FINAL REPORT

Update and further development of transport model TREMOVE

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I Introduction

This final report describes the work done in the TREMOVE update project for the European Commission, DG ENV.

TREMOVE is a policy assessment model, designed to study the effects of different transport and environment policies in the European transport sector. The model estimates transport demand, modal shifts and vehicle stock renewal as well as emissions of air pollutants and welfare level for policies such as road pricing, public transport pricing, emission standards, subsidies for cleaner cars, and others. TREMOVE covers the period 1995-2030 and models both passenger and freight transport, for EU27, CH, NO, TR and HR.

Three main tasks were identified by the Commission:

1. To update the input database for TREMOVE, building on the outcomes of the FLEETS and EX-TREMIS projects, and other recent studies, reports and research literature (chapters II – IV). This about updating data of the past to allow for accurate projections of the future.
2. To formulate a new baseline scenario until the year 2030 based on the updated data and TREMOVE model development as much as possible in line with its involvement in the iTREN-2030 project (chapter V). In this chapter, the basic assumptions for the projections from 2006 on are presented.
3. To include 4 sensitivity runs for both scenarios(chapter VI).

The data update has been completed, while some issues still remain in the scenario development. A detailed note on these issues will be drafted as soon as possible. As a result, while all preparations have been made, the sensitivity runs have not yet been executed.

Additional to the tasks above, an update of the TREMOVE maritime model was performed (chapter VII).

II Vehicle stock updates: Road mode with FLEETS

II.1. Data update

II.1.1. Vehicle stock

Two major steps have been taken to introduce the updated vehicle stock in the model. The first step was to collect data from the FLEETS project for the 31 countries. The data structure of FLEETS follows the same structure as COPERT 4 and similar structure to TREMOVE. No data restructuring was needed in this first step although it was aggregated in 17 major subcategories.

Table 1: Vehicle subcategories (aggregated data)

Gasoline Passenger cars	G<1,4
	G1,4-2
	G>2
Diesel Passenger Cars	D<2
	D>2
LPG Passenger Cars	PCLPG
Gasoline Light Duty Vehicles	LDG
Diesel Light Duty Vehicles	LDD
Rigid Heavy Duty Vehicles	HDVR
Articulated Heavy Duty Vehicles	HDVA
Buses	Buses
Coaches	Coaches
Mopeds	Mopeds
2 stroke Motorcycles	Mot2T
4 stroke Motorcycles	Mot<250
	Mot<250-750
	Mot>750

Data existed for most countries and vehicle categories from year 1990 to 2005. Table 2 and Table 3 describe in detail the years for which data was available per country and vehicle category.

Table 2: First year for which data is available from the FLEETS project

	G<1,4	G1,4-2	G>2	D<2	D>2	PCLPG	LDG	LDD	HDVR	HDVA	Buses	Coaches	Mopeds	Mot2T	Mot<250	Mot<250-750	Mot>750
AT	1990	1990	1990	1990	1990		1991	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990
BE	1990	1990	1990	1990	1990	1990	1992	1990	1990	1990	1994	1990	1990	1990	1990	1990	1990
CH	1990	1990	1990	1990	1990		1990	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990
CZ	1993	1993	1993	1994	1994	1993	1993	1993	1993	1993	1993	1994	1993	1993	1993	1993	1993
DE	1990	1990	1990	1990	1990		1995	1995	1995	1995	1990	1990	1995	1991	1990	1990	1990
DK	1990	1990	1990	1991	1990	1992	1990	1990	1991	1990	1990	1990	1991	1990	1990	1990	1990
ES	1990	1990	1990	1990			1990	1990	1990	1990	1991	1990	1990	1990	1990	1990	1990
FI	1990	1990	1990	1990	1990		1990	1990	1990	1991	1990	1990	1995	1990	1991	1990	1991
FR	1990	1990	1990	1990	1990	1993	1995	1990	1990	1990	1990	1990	1990	1990	1993	1990	1990
GR	1995	1995	1995	1995	1995	1995	1995	1995	1995	1995	1994	1994	1990	1996	1996	1996	1996
HU	1990	1990	1990	1990	1990	1990	2000	2000	2000	2000	1990	1990	2000	2000	2000	2000	2000
IE	1990	1990	1990	1990	1990		1991	1991	1991		1990	1990	1991		1990	1990	1999
IT	1990	1990	1990	1990	1990	1990	1995	1995	1995	1995	1991	1990	1990	1993	1990	1990	1990
LU	1990	1990	1991	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990		1990	1990	1990
NL	1990	1990	1990	1990	1990	1991	1995	1994	1993	1993	1990	1990	1990	1990	1990	1990	1990
NO	1990	1990	1990	1990	1990		1990	1990	1990	1990	1990		1990	1995	1990		
PL	1990	1990	1990	1990	1990	1990	1992	1992	1992	1992	1992	1992	1995	1994	1994	1994	1994
PT	1990	1990	1990	1990	1990	1990		1990	1990	1990	1990	1990	1990	1990	1990	1990	1990
SE	1990	1990	1990	1990	1990		1990	1990	1990	1990	1990	1990	1990	1998	1990	1990	1990
SI	1991	1990	1990	1992	1990		1993	1993	1993	1993	1990	1990		1998	1995	1990	1995
UK	1990	1991	1992	1990	1990		1995	1995	1995	1995	1995	1995	1995	1995	1995	1995	1995
EE	1999	1999	1999	1999	1999		1999	1999	1999	1999	1999	1999			1999	1999	1999
CY	1990	1990	1990	1990	1990		1990	1990	1990	1990	1990	1990	1990		1990	1990	1990
LV	1990	1990	1990	1990	1990	1990	1993	1990	1992		1990	1990	1990		1990	1990	1990
LT	1990	1990	1990	1990	1990	1990	1992	1992	1992	1992	1990	1990		1998	1997	1995	1995
MT	1990	1990	1990	1990	1990		1990	1990	1990	1990	1993	1993	2000		1990	1990	1990
SK	1990	1990	1990	1990	1990	1991	1990	1990	1990	1990	1995	1993	1997	2003	1990	1990	1990
BG	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990
HR	1998	1998	1998	1998	1998	1998	1999	1999	1999	1999	1998	1998	1998	1998	1998	1998	1998
RO	1990	1990	1990	1990	1990	1990	1994	1994	1994	1994	1990	1990	1990	1990	1990	1990	1990
TR	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993

