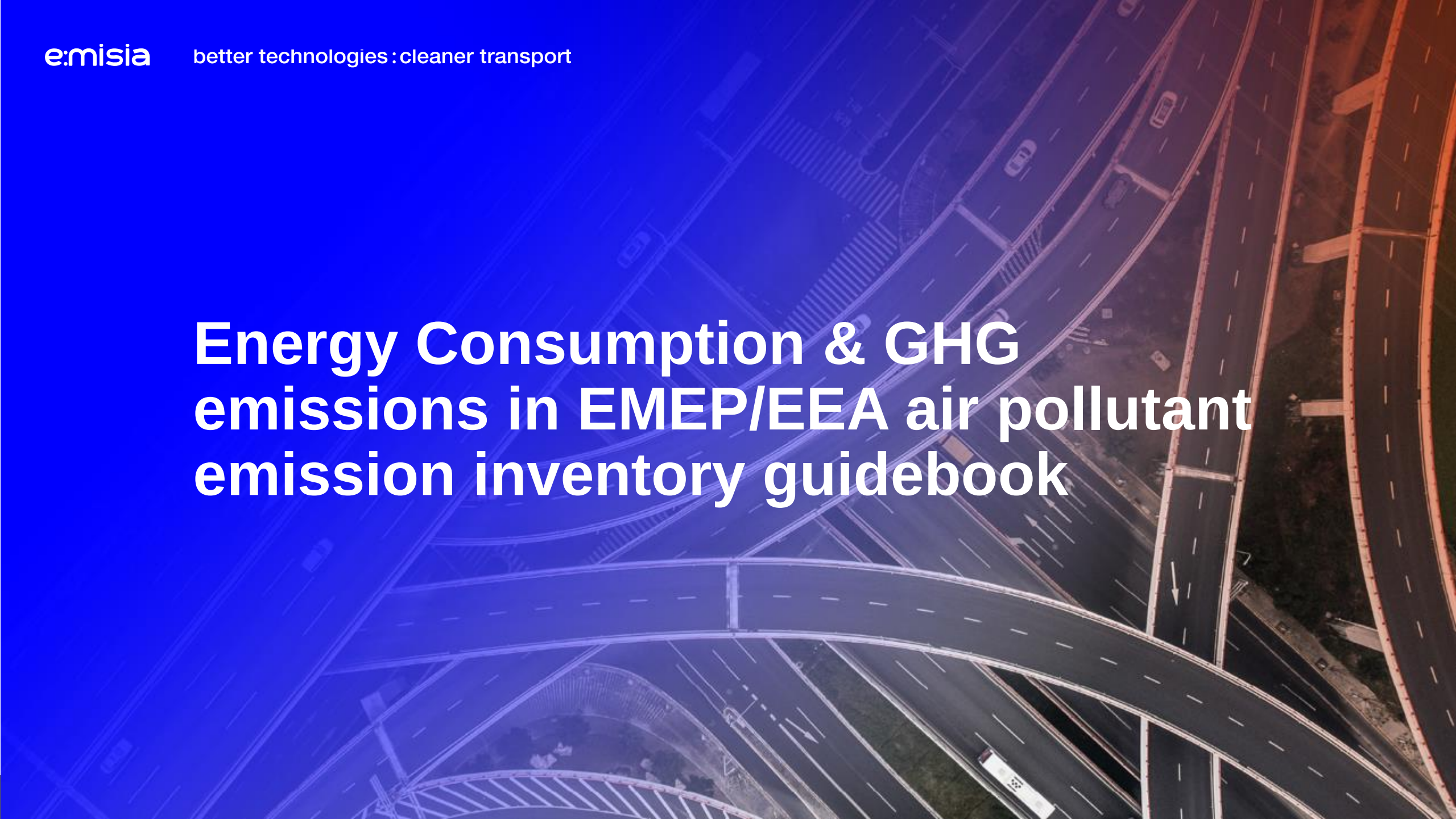
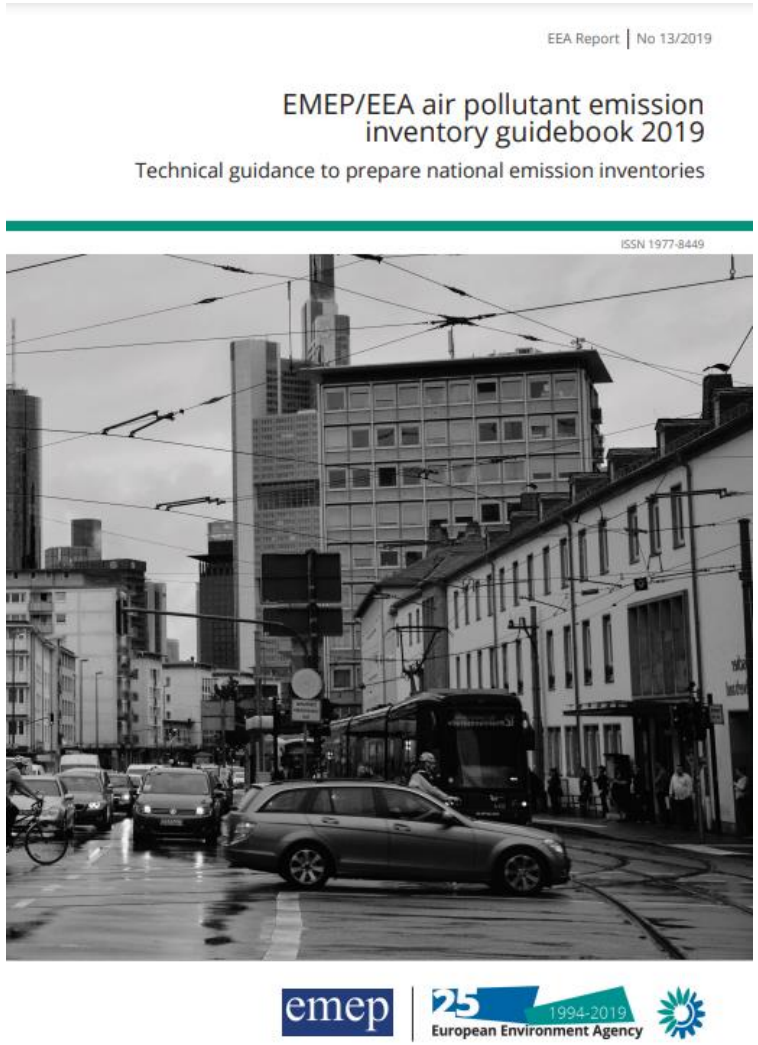
e:misia better technologies : cleaner transport

