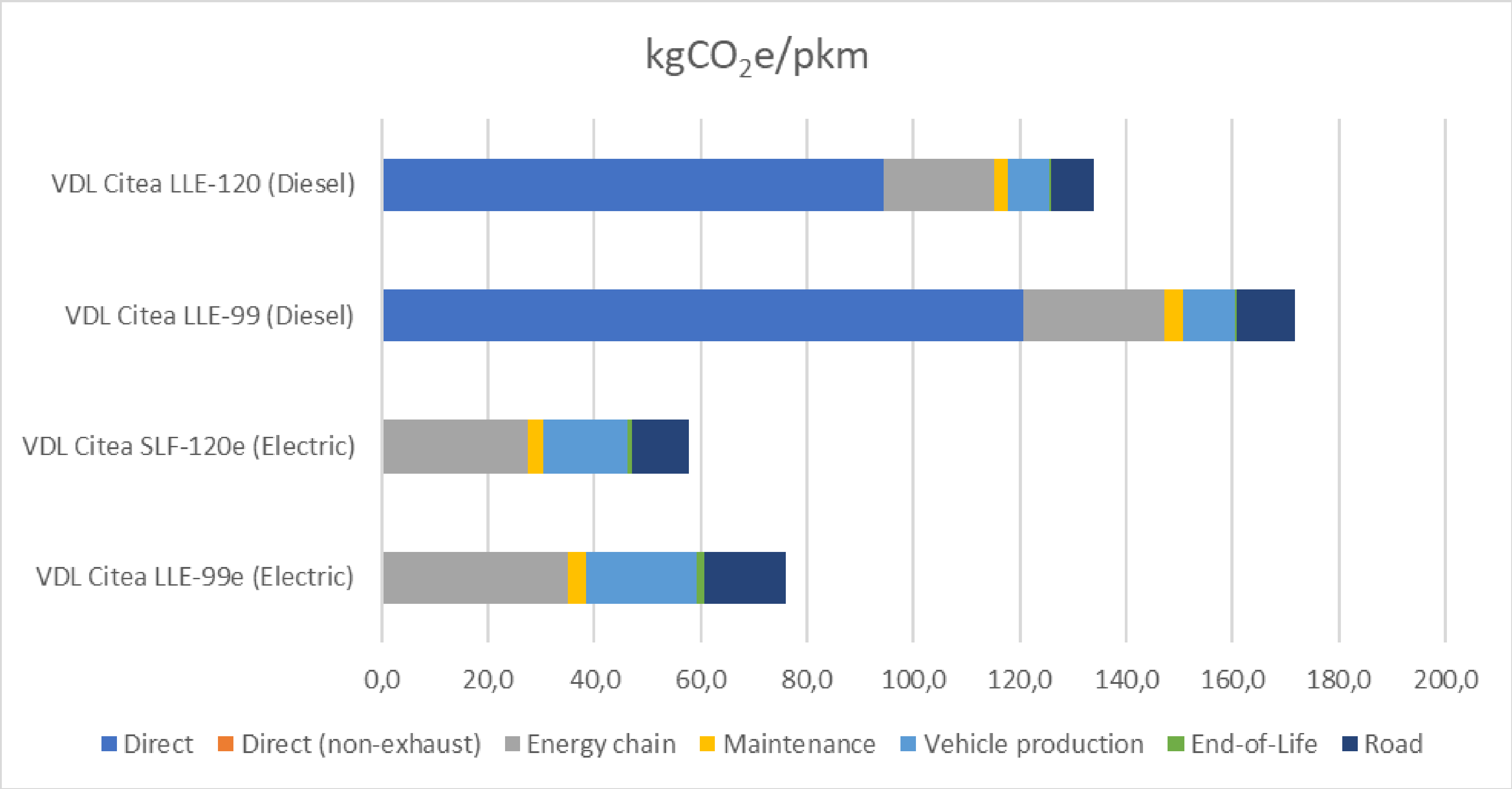
Vehicles and Infrastructure Life Cycle

Most comprehensive emission factors databases

Calculator	Mode/vehicle type coverage
Argonne National Laboratory GREET 2 2023: Vehicle-Cycle Model	• **Road:** passenger car, SUV; including HEV, PHEV, EV, FCV powertrains
mobitool Mobitool factors V3.0	• **Soft mobility:** walking, kick-scooter, bike, e-bike (various speed ranges; cargo bike). • **Road:** scooter (gasoline, e-scooter; various power ranges), city bus (midibus, single deck, double deck, articulated; diesel, hybrid diesel, CNG, battery electric with charging at depot or opportunity charging, hydrogen fuel cell electric), coach (single deck, double deck; diesel, hybrid diesel, CNG, fuel cell electric), trolleybus (articulated; battery-electric), motorbike (gasoline, battery-electric; various power ranges), passenger car (compact, medium, large, large SUV; diesel, gasoline, CNG, hybrid diesel, hybrid gasoline, plug-in hybrid diesel, plug-in hybrid gasoline, battery-electric, fuel cell electric). • **Rail:** tram, train (regional, long distance, high-speed; Switzerland, Germany, France, Italy, Austria). • **Water:** passenger ship (diesel). • **Air:** cable car, helicopter (single engine, twin engine), airplane (within Europe, intercontinental; various classes).

