Benedikt Notter

Handbook of Emission Factors for Road Transport (HBEFA) 4.1

ERMES Meeting, Thessaloniki, May 14, 2019

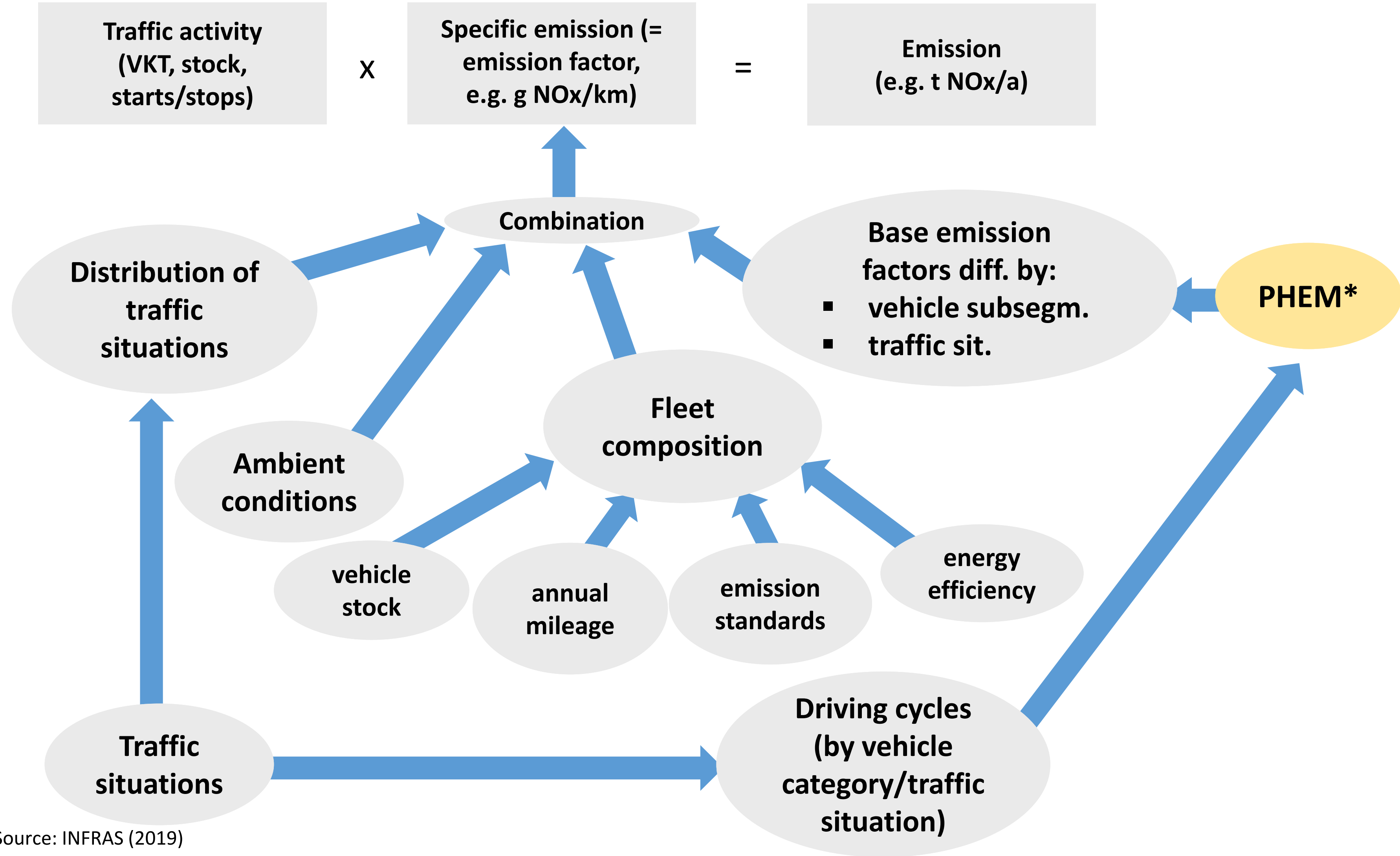
HBEFA 4.1 – Focus of the new version

Besides the usual update of EF based on new measurements, the new features in HBEFA 4.1 mainly have to do with:

