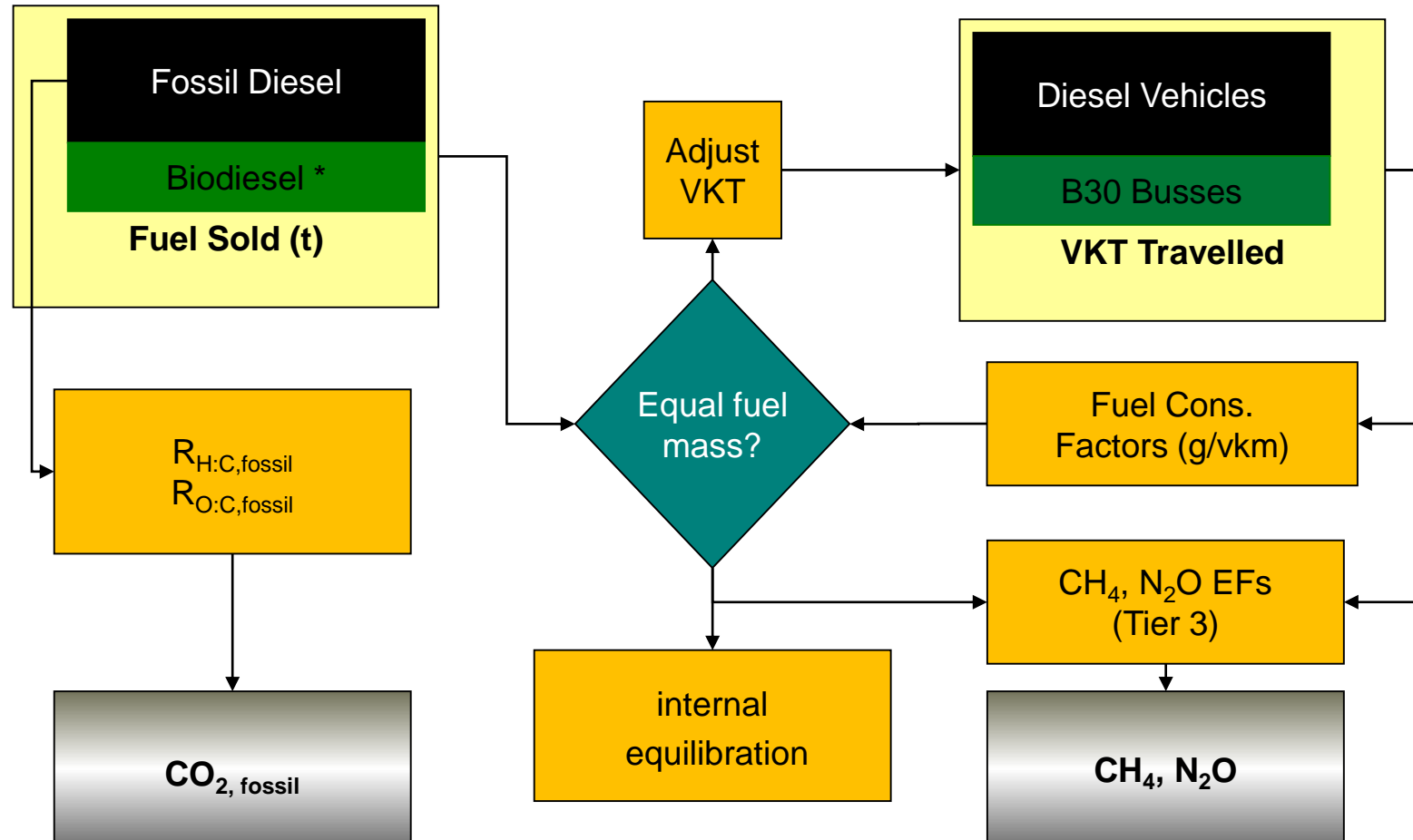


COPERT Training

4. GHG Emissions



Methodology: Algorithm



* Part of FAME biodiesel is fossil!



Methodology: Tier coverage

	CO ₂	CH ₄ , N ₂ O	Urea
Tier 1	FC x EF _{default}	FC x EF _{default}	Urea cons. x 'purity'
Tier 2	FC x EF _{country specific}	FC _{veh. cat.} x EF _{veh. cat.}	NA
Tier 3	NA	VKT _{veh. cat.} x EF _{veh. cat.} ⁺ Cold	NA

 IPCC Method Coverage by COPERT



Methodology: CO₂ calculation

$$E_{\text{CO}_2}^{\text{CALC}} = 44.011 \times \frac{FC^{\text{CALC}}}{12.011 + 1.008R_{\text{H:C}} + 16.000R_{\text{O:C}}}$$

- Calculation of *ultimate* CO₂, i.e. all carbon in fuel oxidized to CO₂
- 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



