Road transport stock and activity dataset

for air pollutant and GHG emission calculations

EMISIA, May 2019

emisia
CONSCIOUS OF TRANSPORT'S IMPACT

Context and background

- EMISIA actively maintains **reliable** and **up-to-date** vehicle fleet and activity road transport data, ready to be used in air pollutant and GHG emission calculation tools
- In 2018, EMISIA performed a **major** update, starting the time series from 1990, with projections to 2050, taking into account all recent statistical data
- Related EC funded previous projects: **FLEETS** and **TRACCS**

Our approach in a nutshell

- A complete and consistent dataset of **historical** data has been created on a per country basis
  - Harmonized with official national statistical data, so as to reflect real situation to the extent possible
  - Used as basis for projections
  - 34 countries coverage: EU28, EFTA (IS, LI, NO, CH), NMK, TR

....

- Historical trends in **fleet turnover** dynamics obtained
  - Fleet structure and evolution, new registrations (sales), petrol/diesel trends and alternative fuels penetration, vehicle lifetime and age distribution

- Projections: total activity **projection** agreed on a political level (EU Reference scenario)

Usage of the dataset

copert

- Official road transport emission inventory preparation software
  - EEA, JRC, EMISIA (https://www.emisia.com/utilities/copert/)

data

- Ready to go vehicle fleet and activity (COPERT) data
  - EMISIA (https://www.emisia.com/utilities/copert-data/)

sibyl

- Vehicle stock, air pollutants, and GHG projection policy evaluation tool
  - EMISIA (https://www.emisia.com/utilities/sibyl/)

Other

- Fleet projections, impact of alternative fuels penetration in the market
- Environmental and energy studies, national emission inventories
- Policy assessment studies for EU institutes and the industry
- Impact of current and future legislation on emission reduction policies

Significant updates compared to previous versions

- Temporal coverage: **1990 – 2050**
- Update of **alternatively fueled** vehicles (LPG, CNG, hybrids, electric) in all categories (cars, vans, trucks, buses, mopeds, motorcycles)
- Disaggregation into **subcategories** based on statistical data (where available)
- Inclusion of **mini-cars** and **ATVs**
- Update of **age distributions**, so that average age is consistent with statistical data
- Consistency of **fuel consumption** with national submissions in UNFCCC down to the vehicle category level

Historical years

Data sources

Source	Main information provided
Eurostat	Stock and new registrations per fuel and engine capacity / GVW
EC Statistical Pocket Book	Stock and new registrations
ACEA (and ANFAC Motor Vehicle Parc)	Stock per fuel, new registrations per fuel and per segment / GVW
ACEM	Stock, new registrations per fuel and engine capacity (only L-vehicles)
CO_2 monitoring database	New registrations per fuel and segment (PCs and LCVs)
EAFO (European Alternative Fuels Observatory)	Stock and new registrations of alternative fuels (LPG, CNG, electric, H_2)
NGVA Europe (Natural Gas Vehicle Association) NGV Global (Natural Gas Vehicle Knowledge Base)	Stock of natural gas vehicles
UNFCCC	Fuel consumption per vehicle category and fuel
Other sources: literature, studies, reports, national statistics web sites	Various information

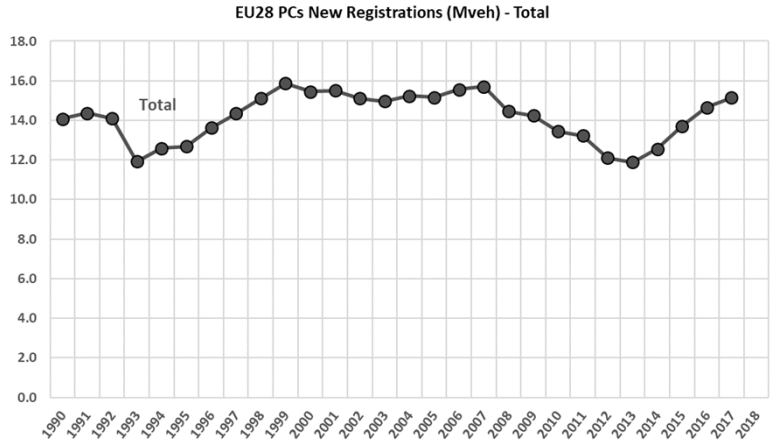
Synthesis of primary information

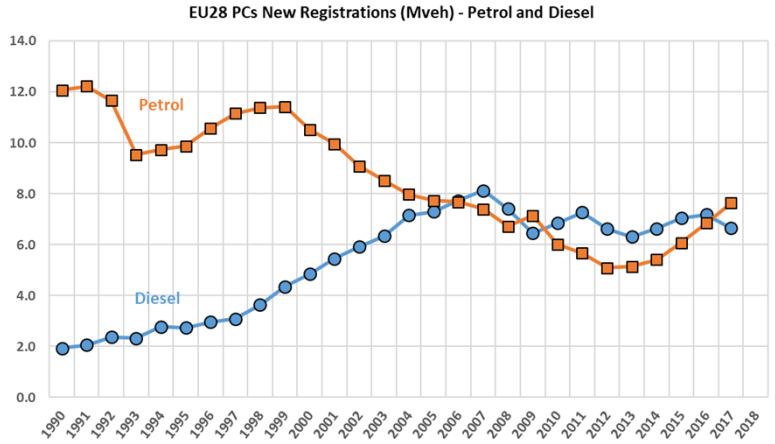
- **No single** source provides all data at the level of detail required
- **Gaps**, incomplete times series, whole countries/years missing
- **Inconsistent** information, values from different sources seldom agree
- **No** common vehicle **classification**, insufficient documentation