- Alternative drivetrains, especially electric vehicles (BEV's, PHEV's), but also gas vehicles (CNG)
  → as a consequence, need to consider upstream emissions
- Improvement of NOx EF, which receive increased attention due to the Dieselgate scandal: e.g. taking into account SCR state on entry into a traffic situation, NH3 storage in SCR catalysts, software updates

→ A pragmatic implementation strategy was necessary to keep complexity at a level acceptable to the users
→ see poster presentation of HBEFA 4.1 at the TAP conference

Basic structure of HBEFA



Source: INFRAS (2019)

* PHEM: Passenger Car and Heavy Duty Emission model (TU Graz)

Revised driving cycles

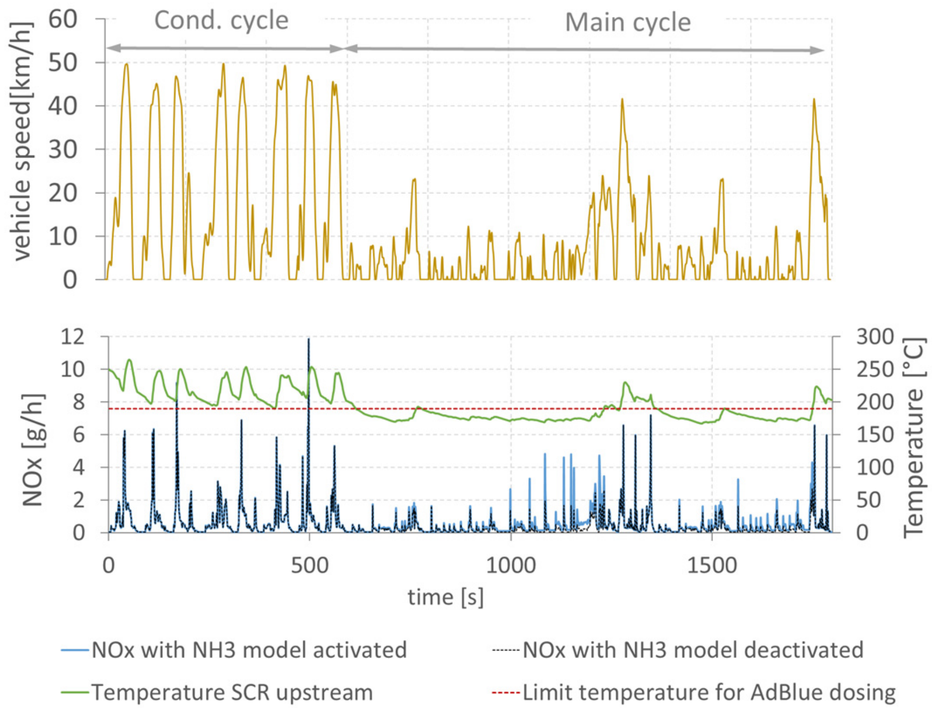
- All driving cycles in HBEFA 4.1 have been revised based on new real-world driving profiles (from Germany, Sweden, Switzerland, Hungary, and Italy)
- The new cycles show a tendency towards a lower average speed, but higher dynamics (RPA)
  → this in tendency leads to higher consumption and emission factors

VehCat	Ratio_duration	Ratio_v_ave	Ratio_RPA	Ratio_p_stop
PC	130%	96%	105%	101%
LCV	133%	96%	104%	100%
Coach	109%	96%	117%	109%
UBus	98%	100%	111%	91%
MC	122%	95%	109%	153%
HGV	101%	96%	118%	102%

Source: INFRAS based on Steven (2019)