Emission factors: CO₂

Fuel	Chemical formula	COPERT					IPCC (kg/TJ)		
		H:C Ratio [-]	O:C Ratio [-]	EF _{CO2} (kg/kg)	LHV (MJ/kg)	EF _{CO2} (kg/TJ)	Default	Lower	Upper
Petrol	[CH _{1.86}] _x	1.86	0.016	3.169	43.77	70,943	69,300	67,500	73,000
Diesel	[CH _{1.86}] _x	1.86	0.005	3.169	42.70	73,810	74,100	72,600	74,800
LPG	C ₃ H ₈ (15%)-C ₄ H ₁₀ (85 %), market fuels may contain different proportions	2.525	0	3.024	46.56	64,933	65,447	61,600	65,600
NG	CH ₄ , market fuels also contain C ₂ H ₆	3.9	0	2.473	48.00	57,514	56,100	54,300	58,300
Ethanol	C ₂ H ₅ OH	3	0.5	1.911	28.80	66,341	66,191		
Bio-Diesel	[CH] _x -COOH	1.94	0.11	2.79	37.30	75,027			



More info: Petrol CO₂

- COPERT higher than IPCC Default by ~5%
- IPCC absolute value (69 kg/TJ) is low → designates use of oxygenates
- European regulations (2009/30/EC) specify 3.7% wt. max oxygen in fuel, i.e. typical Petrol molecule: $[\text{CH}_{1.8}\text{O}_{0.033}]_x$
- Assuming O reduces LHV by 3.3%, then EF_{CO_2} cannot drop below 70 kg/TJ in Europe
- Maybe IPCC value dominated by US standards?



Emission factors: CH₄

- Four values (mg/km) are provided: Cold Urban, Hot Urban, Rural, Highway
- Data mostly based on ARTEMIS project (2000-2006), values differentiated per vehicle category, Euro standard
- Cold/Hot urban part estimated on the basis of cold-start distance
- Emission factors for new technologies based on extrapolation. Low CO₂ equivalent too weak to justify new measurements.



Emission factors: N₂O

- $EF_{N_2O} = (a \times M_{\text{cumulative}} + b) \times EF_{\text{BASE}}$
 - a, b, EF_{BASE} depend on technology level for gasoline PCs & LCVs
 - a, b depend on fuel sulfur content
 - Different factors for cold urban, hot urban, rural, highway
- Much simpler approach for Diesel cars, HDVs and gasoline motorcycles



Lube oil consumption

Category	Fuel / engine category	Age	Kg / 10.000 km		
			Mean	Min	Max
PC	Gasoline	Old	1.45	0.85	2.13
	Gasoline	New	1.28	0.85	1.70
	Diesel	Old	1.49	0.85	2.13
	Diesel	New	1.28	0.43	2.13
LDV	Gasoline	Old	1.45	0.85	2.13
	Gasoline	New	1.28	0.85	1.70
	Diesel	Old	1.49	0.85	2.13
	Diesel	New	1.28	0.43	2.13
Urban Buses	Diesel	Old	8.50		
	Diesel	New	0.85		
Coaches	Diesel	Old	1.91	1.70	2.13
	Diesel	New	1.70	1.28	2.13
HDV	Diesel	Any	1.56		
Mopeds	2-stroke	Old	10.20	6.80	13.60
	2-stroke	New	6.80	5.10	8.50
Motorcycles	4-stroke	Any	0.43		0.85



Lube oil impact

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



CO₂ from urea consumption



- DIN 70070:

- specifies that urea should be in aqueous solution at a content of 32.5% wt ($\pm 0.7\%$) and a density of 1.09 g/cm³.
- If total commercial urea solution sales are known (UC in litres), then total ultimate CO₂ 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]



SCR urea impact on CO₂

	Consumption (Mt)	CO ₂ (Mt)
2010	Gasoline (toe)	298
	Diesel (toe)	556
	Urea	0.238
	Total Road Transport	854
	Urea/Total	0.03%
2020	Gasoline (toe)	281
	Diesel (toe)	578
	Urea	2.92
	Total Road Transport	862
	Urea/Total	0.3%

Notes:

- All diesel vehicles assumed Euro 6/VI in 2020, require SCR agent ~ 6% of FC
- CO₂ and consumption taken from PRIMES 2009 baseline



Automatic XML-file creation

- Automated procedure to export all years to CRF
- CO₂ exported only on the basis of fossil fuel consumption
- Biodiesel/Bioethanol CO₂ emissions are set to zero
- CH₄ and N₂O exports are proportional to fuel consumption, example:

$$CH_{4,XML,BIO,DIESEL} = CH_{4,COPERT} \times FC_{BIO,DIESEL} / FC_{TOT,DIESEL}$$



Thank you for your attention!