Energy Consumption & GHG emissions in EMEP/EEA air pollutant emission inventory guidebook



UNECE CLRTAP and EMEP/EEA air pollutant emission inventory guidebook



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UNECE ENVIRONMENTAL POLICY AIR / EMISSION INVENTORIES AND PROJECTIONS

- Environmental Policy
- Conventions and Protocols
- Air
- 40 years. Clean air.
- The Air Convention and its Protocols
- Convention bodies
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Emission Inventories and Projections

The main role of the Task Force on Emission Inventories and Projections (TFEIP) is to support Parties in the reporting of air pollutant emissions and projections data to the Convention. This includes having responsibility for the development and technical content of the EMEP/European Environment Agency (EEA) Emission Inventory Guidebook used for the estimation and reporting of national emissions. The Task Force also provides a technical forum and expert network to harmonize emission factors, establish methodologies for the evaluation of emission data and projections and identify problems related to emissions reporting. The Task Force further supports Parties in their implementation of the reporting requirements specified in the Convention's emission reporting guidelines. It also focuses on data quality and inventory review. The Task Force is led by the United Kingdom, the European Union (EU) and Finland. It works closely with the Centre on Emission Inventories and Projections (CEIP). CEIP, which is hosted at the Environment Agency Austria (Umweltbundesamt), collects emissions and projections of acidifying air pollutants, heavy metals, particulate matter and photochemical oxidants from Parties to the Convention; reviews submitted inventories in order to improve the quality of reported data; and prepares data sets as input for long-range transport models. The revised mandate of the Task Force can be found in EB decision 2019/6.