Summary of problems with statistical sources

A processing methodology is required in order to create a complete and consistent dataset with no gaps, harmonized with official statistical data, by synthesizing information from the various sources

EU28 passenger cars new registrations (1/2)



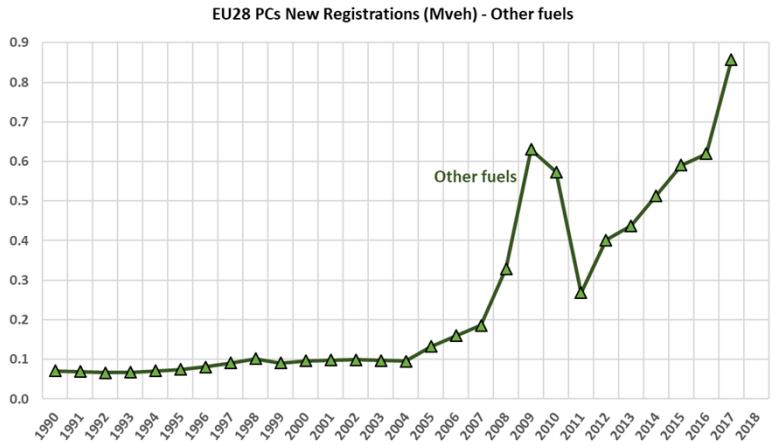


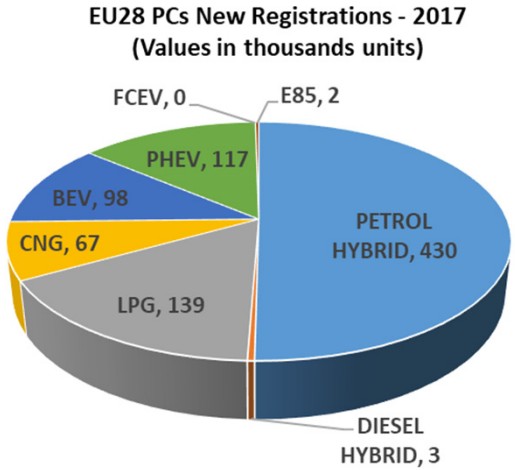
- **Total** sales of cars present the **"rebound effect"** in recent years, after the economic (and sales) crisis in the period 2008-2013 (**15.1M** vehicles sold in 2017)
- Sales of **petrol** continuous **increase** since 2012
  - From **5.1M** to **7.6M** vehicles (2012→2017)
- Sales of **diesel** first time **lower** than petrol in 2017 since 2010
  - **6.6M** vehicles in 2017

Percentage split in 2017:

- **50%** petrol
- **44%** diesel
- **6%** alternative fuels

EU28 passenger cars new registrations (2/2)



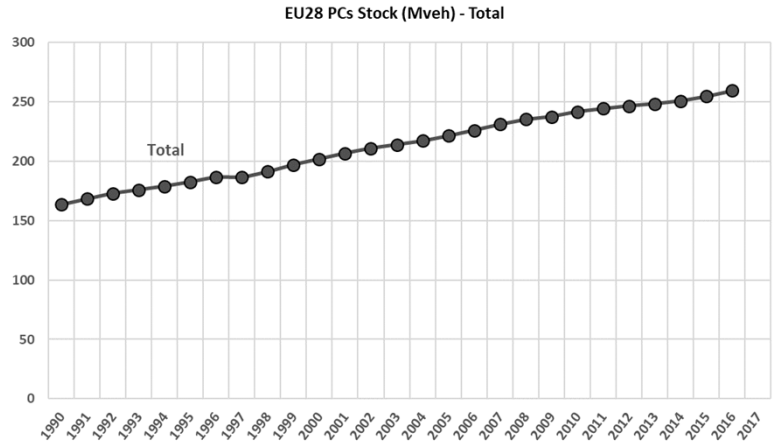


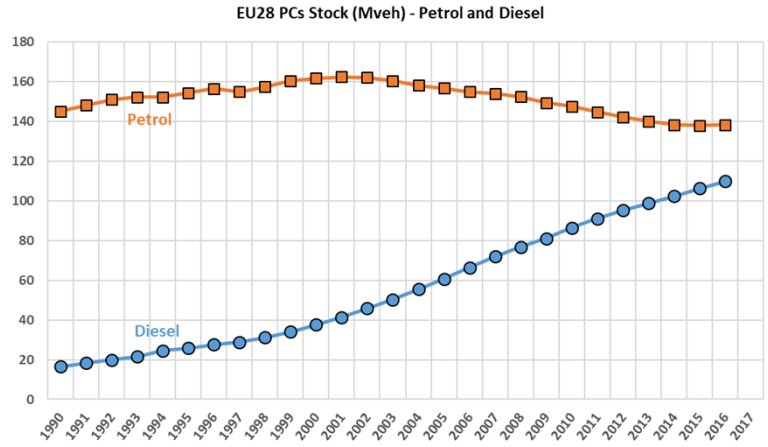
Alternative fuels

- Sales of cars with **alternative fuels** in 2017: **856k** vehicles (continuous **increase** since 2011)
- About **half** of them are **petrol hybrid** (**430k** vehicles)
- **LPG + CNG** : **206k** vehicles (**24%** of alternative fuels)
- **BEV + PHEV** : **215k** vehicles (**25%** of alternative fuels)

EU28 passenger cars stock

(1/2)