„Conditioning cycles“

- «History» of a trip influences the state of the SCR catalyst on entry into a traffic situation and thus the NOx emission level.
- Modelling individual trips would increase complexity and calculation intensity disproportionately
- Therefore, «conditioning cycles» are used, i.e. statistically determined typical «pre-cycles» for every cycle modelled in PHEM

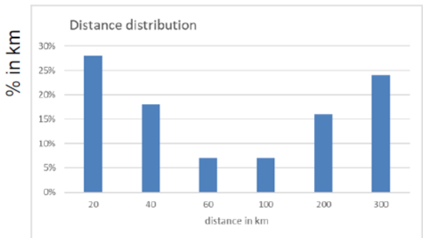


Source: TU Graz (2019)

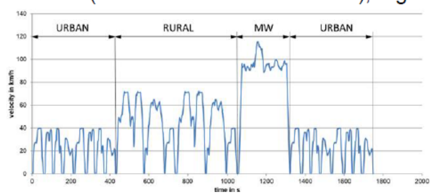
Electrical driving share of PHEV’s

- Same basic problem – depends on individual trips.
- TU Graz combined «micro trips» to typical trips in different distance bands and derived a relationship between average speed and electric driving share
- This is considered in HBEFA at the level of the road category (MW/ rural/urban)

“Variable electrical driving share” elaborated by TUG



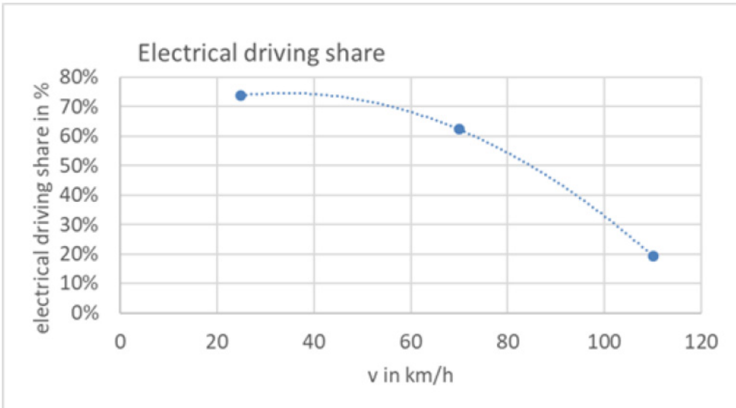
Combine „micro trips“ for each distance class (start and end in urban area), e.g.:



velocity in km/h								
	0-50	SOC 20	51%	51%	47%	47%	43%	29%
		SOC 40	96%	93%	79%	63%	52%	35%
		SOC 60	96%	93%	90%	83%	61%	40%
		SOC 80	97%	95%	92%	90%	69%	46%
	50-90	SOC 20	6%	5%	8%	13%	13%	9%
		SOC 40	88%	87%	62%	39%	28%	19%
		SOC 60	88%	87%	88%	78%	45%	30%
		SOC 80	87%	87%	89%	89%	60%	40%
	>90	SOC 20	18%	23%	24%	25%	12%	8%
		SOC 40	23%	25%	24%	25%	12%	8%
		SOC 60	23%	25%	25%	25%	12%	8%
		SOC 80	26%	26%	25%	26%	13%	9%
distance km			20	40	60	100	200	300