Fuel (energy) types and segment subcategories

Passenger cars

- **Petrol/Diesel** (mini, small, medium, large-SUV-executive)
- **Petrol hybrid** (mini, small, medium, large-SUV-executive)
- **Petrol/Diesel PHEV** (small, medium, large-SUV-executive)
- **LPG/CNG bifuel** (mini, small, medium, large-SUV-executive)
- **BEV** (small, medium, large-SUV-executive)

Light commercial vehicles

- **Petrol**
- **Diesel** (N1-I, N1-II, N1-III)

L-category vehicles

- mopeds (2/4-stroke <50 cm^3) **(petrol)**
- motorcycles (2-stroke, <250 , 250 – 750 , >750 cm^3) **(petrol)**
- mini-cars **(diesel)**
- ATVs **(petrol)**

Heavy duty trucks

- **Petrol** (> 3.5t)
- **Diesel** (14 GVW subcategories)
  - rigid: 3.5 - 7.5 t , 7.5 - 12 t , 12 - 14 t , 14 - 20 t , 20 - 26 t , 26 - 28 t , 28 - 32 t , >32 t
  - articulated: 14 - 20 t , 20 - 28 t , 28 - 34 t , 34 - 40 t , 40 - 50 t , 50 - 60 t

Buses

- **diesel** (5 segment subcategories)
  - urban buses: midi <=15 t , standard 15 - 18 t , articulated >18 t
  - coaches: standard <=18 t , articulated >18 t
- **Diesel hybrid**
- **Biodiesel**
- **CNG**

Vehicle technologies (Euro standards)

Passenger cars	Light commercial vehicles	Heavy duty trucks & buses	L-category vehicles
PRE ECE			
ECE 15/00-01			
ECE 15/02			
ECE 15/03			
ECE 15/04			
Improved Conventional			
Open Loop	Conventional	Conventional	Conventional
Euro 1	Euro 1	Euro I	Euro 1
Euro 2	Euro 2	Euro II	Euro 2
Euro 3	Euro 3	Euro III	Euro 3
Euro 4	Euro 4	Euro IV	Euro 4
Euro 5	Euro 5	Euro V	Euro 5
Euro 6 a/b/c (up to 2016)	Euro 6 a/b/c (up to 2016)	Euro VI A/B/C	
Euro 6 d-temp (2017-2019)	Euro 6 d-temp (2017-2019)	Euro VI D/E	
Euro 6 d (2020+)	Euro 6 d (2020+)		