Table 3: Last year for which data is available from the FLEETS project

	G<1,4	G1,4-2	G>2	D<2	D>2	PCLPG	LDG	LDD	HDVR	HDVA	Buses	Coaches	Mopeds	Mot2T	Mot<250	Mot<250-750	Mot>750
AT	2005	2005	2005	2005	2005		2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
BE	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
CH	2005	2005	2005	2005	2005		2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
CZ	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
DE	2005	2005	2005	2005	2005		2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
DK	2005	2005	2005	2005	2005	2001	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
ES	2005	2005	2005	2005			2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
FI	2005	2005	2005	2005	2005		2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
FR	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
GR	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
HU	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
IE	2005	2005	2005	2005	2005		2005	2005	2005		2005	2005	2005		2005	2005	2005
IT	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	1995	2005	2005	2005
LU	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005		2005	2005	2005
NL	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
NO	2005	2005	2005	2005	2005		2005	2005	2005	2005	2005		2005	2005	2005		
PL	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004
PT	2005	2005	2005	2005	2005	2005		2005	2005	2005	2005	2005	2003	2005	2005	2005	2005
SE	2005	2005	2005	2005	2005		2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
SI	2005	2005	2005	2005	2005		2005	2005	2005	2005	2005	2005		2005	2005	2005	2005
UK	2005	2005	2005	2004	2004		2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
EE	2005	2005	2005	2005	2005		2005	2005	2005	2005	2005	2005			2005	2005	2005
CY	2005	2005	2005	2005	2005		2005	2005	2005	2005	2005	2005	2005		2005	2005	2005
LV	2005	2005	2005	2005	2005	2005	2005	2005	2005		2005	2005	2005		2005	2005	2005
LT	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005		2005	2005	2005	2005
MT	2005	2005	2005	2005	2005		2005	2005	2005	2005	2005	2005	2000		2005	2005	2005
SK	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
BG	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
HR	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
RO	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005
TR	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005

Data for Germany have been reviewed according to the latest TREMOD version. Some differences still remain due to the different vehicle classification in TREMOD and TREMOVE. A further refinement of the data is still possible however this takes time and would delay the preparation of the baseline. It was hence decided to accept the small differences between TREMOVE and German national data at this point and expect a perfect refinement at a subsequent version of TREMOVE.

Data was available for total vehicle fleet as well as new registrations. No gap filling was done at this point; additional information was required to complete the time series. This was done in the following steps.

II.1.2. Lifetime parameters

To complete the necessary data to update the vehicle stock module in TREMOVE an additional step was performed. TREMOVE requires the age distribution for all vehicle categories. To calculate the age distribution one needs to have the survival probability of all vehicle categories. Such data was available in the current version of TREMOVE but when combined with the existing updated population major differences occurred. This lead to an updated calculation of the parameters of the lifetime functions. The flowchart describing the methodology used to calculate the values used to update TREMOVE is shown in Figure 1.