Share in electric driving for each combination of trip length and start SOC

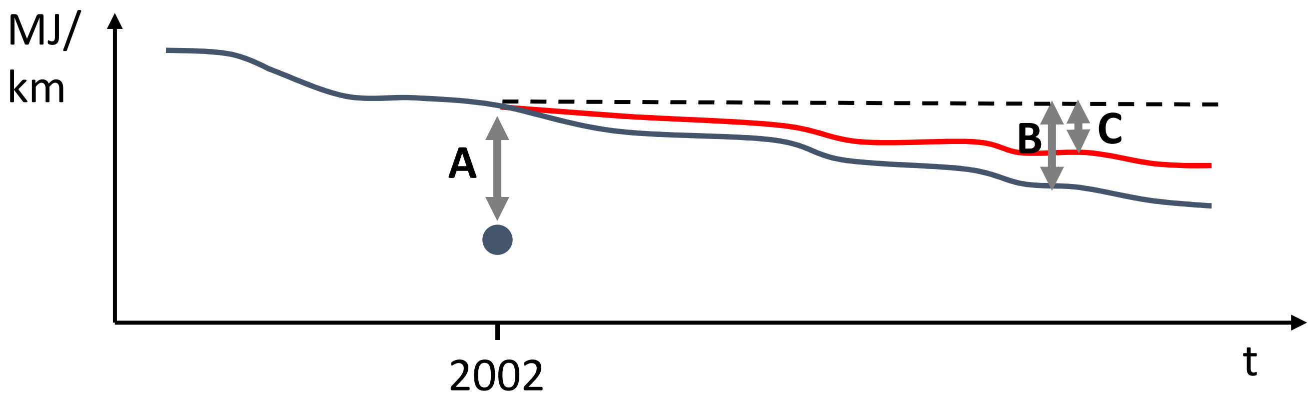
Simulate trips with PHEV model in PHEM for different SOC levels at trip start (not always 100% charged battery at start) Useful SOC assumed to be 20% to 80%)



Source: TU Graz (2018)

Energy consumption of PC up to HBEFA 3.3

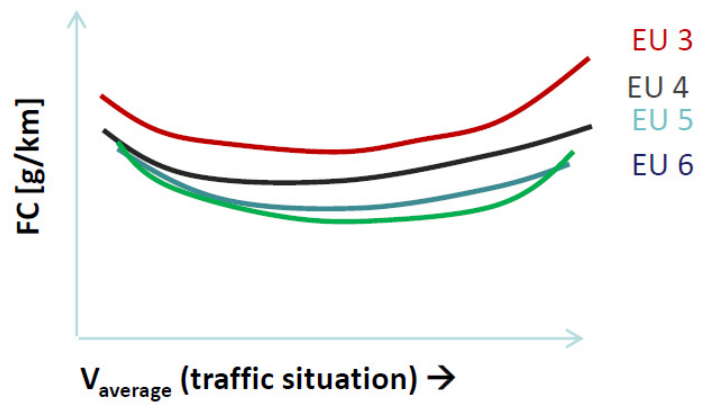
- Fuel consumption was modelled in PHEM for all HBEFA traffic situations plus NEDC for 2 reference vehicles (P/D) registered in 2002
- Consumption factors of new registrations were then scaled using the following parameters:

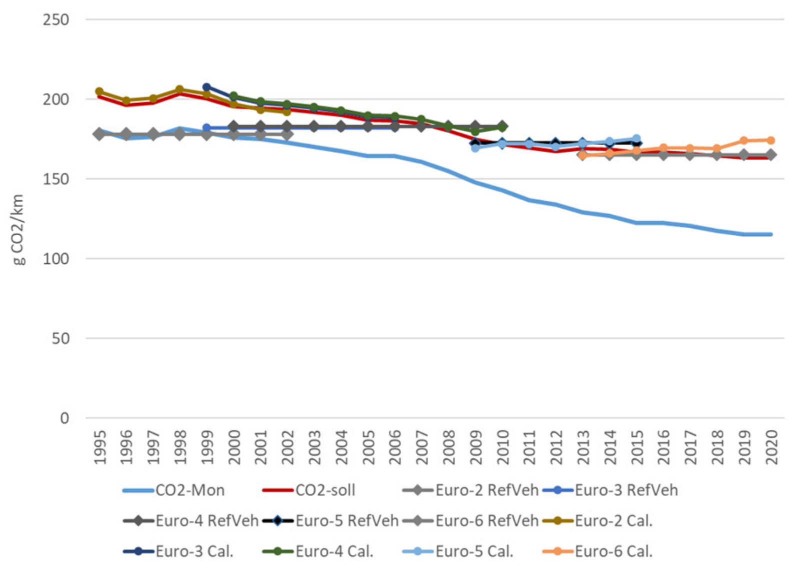


  - **A** = „Base correction“ → level correction, accounts for national fleet compositions
  - **B** = Annal reduction rate, based on CO2 monitoring
  - **C** = B * „Use factor“ = real-world share of reduction