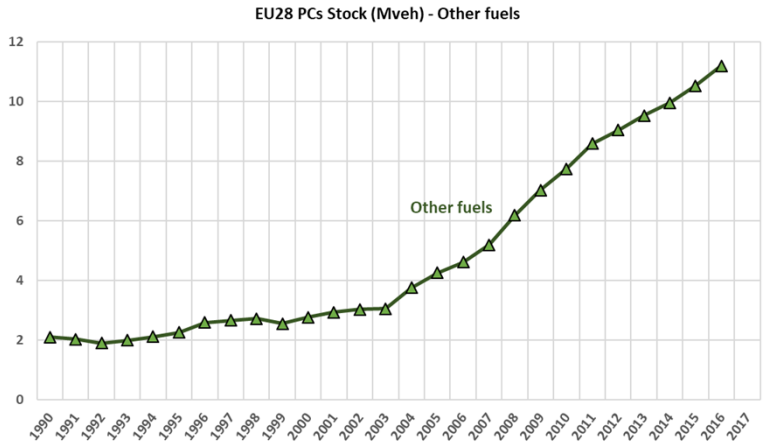
- **Total** stock of cars **increase** from **242M** to **259M** vehicles (2010→2016)
- Stock of **petrol constant** since 2014, after a continuous decrease period 2001→2014
  - **138M** vehicles in 2016
- Stock of **diesel** continuous increase since 1990
  - **110M** vehicles in 2016, still lower than petrol

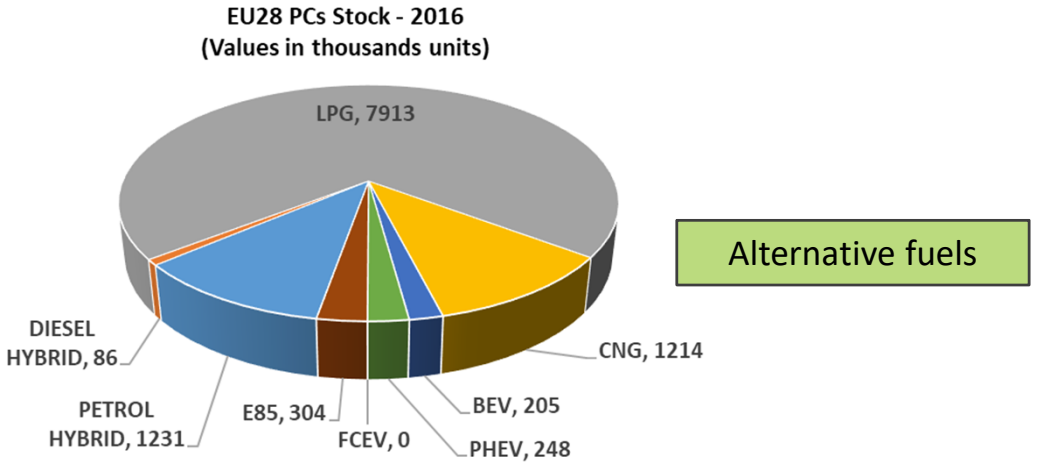
Percentage split in 2016:

- **53%** petrol
- **42%** diesel
- **5%** alternative fuels

EU28 passenger cars stock

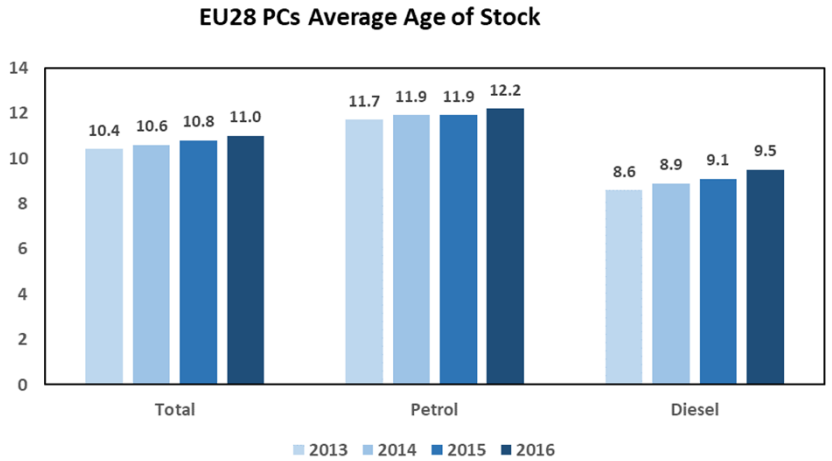
(2/2)





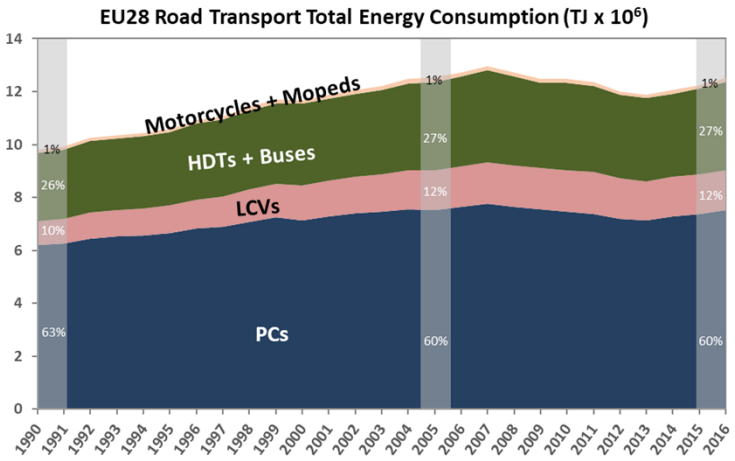
- Stock of cars with **alternative fuels** in 2016: **11.2M** vehicles (continuous **increase** trend)
- **Most** of them (**71%**) are **LPG** (many **conversions** from petrol, not all are actual new sales)
- **CNG**, **petrol hybrid** : **1.2M** vehicles each (**11%** of alternative fuels each)
- **BEV + PHEV** : **453k** vehicles (**4%** of alternative fuels)