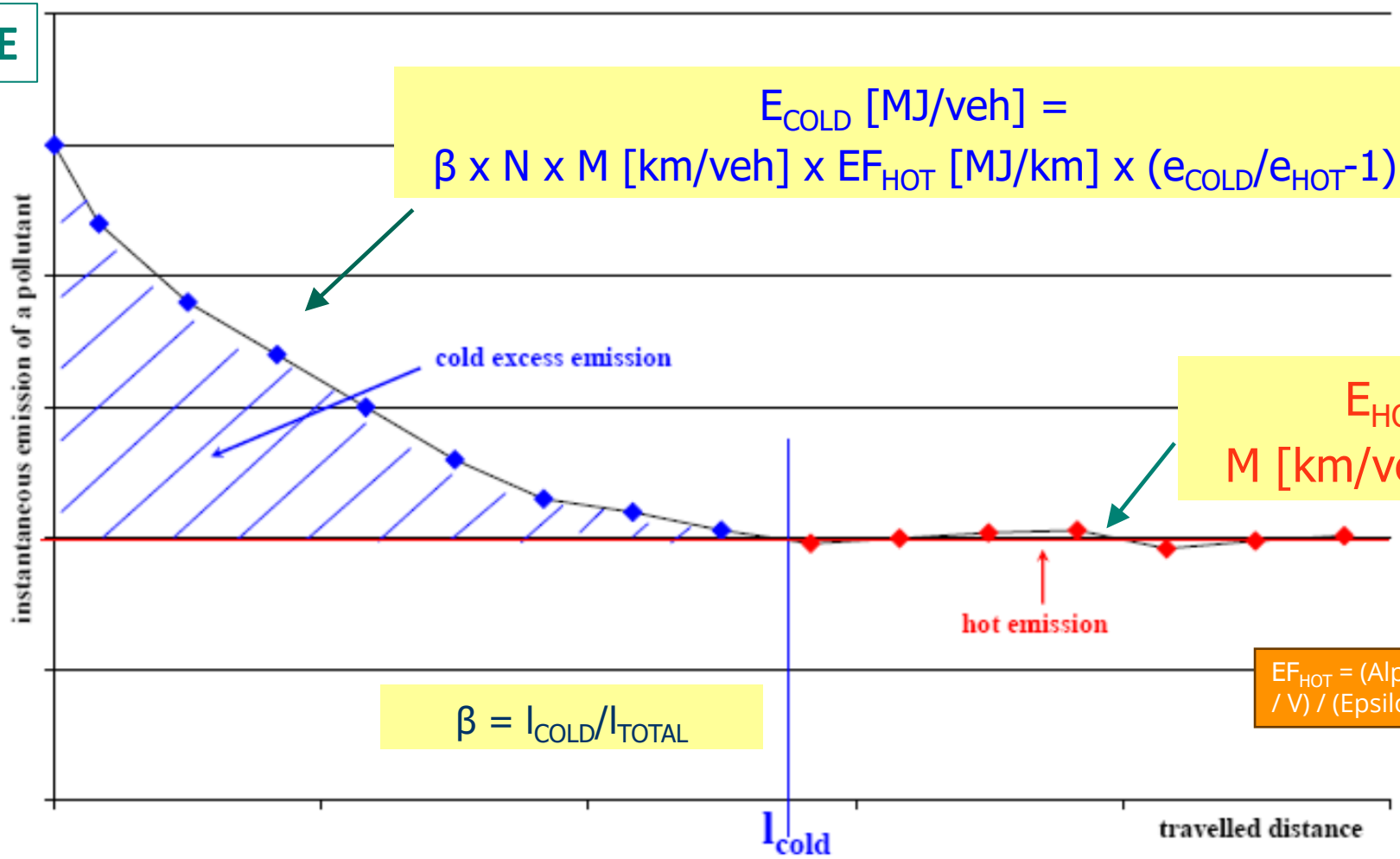
Methodology for calculating emissions/energy consumption

$E_{TOTAL} = E_{HOT} + E_{COLD}$

Data from RDE

Main idea:
Consumption
= distance * EF

E_{COLD} [MJ/veh] =
β x N x M [km/veh] x EF_{HOT} [MJ/km] x (e_{COLD}/e_{HOT}-1)



E_{HOT} [MJ/veh] =
M [km/veh] x EF_{HOT} [MJ/km]