Energy consumption of PC in HBEFA 4.1

- Reference vehicles for all technologies (B, D, CNG, PHEV,…) and emission standards
- Country-specific calibration based on:
  - CO2 monitoring
  - Real-world excess based on analysis of fuel logs (e.g. Spritmonitor)
  - modelled real-world consumption: weighted average of traffic situations and shares of emission standards in new registrations

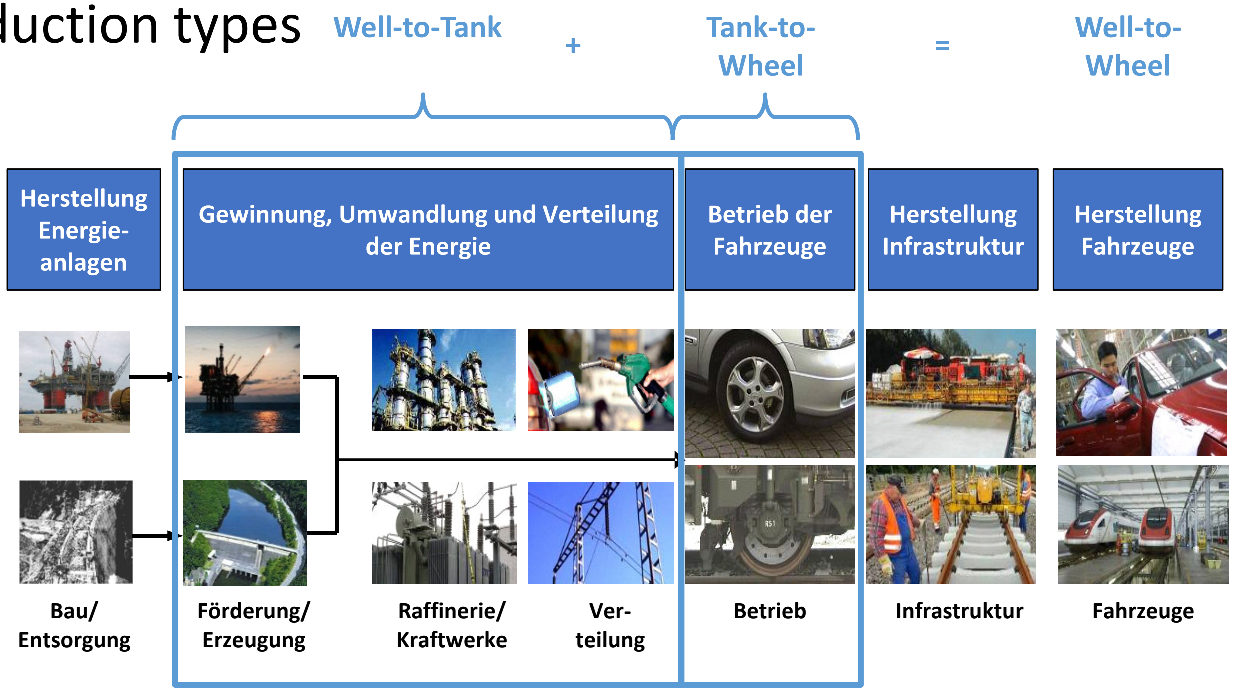




Sources: TUG, INFRAS 2018

WTT CO2e emissions

- No direct emissions from electricity or biofuels - however, relevant indirect (upstream) emissions depending on the mix of production types
- Therefore WTT (Well-to-tank) emission factors for CO2 are available in HBEFA 4.1
- Based on average EU or (optionally) country-specific mix of production types