EU28 passenger cars stock - average age

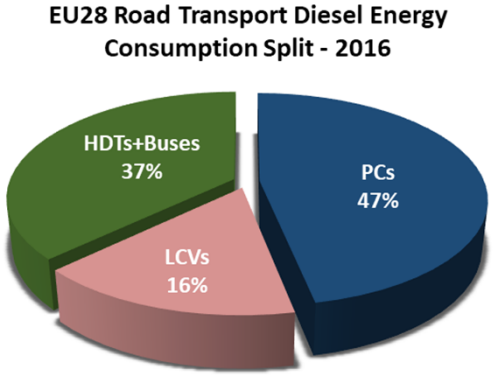


- Passenger cars fleet is getting **older** year by year (from **10.4** years in 2013 to **11** years in 2016)
- Many older vehicles **remain** in the fleet and are not deregistered → **impact** on the age distribution of the dataset (more vehicles in the age groups 10-20 and 20-30)
- **Petrol** fleet **older** than **diesel** fleet due to past sales patterns
  - **Sales** of diesel cars have increased significantly since 2000, compared to the 90's, while sales of petrol cars have declined from 2000 to 2012, hence, diesel fleet is **younger** than petrol fleet

EU28 road transport energy consumption



Total



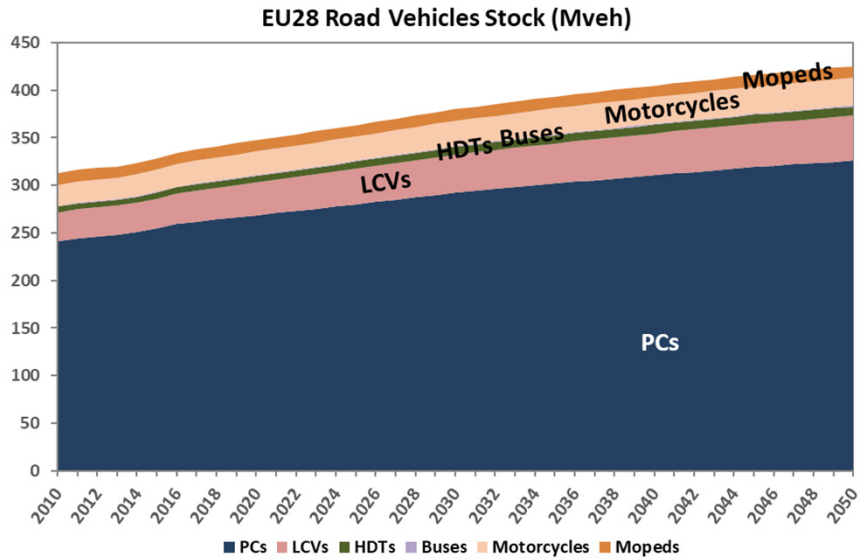
Diesel

- Despite a period of decline in 2008-2013, **total** energy consumption from road transport has **increased** again recently (12.5 x 10^6 TJ in 2016)
- Percentage split in 2016 (**no** significant **differences** over time)
  - **60%** PCs
  - **12%** LCVs
  - **27%** HDTs + Buses
  - **1%** Motorcycles + Mopeds

- Percentage split of **diesel** energy consumption in 2016
  - **47%** PCs
  - **16%** LCVs
  - **37%** HDTs + Buses

Projections

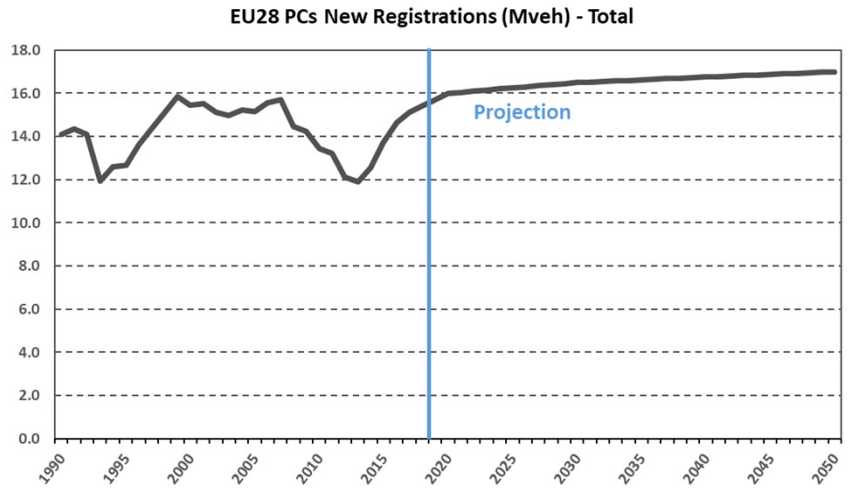
EU28 road vehicles stock development



2050 increase over 2015	
PCs	28%
LCVs	50%
HDTs	50%
Buses	21%
Motorcycles	25%
Mopeds	5%