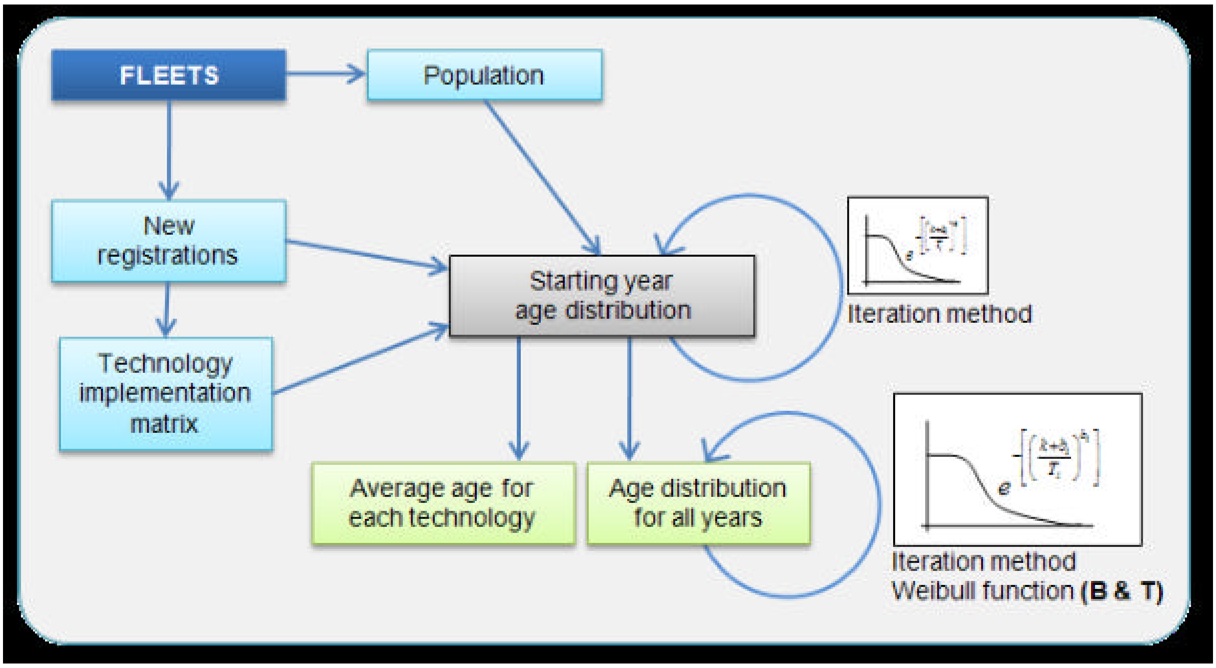

Figure 1: Flowchart describing the methodology used to calculate the lifetime parameters

The survival probability is based on the Weibull function (Eq 1). The parameters of this function were calculated based on the available population data originating from FLEETS.

$$j_i(k) = \exp - \left[\left(\frac{k + B_i}{T_i} \right)^{b_i} \right] \qquad \text{Eq 1}$$

- k — age, expressed in years (k = 0 ¸ 29)
- ji(k) — probability of vehicle type i to be older than age k
- Bi — failure rate for vehicle type i (bi > 1, rate is increasing each year)
- Ti — lifetime of vehicle type i

To estimate the Weibull parameters an iterative method was used consisting of 3 steps. The aggregation level of the calculation was the 17 subcategories already defined in the previous section.

The first step was to create the technology implementation matrix based on the FLEETS data. This matrix displays the years which each vehicle technology (pre-Euro, Euro I etc) is introduced in the fleet. Where data was incomplete the legislation was taken into account to generate the complete dataset. An example of a technology implementation matrix can be found in Table 4.

Table 4: Technology implementation matrix for Germany

Sector	Subsector	Technology	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Passenger Cars	Gasoline <1,4 l	PRE ECE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	ECE 15/02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	ECE 15/03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	ECE 15/04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	Improved Conventional	0,2	0,2	0,2	0,2	0	0,06	0	0	0	0	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	Open Loop	0,37	0,37	0,37	0,37	0	0,07	0	0	0	0	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	PC Euro I - 91/441/EEC	0,43	0,43	0,43	0,43	1	0,87	1	1	0,76	0,5	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	PC Euro II - 94/12/EEC	0	0	0	0	0	0	0	0	0,24	0,5	0,89	0,4	0,11	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	PC Euro III - 98/69/EC Stage2000	0	0	0	0	0	0	0	0	0	0	0,11	0,59	0,73	0,61	0,33	0,28	0,21	0,18	0,15
Passenger Cars	Gasoline <1,4 l	PC Euro IV - 98/69/EC Stage2005	0	0	0	0	0	0	0	0	0	0	0	0,01	0,16	0,39	0,67	0,72	0,79	0,82	0,85
Passenger Cars	Gasoline <1,4 l	PC Euro V (post 2005)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The second step was to estimate the age distribution for the first year of the calculations (1990 or later). The age distribution is the percentage of vehicles of the subcategory X (e.g. Gasoline Passenger Cars <1,4l) of a specific age Y in a specific year (1990). Total vehicles and new registrations (vehicles of age=0) for this subcategory were taken from the FLEETS database. For the remaining age categories we used a sigmoid function similar to the Weibull function. In order to find which function best describes the first year, we estimated an initial set of function parameters and calculated the age distribution. By applying the technology implementation matrix the technology distribution was created for this year and checked against data coming from the FLEETS database. This process was repeated as many times as needed to achieve the best fit between the calculated data and data coming from the database. Table 5 shows such a comparison for the two datasets.