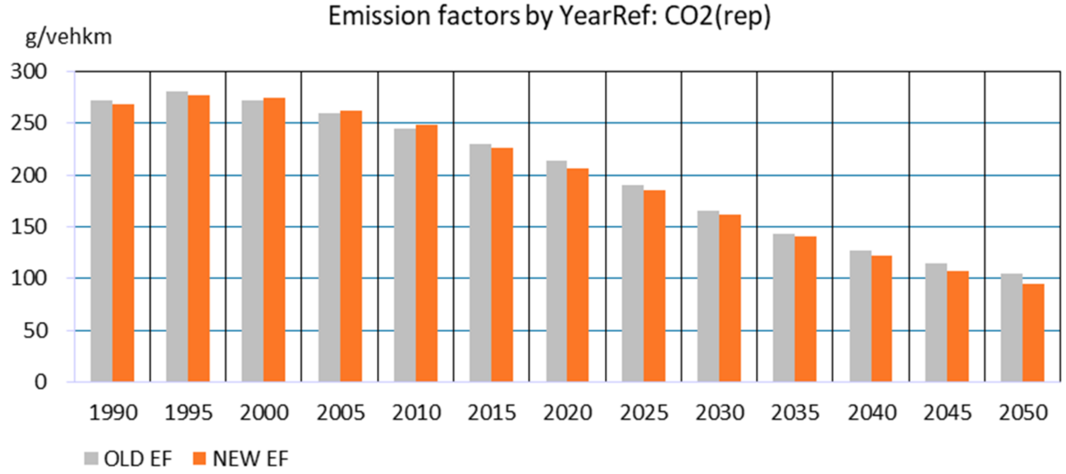


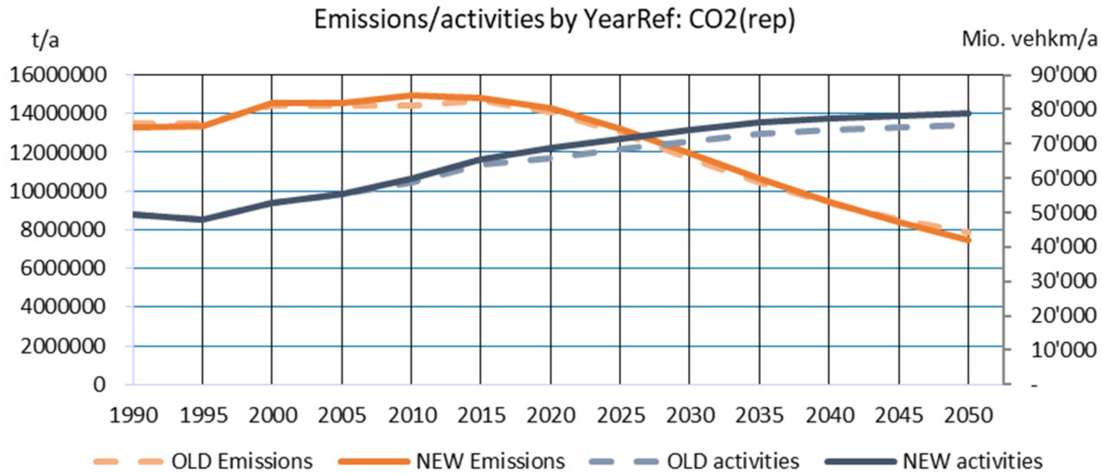
Source: adapted from SBB (2008)

Other new features

- Changes in hot EF (see following slides) due to:
  - new driving cycles
  - new PHEM version (incl. new gearshift model, new NH3 model, new vehicle parameter from CO2 project etc.)
  - new ageing/deterioration functions for catalysts
  - new functions for ambient T dependency of NOx emissions of diesel PC and LCV
- Revised cold start and evaporation EF (COPERT 5)
- Revised EF of non-regulated pollutants
  → PM-nonexhaust now also in Public Version
- New traffic situations: LOS 5 (“Heavy stop+go”), 30 km/h speed limits on main roads