Vehicles and Infrastructure Life Cycle

Arriva Nederland Case



Life cycle GHG emissions for selected buses from Arriva fleet calculated using ISO 14083, GLEC and mobitool factors

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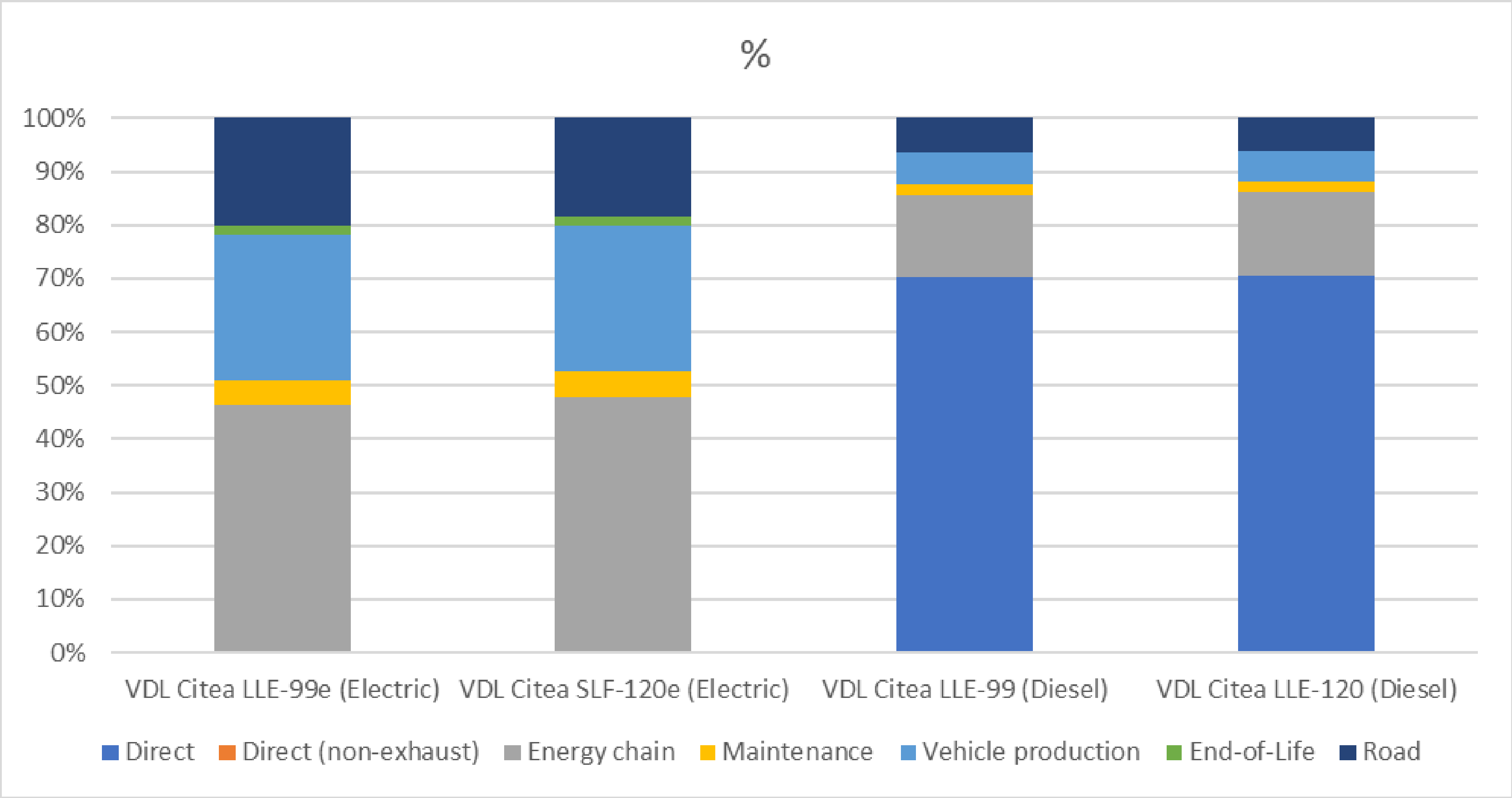
Vehicles and Infrastructure Life Cycle

Arriva Nederland Case



Relative contribution of each life cycle stage to the overall life cycle GHG emissions for selected buses from Arriva fleet

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Way Forward

Methodology – from WTW to life cycle

- Revision/update of the methodology of current standards (e.g., ISO 14083) by extending the scope of calculations from WTW to full life cycle perspective.

Access to life cycle inventory databases

- Enabling open access to the most comprehensive commercial life cycle inventory databases (e.g., ecoinvent).

Environmental Product Declarations

- Enforce/stimulate production of Environmental Product Declarations (EPDs) by vehicle and equipment manufacturers.

Harmonization & regular update

- Involvement of all main stakeholders (national and international standardization bodies, transport sector, manufacturing sector) in the process of harmonization across different geographical industry contexts.

Questions???

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