- EU28 road vehicles **stock** projection exhibits a continuous **increase** from year to year (till 2050), following corresponding passenger and freight transport **activity** increase (EU REF2016)
- Although this increase may be **questionable**, the EU Reference Scenario is one of the EC's **key analysis tools** in the areas of energy, transport and climate action

EU28 passenger cars total sales projection



- EU28 passenger car sales per year from 1990 until now are between **12M** and **16M**
- Usually correlated to **GDP**, but still difficult to make **prediction** to 2050
- **Our approach:** following the "rebound effect" of recent years (after the 2008-2013 crisis), sales are projected to reach **16M** in 2020, **16.5M** in 2030, and **17M** in 2050
- This increase is also **in accordance** with the stock increase based on EU REF2016

EU28 PCs sales penetration of electric vehicles

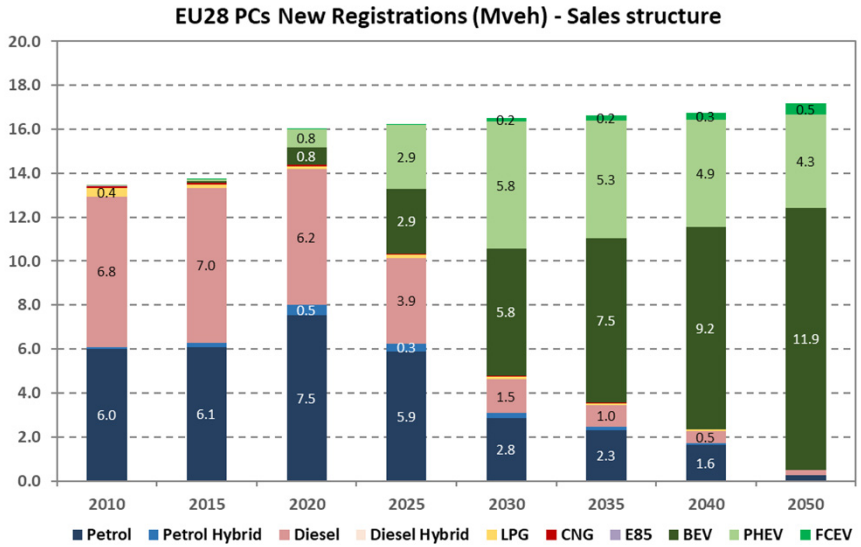
	2020	2025	2030	2035	2040	2050
BEV	5%	18%	35%	45%	55%	70%
PHEV	5%	18%	35%	32%	29%	25%
FCEV	0.0%	0.3%	1%	1.5%	2%	3%
Petrol	47.2%	36.3%	17.2%	13.9%	9.8%	1.6%
Diesel	38.6%	24.2%	9.3%	5.9%	3.3%	0.4%
LPG+CNG+E85+ Hybrid-petrol+ Hybrid-diesel	4.2%	3.2%	2.5%	1.7%	0.9%	0.0%

Relevant studies

- "The transition to a Zero Emission Vehicles fleet for cars in the EU by 2050", EAFO, EC DG MOVE, 2017
- "European Roadmap Electrification of Road Transport", ERTRAC, 2017

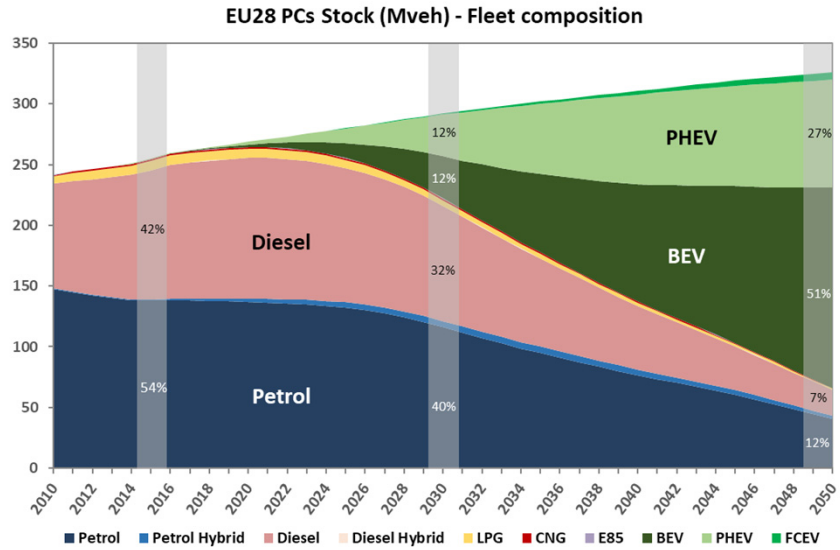
Our approach: electric vehicles increase their market share with a fashion **in-between** other scenarios, considered as **'boundary'** ones (e.g. there are more **conservative** scenarios compared to our approach and there are even more **aggressive** ones where electric vehicles replace 100% the ICE vehicles by 2035)

EU28 passenger cars sales structure projection



- Projected passenger car sales **structure** follows our assumptions on penetration of electric vehicles
- **11.6M BEV+PHEV** sales in 2030, increasing to **16.2M** in 2050
- **2.8M petrol** sales in 2030, declining to **<0.3M** in 2050
- **1.5M diesel** sales in 2030, declining to **<0.1M** in 2050

EU28 passenger cars fleet composition



- Our approach results in a **significant** number of electric vehicles in the **future** fleet
- **24%** BEV+PHEV in 2030, increasing to **78%** in 2050
- **76%** ICE vehicles in 2030, decreasing to **20%** in 2050 → ICE vehicles still **remain** in 2050