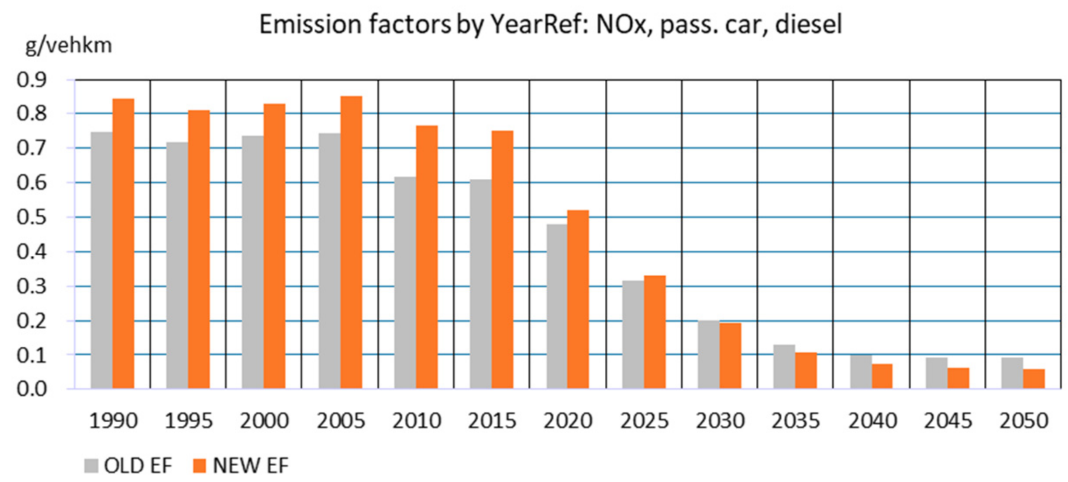
HBEFA 4.1 – Changes in EF and emissions: CO2 (Switzerland, preliminary results)

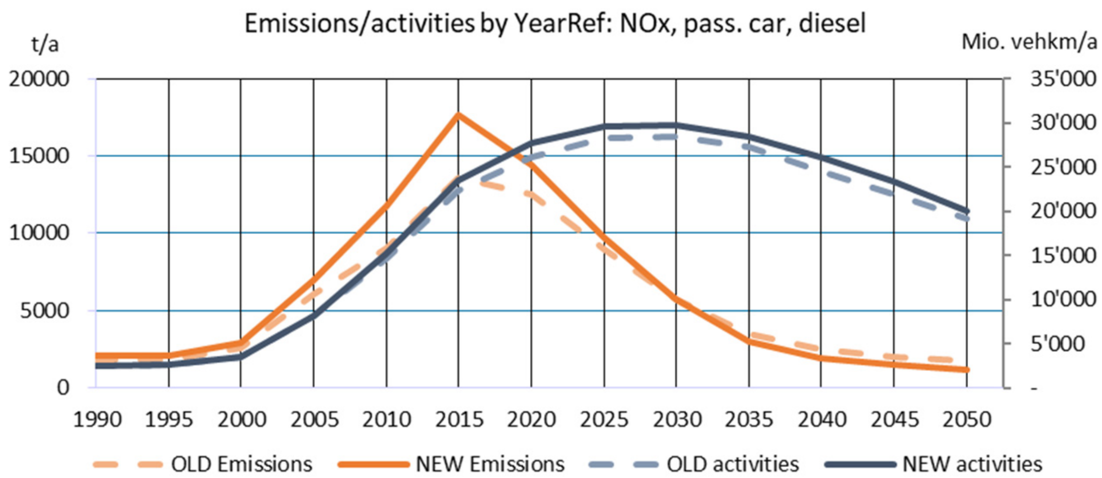




- Only slight changes in total levels, since CO2 is calibrated based on fuel sales
- Changes in the totals are therefore due to changes in VKT statistics rather than HBEFA