Table 5: Comparison between calculated data and FLEETS data for year 1990

Subsector	Technology	Calculated Data	Fleets Data
Gasoline <1,4 l	PRE ECE	0,0	186.508,2
Gasoline <1,4 l	ECE 15/00-01	107.109,9	0,0
Gasoline <1,4 l	ECE 15/02	945.820,8	990.811,4
Gasoline <1,4 l	ECE 15/03	2.069.253,2	2.797.758,4
Gasoline <1,4 l	ECE 15/04	1.096.643,1	858.562,7
Gasoline <1,4 l	Improved Conventional	690.259,4	599.554,8
Gasoline <1,4 l	Open Loop	1.276.979,8	1.093.880,4
Gasoline <1,4 l	PC Euro I - 91/441/EEC	1.484.057,6	1.143.047,9
Gasoline <1,4 l	PC Euro II - 94/12/EEC	0,0	0,0
Gasoline <1,4 l	PC Euro III - 98/69/EC Stage2000	0,0	0,0
Gasoline <1,4 l	PC Euro IV - 98/69/EC Stage2005	0,0	0,0
Gasoline <1,4 l	PC Euro V (post 2005)	0,0	0,0

The third step was to calculate the age distribution for the following years up to 2005. By applying the Weibull function, one can estimate the possibility a vehicle of an age Y to "survive" to the following year. Having a complete distribution for the first year it was possible to calculate data for the following years. New registrations were calculated for each year by subtracting vehicles of age greater than 0 from the total fleet. The 5 passenger cars subcategories new registrations were compared against the CO_2 Monitoring database[1]. New registration population used to calculate the Weibull parameters was substituted by the values included in the CO_2 Monitoring database. To ensure that the total fleet for the specific year would remain the same the rest of the age distribution values were changed proportionally. Table 6 shows the age distribution for the first 5 years in France for Gasoline Passenger Cars <1,4l.

[1] http://ec.europa.eu/environment/air/transport/co2/co2_monitoring.htm

Table 6: Age distribution for France Passenger cars <1,4 l, 1990 (first year) - 1994

YEAR		1990	1991	1992	1993	1994
Number of vehicles		**12.996.311**	**12.889.167**	**12.386.949**	**12.262.063**	**12.098.201**
Deregistrations calc			**605.583**	**664.323**	**716.099**	**762.236**
New registrations calc		**819.906**	**498.438**	**162.105**	**591.213**	**598.374**
Age distribution						
0	6,31%	819.906	498.438	162.105	591.213	598.374
1	7,44%	966.381	815.762	495.919	161.285	588.225
2	7,44%	966.284	958.341	808.975	491.793	159.944
3	7,43%	966.055	954.316	946.471	798.955	485.701
4	7,43%	965.533	949.397	937.860	930.150	785.178
5	7,42%	964.384	943.441	927.674	916.401	908.868
6	7,40%	961.935	936.144	915.814	900.509	889.566
7	7,36%	956.878	926.886	902.034	882.446	867.698
8	7,28%	946.752	914.468	885.805	862.055	843.334
9	7,13%	927.128	896.648	866.073	838.927	816.434
10	6,85%	890.520	869.447	840.863	812.190	786.733
11	6,35%	825.498	826.243	806.690	780.170	753.567
12	5,52%	717.784	757.153	757.836	739.902	715.578
13	4,29%	557.351	650.291	685.958	686.577	670.330
14	2,74%	355.535	498.348	581.449	613.341	613.894
15	1,25%	162.070	313.487	439.410	512.683	540.802
16	0,32%	41.969	140.804	272.353	381.753	445.412
17	0,03%	4.254	35.897	120.434	232.951	326.524
18	0,00%	93	3.579	30.203	101.331	196.001
19	0,00%	0	77	2.960	24.978	83.800
20	0,00%	0	0	62	2.404	20.286
21	0,00%	0	0	0	50	1.916
22	0,00%	0	0	0	0	39
23	0,00%	0	0	0	0	0

By applying the technology implementation matrix for all years we derived the technology distribution. In order to find the best function that delivers the data coming from FLEETS, both datasets were compared (calculated and FLEETS data). The whole process was then repeated by changing the Weibull factors (B and T) and recalculating the technology distribution. When an optimal solution was met the iteration was interrupted and the Weibull function and parameters were fixed.

This method was applied to all 31 countries and for all 17 vehicle categories. Table 7 shows such a comparison for the two datasets.

Table 7: Comparison between calculated data and FLEETS data for years 1990-1997 (France)

FLEETS data			**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Passenger Cars	Gasoline <1,4 l	PRE ECE	390.558	188.730	10	9	8	7	6	5
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	744.396	815.304	857.192	709.886	594.494	470.925	201.977	10
Passenger Cars	Gasoline <1,4 l	ECE 15/02	3.313.847	2.907.951	2.463.718	2.112.869	1.716.074	1.321.860	1.112.628	986.313
Passenger Cars	Gasoline <1,4 l	ECE 15/03	4.950.052	4.597.888	4.007.706	3.824.660	3.595.234	3.271.369	2.796.766	2.497.186
Passenger Cars	Gasoline <1,4 l	ECE 15/04	3.597.458	4.379.294	5.058.323	5.302.660	5.202.606	5.066.399	4.886.324	4.746.058
Passenger Cars	Gasoline <1,4 l	Improved Conventional	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	Open Loop	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	PC Euro I - 91/441/EEC	0	0	0	311.979	989.786	1.731.000	2.580.024	3.006.501
Passenger Cars	Gasoline <1,4 l	PC Euro II - 94/12/EEC	0	0	0	0	0	0	0	311.995
Passenger Cars	Gasoline <1,4 l	PC Euro III - 98/69/EC Stage2000	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	PC Euro IV - 98/69/EC Stage2005	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	PC Euro V (post 2005)	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	All	12.996.311	12.889.167	12.386.949	12.262.063	12.098.201	11.861.561	11.577.724	11.548.069
Calculated Data			**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Passenger Cars	Gasoline <1,4 l	PRE ECE	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	1.121.273	1.042.037	927.983	805.549	689.931	582.946	485.948	399.783
Passenger Cars	Gasoline <1,4 l	ECE 15/02	2.433.803	2.233.687	2.025.243	1.812.600	1.600.107	1.392.104	1.192.677	1.005.442
Passenger Cars	Gasoline <1,4 l	ECE 15/03	3.792.693	3.607.449	3.399.432	3.171.190	2.926.207	2.668.782	2.403.841	2.136.698
Passenger Cars	Gasoline <1,4 l	ECE 15/04	5.648.543	6.005.994	6.034.291	6.183.030	5.995.352	5.772.621	5.515.159	5.224.629
Passenger Cars	Gasoline <1,4 l	Improved Conventional	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	Open Loop	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	PC Euro I - 91/441/EEC	0	0	0	289.694	886.604	1.445.108	1.980.099	2.444.895
Passenger Cars	Gasoline <1,4 l	PC Euro II - 94/12/EEC	0	0	0	0	0	0	0	336.622
Passenger Cars	Gasoline <1,4 l	PC Euro III - 98/69/EC Stage2000	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	PC Euro IV - 98/69/EC Stage2005	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	PC Euro V (post 2005)	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1,4 l	All	12.996.311	12.889.167	12.386.949	12.262.063	12.098.201	11.861.561	11.577.724	11.548.069