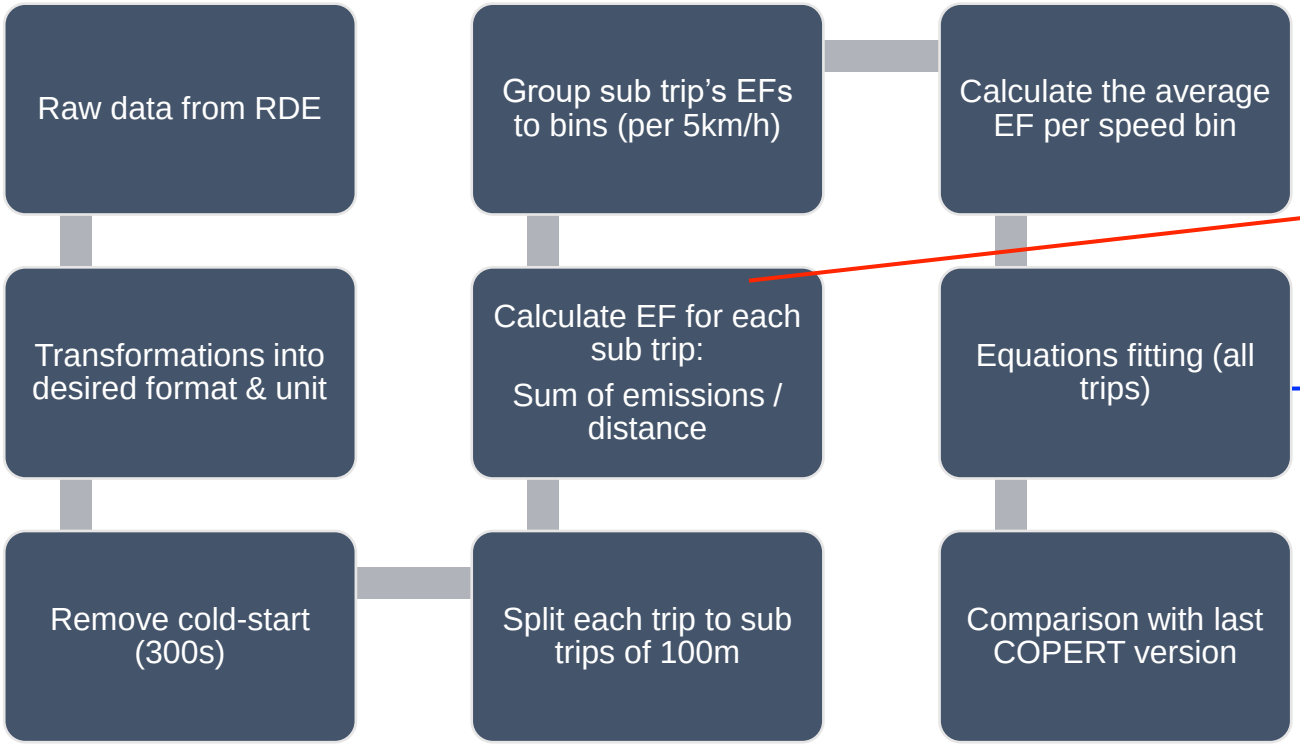
EF_{HOT} = (Alpha x V^2 + Beta x V + Gamma + Delta / V) / (Epsilon x V^2 + Zeta x V + Eta) x (1 - RF)

$\beta = l_{COLD}/l_{TOTAL}$

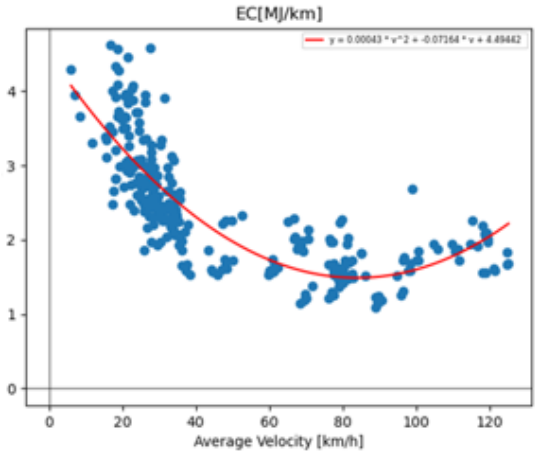
*Calculation of energy consumption follows similar methodology with exhaust emissions of main pollutants

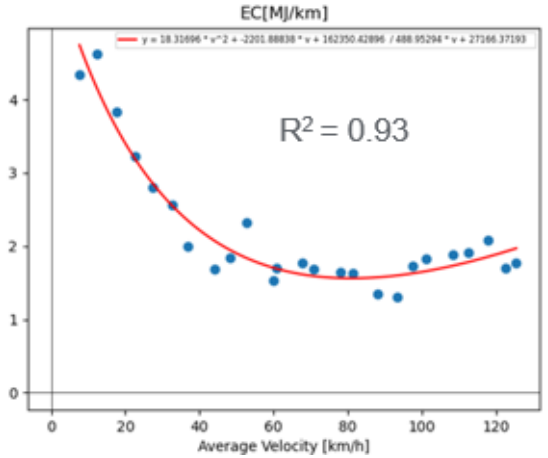
How hot emission/energy consumption factors are produced?