Thank you for your attention

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Backup slides

Related EC funded previous projects

The FLEETS project

European Database of Vehicle Stock for the Calculation and Forecast of Pollutant and Greenhouse Gases Emissions with TREMOVE and COPERT

EC / DG Environment

December 2006 – April 2008

LAT/AUTh, KTI, Renault, E3M-Lab/NTUA, Ökopol, Dr Zierock

Under the coordination of LAT/AUTH

Data cover the period **2000-2005**

The TRACCS project

Transport data collection supporting the quantitative analysis of measures relating to transport and climate change

EC / DG Climate Action

January 2012 – December 2013

emisia, INFRAS, IVL

Under the coordination of EMISIA

Data cover the period **2005-2010**

Vehicle categories and fuels (energy) considered

Vehicle category	EU classification	Petrol	Diesel	LPG	CNG	E85	Hybrid-petrol	Hybrid-diesel	BEV	PHEV	FCEV
Passenger cars	M1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Buses	M2, M3	✓	✓	✓	✓	-	-	-	✓	✓	-
Light commercial vehicles (vans)	N1	✓	✓	✓	✓	-	-	-	✓	-	-
Heavy duty trucks	N2, N3	✓	✓	✓	✓	-	-	-	-	-	-
Mopeds (two- and three-wheel)	L1, L2	✓	-	-	-	-	-	-	✓	-	-
Motorcycles (two-wheel and tricycles)	L3, L4, L5	✓	-	-	-	-	-	-	✓	-	-
Mini-cars (or micro cars) (on-road quads)	L6	-	✓	-	-	-	-	-	✓	-	-
ATVs (all-terrain vehicles and side-by-side buggies)	L7	✓	-	-	-	-	-	-	-	-	-

Disaggregation into segments

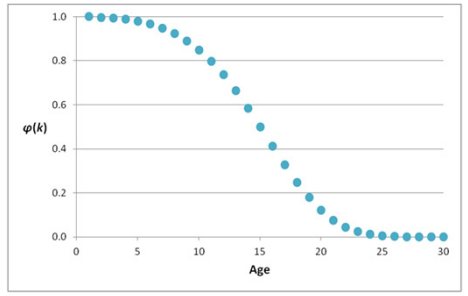
Vehicle category	Following COPERT / SIBYL segment subcategories
Passenger cars	➢ Small / Medium / Large-SUV-Executive
Buses	➢ Urban Buses: Midi <=15 t / Standard 15 - 18 t / Articulated >18 t ➢ Coaches: Standard <=18 t / Articulated >18 t
Light commercial vehicles	➢ N1-I / N1-II / N1-III
Heavy duty trucks	➢ Rigid: <=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
Mopeds	➢ 2-stroke <50 cm^3 / 4-stroke <50 cm^3
Motorcycles	➢ 2-stroke >50 cm^3 ➢ 4-stroke: <250 cm^3 / 250 - 750 cm^3 / >750 cm^3
Mini-cars / ATVs	-

Technology / Euro standards

Vehicle category	Following COPERT / SIBYL Euro standard subcategories
Passenger cars	➢ Conventional: PRE ECE, ECE 15/00-01, ECE 15/02, ECE 15/03, ECE 15/04, Improved Conventional, Open Loop ➢ Euro 1, 2, 3, 4, 5 ➢ Euro 6: up to 2016, 2017-2019, 2020+
Light commercial vehicles	➢ Conventional ➢ Euro 1, 2, 3, 4, 5 ➢ Euro 6: up to 2017, 2018-2020, 2021+ (or up to 2016, 2017-2019, 2020+ depending on the N1-subcategory)
Buses / Heavy duty trucks	➢ Conventional ➢ Euro I, II, III, IV, V, VI
Mopeds / Motorcycles / Mini-cars / ATVs	➢ Conventional ➢ Euro 1, 2, 3, 4, 5

Main steps for age distribution (total stock)

- First, an age distribution (0-30) for total stock has been created (for each vehicle category), so that average age is **consistent** with statistical data
  - Start with an estimation of the age distribution in **1990**
  - Following years were derived with **lifetime functions**, which model how vehicles are deregistered according to their age (e.g. an increasing age leads to an increased probability of breakdown)
    - *φ(k)*: probability that a vehicle will **survive** *k* years after its registration



Example of a lifetime function

  - Modifications in the age distribution, by internal 'transferring' of vehicles among age groups, so as to achieve **matching** with average age statistical
    - For example, a country with average age 14 years has more vehicles in the **age groups** 10-20 and 20-30 than in the age group 0-10, compared to a country with average age 9 years

Main steps for age distribution (fuels and segments)

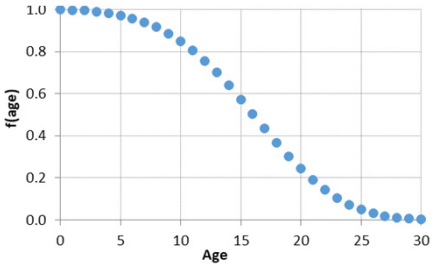
- Age distribution of total stock has been used as a 'guide' for age distribution per fuel and segment, taking into account **peculiarities** of individual sub-categories, e.g.
  - Many **LPG** vehicles are conversions from petrol ones, not actual sales (brand new vehicles)
  - **Electric** vehicles have entered into the fleet only recently, hence, their age distribution is completely different compared to conventional vehicles (e.g. petrol/diesel ones)
  - Differentiation among **petrol/diesel**: mostly driven by past sales patterns
    - For example, **sales** of diesel cars have increased significantly since 2000, compared to the 90's, while sales of petrol cars have declined from 2000 to 2012 (EU28)
    - As a result, the average age of diesel cars stock is **lower** compared to petrol ones in most countries and years → younger fleet (current situation, may change in the future)