By obtaining the Weibull parameters, it is possible to calculate population data missing from the database by forecasting from the last year of available data up to 2005, as well as the average age of all vehicle technologies for each year and country. For example, the FLEETS database includes data for Poland up to 2004, so by using the Weibull parameters for Poland data for year 2005 was calculated.

Data structure however is not completely consistent with the TREMOVE input database, so minor restructuring was necessary. Diesel passenger cars in FLEETS database are split into two categories (<2l and >2l), while TREMOVE uses three (<1,4 l, 1,4-2, >2). To split the <2l category in two separate, new registrations data from the CO_2 Monitoring database for small diesel vehicles were extracted. By using the Weibull function parameters for diesel passenger cars <2l, the age distribution for the small diesel vehicles was calculated. This data was then proportionally subtracted from the diesel passenger cars <2l to formulate the new vehicle category data.
Also, FLEETS include 2 vehicle categories for BUSES (Buses and Coaches) while TREMOVE input database only 1 (Buses). For this reason these 2 categories were aggregated into one by adding the corresponding population data.
Regarding heavy duty trucks, FLEETS database uses the COPERT 4 vehicle categories which are different than the ones used in TREMOVE since the model still uses the older COPERT III categorization. To deliver data in the required format COPERT 4 methodology describes in detail the way to transform the heavy duty vehicle population from the COPERT III to the COPERT 4 categorization. By reversing this methodology, data was restructured and delivered in the TREMOVE input database.
As an example, data (age distribution and Weibull parameters) delivered for Germany in the format used by the TREMOVE input database can be found in the following tables (Table 8, Table 9).

Table 8: TREMOVE age distribution data for Germany (Gasoline Passenger Cars <1,4l), T_VEHICLE_AGE_PARAMETER table in the input database file

Country	Year	Veh	Age	Name	Value
DE	2005	G<1,4	0	RSTNBY	703.396
DE	2005	G<1,4	1	RSTNBY	603.974
DE	2005	G<1,4	2	RSTNBY	661.753
DE	2005	G<1,4	3	RSTNBY	659.526
DE	2005	G<1,4	4	RSTNBY	33.693
DE	2005	G<1,4	5	RSTNBY	719.699
DE	2005	G<1,4	6	RSTNBY	846.794
DE	2005	G<1,4	7	RSTNBY	632.413
DE	2005	G<1,4	8	RSTNBY	594.978
DE	2005	G<1,4	9	RSTNBY	532.492
DE	2005	G<1,4	10	RSTNBY	0
DE	2005	G<1,4	11	RSTNBY	634.919
DE	2005	G<1,4	12	RSTNBY	1.045.969
DE	2005	G<1,4	13	RSTNBY	1.143.641
DE	2005	G<1,4	14	RSTNBY	406.201
DE	2005	G<1,4	15	RSTNBY	1.239.869
DE	2005	G<1,4	16	RSTNBY	353.481
DE	2005	G<1,4	17	RSTNBY	326.121
DE	2005	G<1,4	18	RSTNBY	298.116
DE	2005	G<1,4	19	RSTNBY	269.788
DE	2005	G<1,4	20	RSTNBY	241.358
DE	2005	G<1,4	21	RSTNBY	212.898
DE	2005	G<1,4	22	RSTNBY	184.259
DE	2005	G<1,4	23	RSTNBY	155.053
DE	2005	G<1,4	24	RSTNBY	124.743
DE	2005	G<1,4	25	RSTNBY	4.797
DE	2005	G<1,4	26	RSTNBY	0
DE	2005	G<1,4	27	RSTNBY	0
DE	2005	G<1,4	28	RSTNBY	0
DE	2005	G<1,4	29	RSTNBY	0
DE	2005	G<1,4	30	RSTNBY	0

Table 9: TREMOVE data for Germany – Weibull parameters, VEHICLE_PARAMETER table in the input database file