EF_{HOT} = (Alpha x V^2 + Beta x V + Gamma + Delta / V) / (Epsilon x V^2 + Zeta x V + Eta) x (1 - RF)



Example: PC-CNG-Medium-Euro 6d
with PEMS by Innovhub



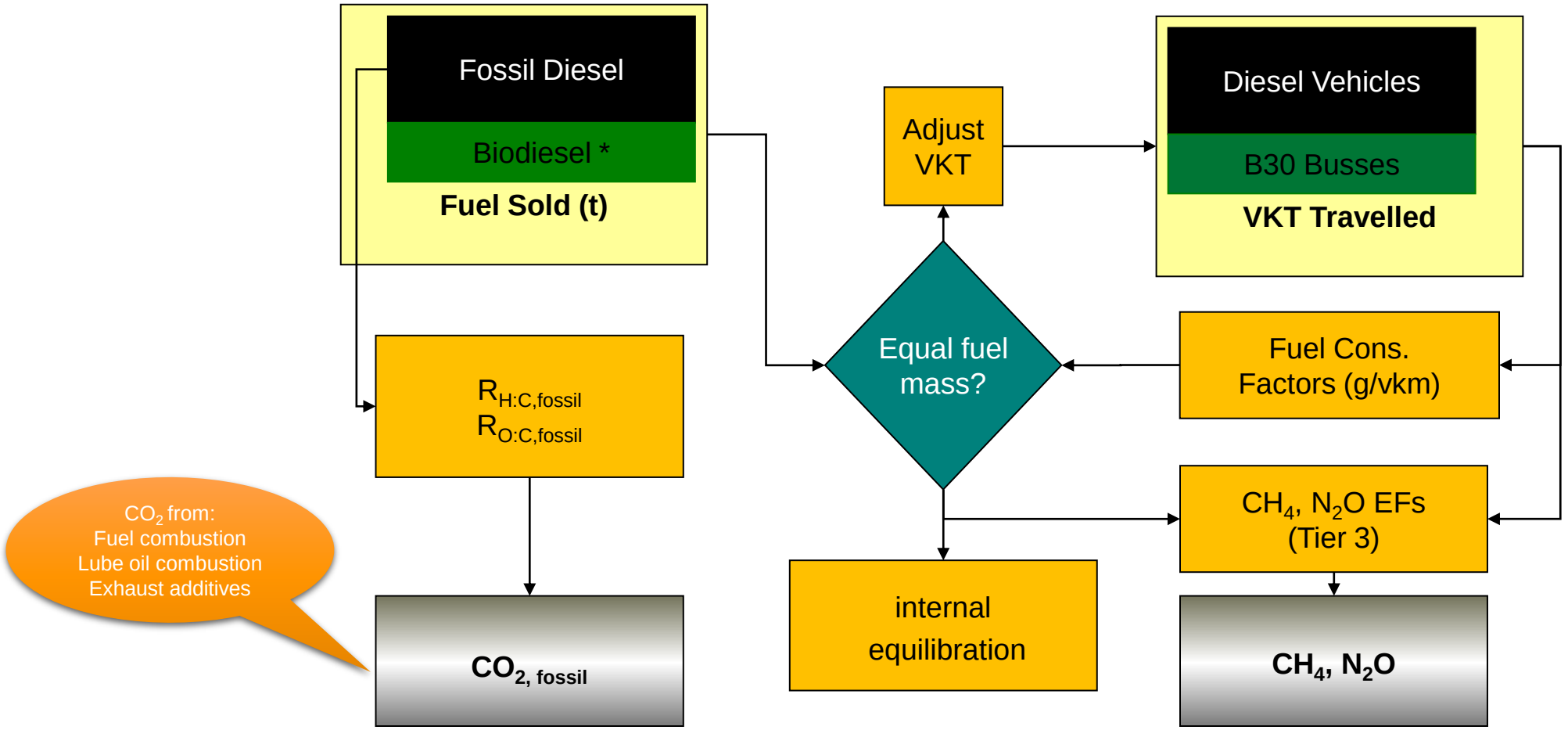


Alpha	Beta	Gamma	Delta	Epsilon	Zita	Eta	RF [%]
18.3	-2202	162350	0	0	489.0	27166	0

What is energy consumption depending on?