From age distributions to Euro standards

- Technology **matrices** based on previous experience and related projects
  - Recent developments in **legislation** have been taken into account in all vehicle categories
- Vehicles are **allocated** to Euro (emission) standards based on their age distribution and technology matrices
- **Example**: petrol passenger cars
  - pre ECE — up to 1971
  - ECE 15/00-01 — 1972 to 1977
  - ECE 15/02 — 1978 to 1980
  - ECE 15/03 — 1981 to 1984
  - … — …
  - Euro 5 — 2010 to 2014
  - Euro 6 up to 2016 — 2015 to 2016
  - … — …

Typical mileage and vkm

- Mileage: average **annual** distance driven (km/year)
- **Typical** values for each vehicle category (previous experience and related projects)
- **Differentiated** by fuel, segment, and age
- **Examples** of general rules (differentiations may occur):
  - **Diesel** vehicles have higher mileage than petrol ones
  - Mileage **drops** as vehicles grow older, i.e., older vehicles are driven less than newer ones



Example of mileage as a function of age

- Fleet * mileage = **vkm** (total annual activity, vehicle-kilometers per year)
  - Some of the **older** vehicles (>25 years) may remain in the fleet (not deregistered), but their mileage (hence, contribution to activity) is very small (or even negligible)

Other activity parameters

- **Estimates** based on previous experience and related projects
- Need to be **reasonable**, but not exact ('soft' data, higher uncertainty)
- Example of typical values for travelling **speeds** and **shares** of activity of passenger cars in various driving modes (differentiations may occur):

Mode	Speed	Share
Urban	25-35 km/h	35%
Rural	60-70 km/h	35%
Highway	90-100 km/h	30%

Statistical fuel consumption

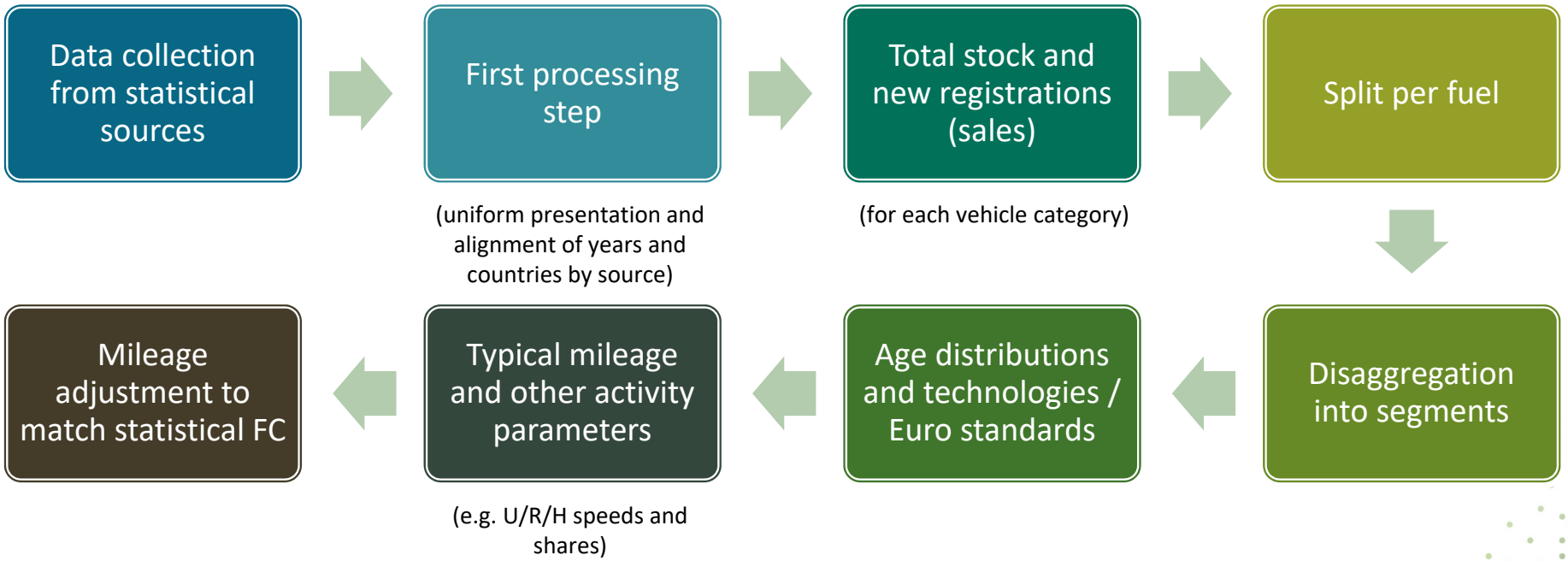
- Obtained from national **inventory** submissions in UNFCCC (also compared with Eurostat)
- Used to **adjust** mileage to match the calculated with statistical fuel consumption
- From 2015 UNFCCC submission, **split** per vehicle category: cars, light duty trucks, heavy duty trucks and buses, motorcycles
- **Problems** that had to be addressed in some countries:
  - Fuel consumption provided only as total (no split to vehicle categories)
  - Fuel consumption reported under passenger cars category only
  - LPG/biomass provided only as total (no split to vehicle categories)
  - Fuel consumption of cars and light duty trucks reported under passenger cars category only