Country	Veh	Name	Value		Country	Veh	Name	Value
DE	BUS	paraB	3,0		DE	BUS	paraT	19,4
DE	HTD1	paraB	1,0		DE	HTD1	paraT	9,2
DE	HTD2	paraB	2,4		DE	HTD2	paraT	10,8
DE	HTD3	paraB	3,5		DE	HTD3	paraT	11,9
DE	HTD4	paraB	5,6		DE	HTD4	paraT	14,3
DE	LTD	paraB	15,8		DE	LTD	paraT	29,6
DE	LTG	paraB	7,8		DE	LTG	paraT	22,6
DE	MC1	paraB	1,0		DE	MC1	paraT	14,6
DE	MC2	paraB	13,8		DE	MC2	paraT	35,8
DE	MC3	paraB	13,8		DE	MC3	paraT	28,6
DE	MC4	paraB	13,6		DE	MC4	paraT	27,6
DE	MP	paraB	0,8		DE	MP	paraT	13,2
DE	PCDB	paraB	2,0		DE	PCDB	paraT	10,2
DE	PCDM	paraB	3,6		DE	PCDM	paraT	15,4
DE	PCDS	paraB	3,6		DE	PCDS	paraT	15,4
DE	PCGB	paraB	9,6		DE	PCGB	paraT	22,4
DE	PCGM	paraB	3,6		DE	PCGM	paraT	21,4
DE	PCGS	paraB	3,4		DE	PCGS	paraT	24,6
DE	PCL	paraB	4,0		DE	PCL	paraT	10,0
DE	VAND	paraB	15,8		DE	VAND	paraT	29,6
DE	VANG	paraB	7,8		DE	VANG	paraT	22,6

II.1.3. Mileage parameters

FLEETS also delivered annual mileage data for a number of countries. This data however included the mileage dependency to the age of the vehicle so it was necessary to calculate the dependency of the mileage to the vehicle age F $_m$(age) as well as the reference mileage M_o (mileage of e new vehicle), according to Eq 2.

$$\Phi_m(age) = \exp - \left[\left(\frac{Age + B_m}{T_m} \right)^{B_m} \right] \qquad \textbf{\textit{Eq 2}}$$

Finally Eq 3 combines the two elements and calculates the mileage as a function of the vehicle age.

$$M(age) = Mo \cdot \Phi_m(age) \qquad \textbf{\textit{Eq 3}}$$

The flowchart describing the methodology used to calculate the values used to update TREMOVE is shown in Figure 2.

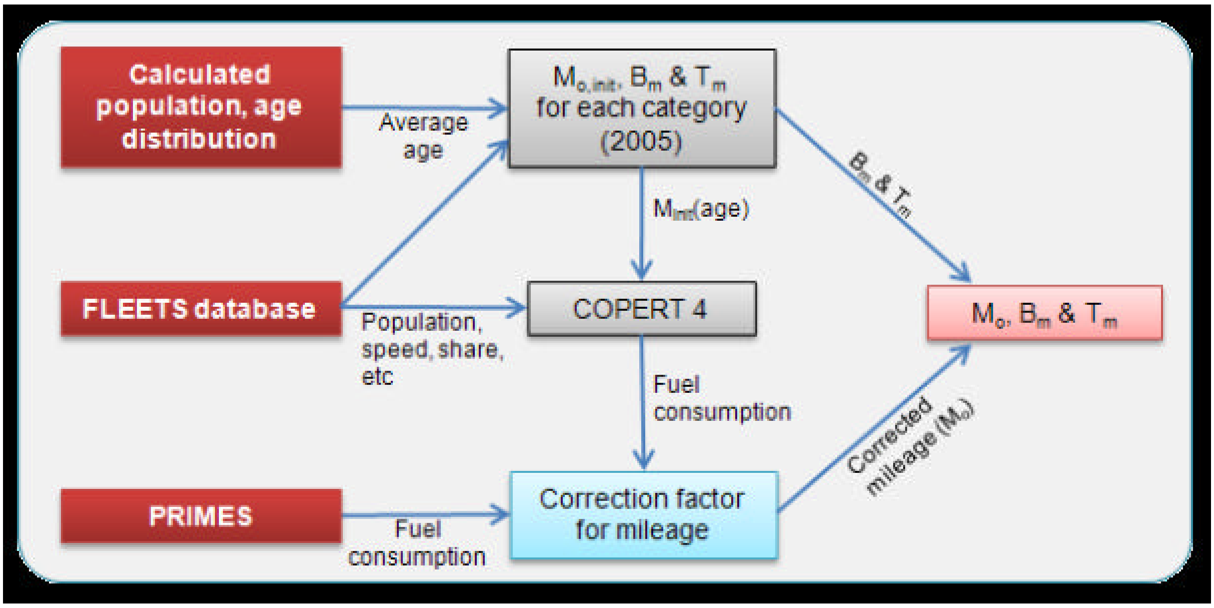

Figure 2: Flowchart describing the methodology used to calculate the mileage parameters

To calculate the initial reference mileage $M_{o,init}$, we used the average age calculated in the previous steps with the mileage given directly from FLEETS. Table 10 shows the two sets of data for Germany. By using a linear regression method we calculated the correlation between then two sets of data and hence the best linear equation that describes them.

$$M_{init}(age) = a \cdot age + b$$

By setting Age=0 we get the reference mileage $M_{o,init}$ for this vehicle category.