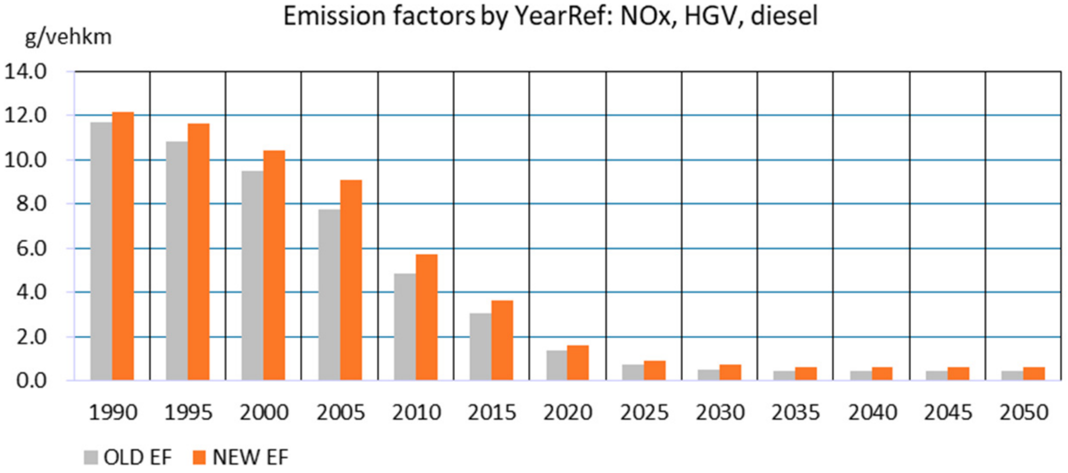
HBEFA 4.1 – Changes in EF and emissions: NOx, PC diesel (Switzerland, preliminary results)

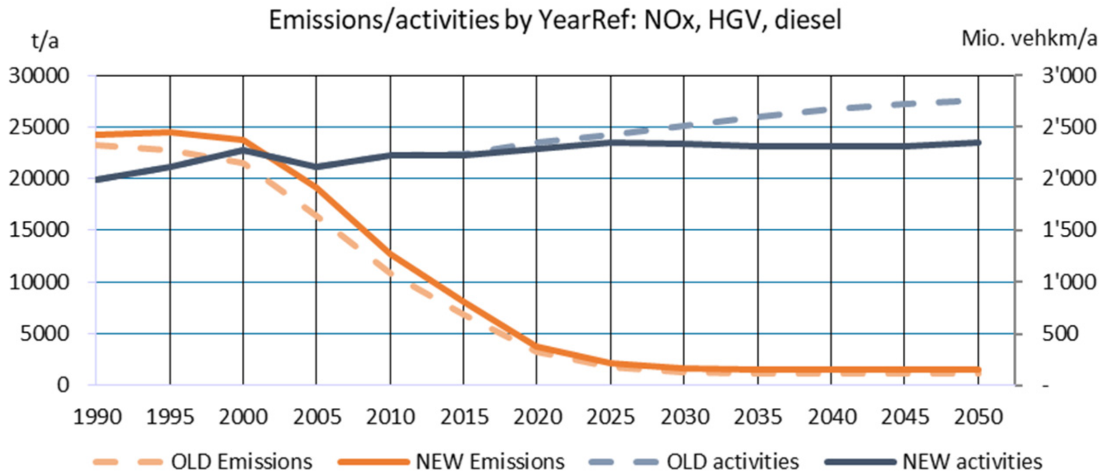




- Significant increase of EF of diesel PC and LCV, except the newest emission standards (i.e. from Euro 6c)
- In early years compensated by lower EF of petrol PC

HBEFA 4.1 – Changes in EF and emissions: NOx, HGV diesel (Switzerland, preliminary results)





- Moderate increase of Nox EF and emissions over entire time series and most subsegments

Thank you for your attention!

Dr. Benedikt Notter

Senior project manager
Transport and environment

INFRAS
Sennweg 2
3012 Bern

benedikt.notter@infras.ch

Dr. Brian Cox

Consultant
Transport and environment

INFRAS
Sennweg 2
3012 Bern

brian.cox@infras.ch

Dr. Hans-Jörg Althaus

Associate partner
Transport and environment

INFRAS
Sennweg 2
3012 Bern

hans-joerg.althaus@infras.ch