Splits made based on other countries' data

- **Biomass** had to be split to biodiesel and bioethanol in all countries

Based on Eurostat

Flowchart of dataset creation



Main steps for stock and new registrations

Comparison of sources; one of them is selected as the main source to start with (based on data quantity and quality)

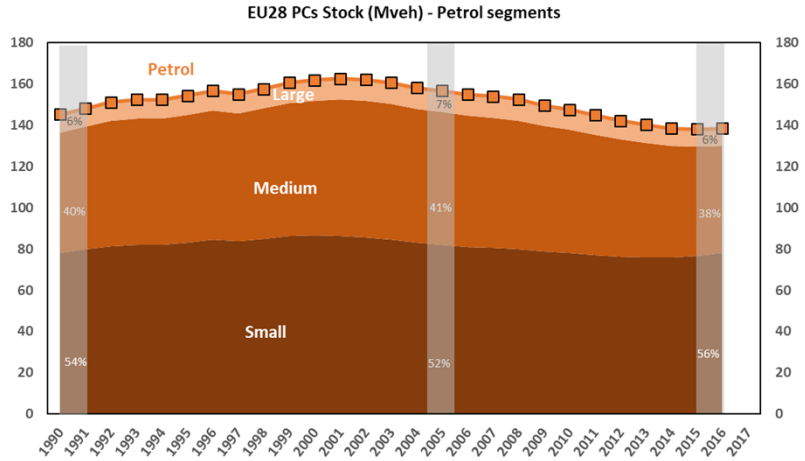
Gap-filling from other sources; attention for inconsistencies (e.g. trend instead of absolute value in case of significant differences between sources)

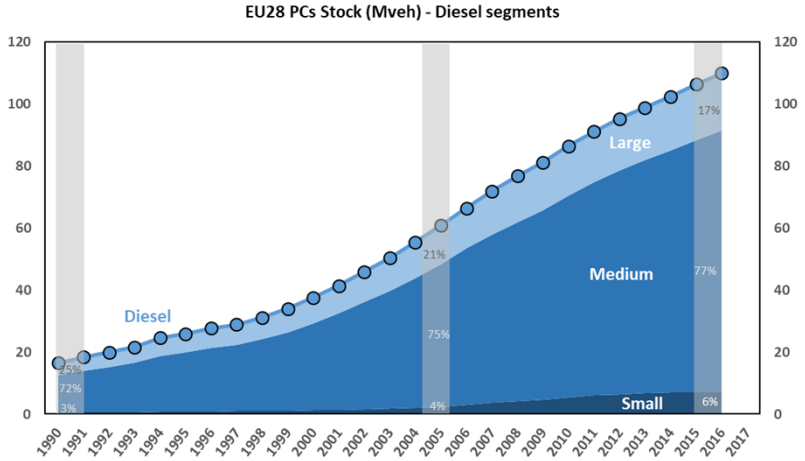
If gaps still exist, then: interpolation, trend or data from other countries (e.g. percentages for split/disaggregation), estimates and expert judgement calculations

Checking rules, e.g. all fuels add up to total, all segments of a fuel add up to this specific fuel, no negative values, percentages add up to 100%, etc.

- Total (for each vehicle category)
- Split per fuel
- Disaggregation into segments

EU28 passenger cars stock - segments





- The segmentation of **petrol** cars stock **does not** alter significantly over time
- Percentage split in 2016:
  - **56%** small
  - **38%** medium
  - **6%** large

- In **diesel** cars there has been a **small shift** from large to medium and small vehicles
- Percentage split in 2016:
  - **6%** small
  - **77%** medium
  - **17%** large

Main parameters to consider

Evolution of total stock and new registrations (sales)

Survival rates (i.e. lifetime functions and age distribution)

Penetration of alternative fuels and, especially, electric vehicles in the market

Stock evolution per fuel and segment

Uncertainties

- Large **uncertainty** in all main parameters
- A single dataset **cannot** cover all possible developments
- Our **baseline** projection has been created taking into account
  - The **historical** trends in fleet turnover dynamics
  - Relevant **studies**
- The **impact** of different scenarios can be investigated with the sibyl tool
  - For example, road transport **electrification** is considered to significantly contribute towards EU environmental targets
  - Hence, it is interesting to predict the impact of different **penetration** scenarios

Our approach for the projections

EU Reference Scenario
REF2016/PRIMES total activity trends used to derive total stock projections per vehicle category (assumption: future vehicles will be driven as much as today's ones)

Total new registrations (sales) per vehicle category are estimated based on historical trends

Age distribution for total stock is derived with lifetime functions, respecting total stock change from year-to-year and new registrations (smooth transition from historical to future data)

Penetration of alternative fuels and, especially, electric vehicles in the market is estimated based on relevant studies

Survival rates (i.e. lifetime functions) of total stock are used as a 'guide' to derive age distributions per fuel and segment

Stock evolution per fuel and segment is derived from corresponding survival rates and new registrations

Summary

- In 2018, EMISIA has performed a **major** update in the vehicle fleet and activity road transport dataset, taking into account all recent statistical data
- **34 countries** (EU28, EFTA, FYROM, TR), **1990-2050** time series
- Reliable data with ensured **quality**, **completeness**, and **consistency**; can be used in air pollutant and GHG emission calculation tools
- **Historical** data harmonized with official national statistical data, so as to reflect real situation to the extent possible
- **Projections** based on activity evolution as agreed in high-level EU policy related studies; penetration of electric vehicles one of the most critical parameters