Table 10: Average age (calculated data) and annual mileage (FLEETS data) for Germany – Year 2005

			2005	
Sector	**Subsector**	**Technology**	**Average Age**	**Annual Mileage**
Passenger Cars	Gasoline <1,4l	PRE ECE		
Passenger Cars	Gasoline <1,4l	ECE 15/00-01		
Passenger Cars	Gasoline <1,4l	ECE 15/02	25,0	5.163
Passenger Cars	Gasoline <1,4l	ECE 15/03	22,3	6.127
Passenger Cars	Gasoline <1,4l	ECE 15/04	19,5	7.287
Passenger Cars	Gasoline <1,4l	Improved Conventional	15,5	6.993
Passenger Cars	Gasoline <1,4l	Open Loop	15,6	7.252
Passenger Cars	Gasoline <1,4l	PC Euro I - 91/441/EEC	12,9	14.090
Passenger Cars	Gasoline <1,4l	PC Euro II - 94/12/EEC	7,8	10.783
Passenger Cars	Gasoline <1,4l	PC Euro III - 98/69/EC Stage2000	4,9	11.603
Passenger Cars	Gasoline <1,4l	PC Euro IV - 98/69/EC Stage2005	2,1	12.695
Passenger Cars	Gasoline <1,4l	PC Euro V (post 2005)		

A linear function does not however describe in the best way the correlation between the average mileage and the vehicle age. For this reason, equation Eq 2 was used. By using MS Excel Solver we calculated which parameters (B_m, T_m) best describe the F_m(age) function (Annual Mileage/$M_{o,init}$).

Table 11: Values used to calculate the B_m and T_m parameters

			2005				
Sector	**Subsector**	**Technology**	**Average Age**	**Annual Mileage**	**a**	**b = Mo,init**	**Annual Mileage/Mo,init = Fm**
Passenger Cars	Gasoline <1,4 l	PRE ECE					
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01					
Passenger Cars	Gasoline <1,4 l	ECE 15/02	25,0	5.163			0,387
Passenger Cars	Gasoline <1,4 l	ECE 15/03	22,3	6.127			0,459
Passenger Cars	Gasoline <1,4 l	ECE 15/04	19,5	7.287			0,546
Passenger Cars	Gasoline <1,4 l	Improved Conventional	15,5	6.993	-339	13.344	0,524
Passenger Cars	Gasoline <1,4 l	Open Loop	15,6	7.252			0,543
Passenger Cars	Gasoline <1,4 l	PC Euro I - 91/441/EEC	12,9	14.090			1,056
Passenger Cars	Gasoline <1,4 l	PC Euro II - 94/12/EEC	7,8	10.783			0,808
Passenger Cars	Gasoline <1,4 l	PC Euro III - 98/69/EC Stage2000	4,9	11.603			0,870
Passenger Cars	Gasoline <1,4 l	PC Euro IV - 98/69/EC Stage2005	2,1	12.695			0,951
Passenger Cars	Gasoline <1,4 l	PC Euro V (post 2005)					

In order to provide a value for the reference mileage for each category, we used the fuel consumption from PRIMES (2007 runs). A COPERT 4 run was prepared including all the calculated and statistical data (Population, Mileage, vehicle speeds, driving mode share etc) and fuel consumption was calculated aggregated in two categories (gasoline and diesel). This was compared against PRIMES data and a correction factor was calculated (PRIMES/COPERT 4). This correction factor was then applied to the initial reference mileage ($M_{o,init}$) providing the corrected value (M_o). This reference mileage value is expected to change during the TREMOVE calibration procedure, as TREMOVE will not be calibrated to PRIMES data. However, only the M_o values will have to change and not the mileage function parameters (B_m and T_m) which will not be changed by the model calculations.

Since the FLEETS database does not include a complete set of annual mileage data for all countries, generic values based on some countries were calculated. The countries that provided data for each of the 17 vehicle categories can be found in table Table 12.

Table 12: Countries and vehicle categories which contain sufficient information to calculate own parameters, that was later used to calculate the generic values

Countries	AT	BE	BG	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HR	HU	IE	IT	LT	LU	LV	MT	NL	NO	PL	PT	RO	SE	SI	SK	TR	UK
Gasoline <1,4 l				X				X				X					X										X				X
Gasoline 1,4 - 2,0 l				X			X	X			X	X					X										X				X
Gasoline >2,0 l				X			X	X			X	X					X										X				X
Diesel <2,0 l				X			X	X			X	X					X										X				X
Diesel >2,0 l				X			X	X			X	X					X										X				X
LPG Cars												X					X														
Gasoline LDV <3,5t				X			X				X	X					X										X				X
Diesel LDV <3,5 t				X			X				X	X					X										X				X
Heavy Duty Rigid				X			X				X	X					X										X				X
Heavy Duty Articulated				X			X				X	X					X										X				X
Urban Buses				X			X				X	X															X				X
Coaches				X			X				X	X															X				X
Mopeds				X			X																								
2-stroke >50 cm³							X				X																X				
4-stroke <250 cm³				X			X				X						X					X					X				
4-stroke 250 - 750 cm³				X			X										X					X					X				
4-stroke >750 cm³				X			X				X						X					X					X				

Generic data was used as is or with minor modifications based on the countries individual characteristics. The countries for which this data was used can be found in Table 13.