Activity	Hot emissions	Cold emissions
Number of vehicles	Technology / emission standard	Technology / emission standard
Distance travelled [km]	Mean travelling speed [km/h]	Mean travelling speed [km/h]
	Efficiency improvement	Ambient temperature [°C]
		Mean trip distance [km]

Energy Balance & calculation of GHG emissions



CO_2 calculation from fuel combustion (1/2)

$$E_{CO_2}^{CALC} = 44.011 \times \frac{FC^{CALC}}{12.011 + 1.008R_{H:C} + 16.000R_{O:C}}$$

- Calculation of *ultimate* CO_2, i.e. all carbon in fuel oxidized to CO_2
- Operates on the basis of g/km emission factors for consistency with other pollutants
- $R_{H:C}$, $R_{O:C}$ are the ratios of H to C and O to C atoms, respectively in the average fuel molecule

CO_2 emission factors from fuel combustion (2/2)

Fuel (*m*)	Typical Molecule	Ratio of hydrogen to carbon ($r_{H:C}$)	Ratio of oxygen to carbon ($r_{O:C}$)	kg CO_2 per kg of fuel*
Petrol	$[CH_{1.86}]_x$	1.86	0.0	3.169
Diesel	$[CH_{1.86}]_x$	1.86	0.0	3.169
Ethanol	C_2H_5OH	3.00	0.5	1.911
Methanol	CH_3OH	4.00	1.00	1.373
Biodiesel	[CH]x-COOH	1.95-2.03	0.11-0.13	2.797-2.727
ETBE	$C_6H_{14}O$	2.33	0.167	2.584
MTBE	$C_5H_{12}O$	2.40	0.20	2.496
Natural Gas / Biogas (REF)	CH4, market fuels also contain C_2H_6	4.00	0.00	2.473
LPG (REF)	C_3H_8 (15%) – C_4H_{10} (85%)	2.525	0.00	3.024
E5		1.92	0.026	3.063
E10 (REF)		1.98	0.053	2.694
E75		2.73	0.38	2.111
E85 (REF)		2.84	0.429	2.026
ETBE11		1.91	0.018	3.094
ETBE22		1.96	0.036	3.021
B7 (REF)		1.86	0.007	3.144
B10		1.86	0.010	3.133
B20		1.87	0.020	3.096
B30		1.88	0.030	3.059

*CO2 emission factors are based on an assumed 100% oxidation of the fuel carbon (ultimate CO2)

CO_2 from lubricant oil consumption

$$E_{CO_2}^{CALC} = 44.011 \times \frac{FC^{CALC}}{12.011 + 1.008R_{H:C} + 16.000R_{O:C}}$$

Category	% of fuel consumption
Passenger cars	0.1
Heavy-duty vehicles	0.3
2-stroke mopeds	5…50

- Total contribution 0.2–0.3% for developed countries
- Contribution potentially more important for developing countries

CO_2 from urea consumption

- Urea used in SCR systems to reduce NOx emissions
- DIN 70070 specifies that urea should be in aqueous solution at a content of 32.5% wt (±0.7%) and a density of 1.09 g/cm^3
- Small amounts of CO_2 emissions are also produced

$$(NH_2)_2CO + H_2O \rightarrow 2NH_3 + CO_2$$

Urea

$$6NO + 4NH_3 \rightarrow 5N_2 + 6H_2O$$
$$6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$$

- If total commercial urea solution sales are known (UC in litres), then total ultimate CO_2 emissions (in kg) are:

$$E_{CO_2,\,urea} = 0.26 \times UC$$

- If total urea is not known, this can be assumed 5-6% @ Euro V and 3-4% @ Euro VI of fuel consumption (percentages are in lt AdBlue / lt Fuel)

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Thank you!