Table 13: Countries and vehicle categories for w hich generic data was used

Countries	AT	BE	BG	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HR	HU	IE	IT	LT	LU	LV	MT	NL	NO	PL	PT	RO	SE	SI	SK	TR	UK
Gasoline <1,4 l	X	X	X		X	X	X		X	X	X		X	X	X	X		X	X	X	X	X		X	X	X		X	X	X	
Gasoline 1,4 - 2,0 l	X	X	X		X	X			X	X			X	X	X	X		X	X	X	X	X		X	X	X		X	X	X	
Gasoline >2,0 l	X		X		X	X			X	X			X	X	X	X		X	X	X	X	X		X	X	X		X	X	X	
Diesel <2,0 l	X	X	X		X	X			X	X				X	X	X		X	X	X	X	X		X	X	X		X	X	X	
Diesel >2,0 l	X	X	X		X	X			X	X				X	X	X		X	X	X	X	X		X	X	X		X	X	X	
LPG Cars	X	X	X	X	X	X	X	X	X	X	X			X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Gasoline LDV <3,5t		X	X		X	X			X					X	X			X	X	X	X	X		X	X	X		X	X	X	
Diesel LDV <3,5 t	X	X	X		X	X			X	X				X	X			X	X	X	X	X		X	X	X		X	X	X	
Heavy Duty Rigid		X	X			X		X	X	X			X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	
Heavy Duty Articulated		X	X			X		X	X	X			X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	
Urban Buses		X	X		X	X			X	X			X	X	X			X	X	X	X	X		X	X	X		X	X	X	
Coaches		X	X		X	X			X	X				X	X			X	X	X	X	X	X	X	X	X		X	X	X	
Mopeds																	X										X				
2-stroke >50 cm³				X													X					X									
4-stroke <250 cm³																															
4-stroke 250 - 750 cm³																															
4-stroke >750 cm³																															

Where no clear indication for the correlation between the vehicle age and the mileage could be substantiated the B_m and T_m factors were set equal to zero and M_o was used independent of vehicle age. Countries and vehicle categories with this characteristic can be found in Table 14.

Table 14: Countries and vehicle categories with no clear indication of a correlation between vehicle age and annual mileage

Countries	AT	BE	BG	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HR	HU	IE	IT	LT	LU	LV	MT	NL	NO	PL	PT	RO	SE	SI	SK	TR	UK
Gasoline <1,4 l																							X								
Gasoline 1,4 - 2,0 l																							X								
Gasoline >2,0 l		X																					X								
Diesel <2,0 l													X										X								
Diesel >2,0 l													X										X								
LPG Cars													X																		
Gasoline LDV <3,5t	X							X		X			X			X							X								
Diesel LDV <3,5 t								X					X			X							X								
Heavy Duty Rigid	X				X																										
Heavy Duty Articulated	X				X																										
Urban Buses	X							X								X	X						X								
Coaches	X							X					X			X	X														
Mopeds	X	X	X		X	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X
2-stroke >50 cm³	X	X	X		X	X		X	X	X		X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X
4-stroke <250 cm³	X	X	X		X	X		X	X	X		X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X
4-stroke 250 - 750 cm³	X	X	X		X	X		X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X
4-stroke >750 cm³	X	X	X		X	X		X	X	X		X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X

Data for the mileage calculations follow a slightly different structure than the current TREMOVE database file. An update on the model code and input database will be needed. A sample of the data delivered is shown in Table 15.

Table 15: TREMOVE mileage data for Germany

Sector	Subsector	M_o	B_m	T_m
Passenger Cars	Gasoline <1,4 l	14.762,7	1,67	22,80
Passenger Cars	Gasoline 1,4 - 2,0 l	15.452,7	1,16	26,74
Passenger Cars	Gasoline >2,0 l	15.689,4	1,16	25,93
Passenger Cars	Diesel <1,4 l	23.179,2	1,62	15,36
Passenger Cars	Diesel 1.4-2.0l	23.179,2	1,62	15,36
Passenger Cars	Diesel >2,0 l	22.770,8	1,65	15,09
Passenger Cars	car - LPG	15.452,7	4,52	14,58
Light Duty Vehicles	Light duty truck - Gasoline	33.835,0	1,85	11,41
Light Duty Vehicles	Light duty truck - Diesel	25.764,7	1,86	12,22
Vans	Van - Gasoline	33.835,0	1,85	11,41
Vans	Van - Diesel	25.764,7	1,86	12,22
Heavy Duty Trucks	Heavy duty truck >32t - diesel	55.022,7	1,04	17,71
Heavy Duty Trucks	Heavy duty truck 16-32t - diesel	55.022,7	1,04	17,71
Heavy Duty Trucks	Heavy duty truck 3.5-7.5t - diesel	119.467,4	1,71	10,46
Heavy Duty Trucks	Heavy duty truck 7.5-16t - diesel	119.467,4	1,71	10,46
Buses	Urban Buses Midi <=15 t	46.082,9	1,40	22,32
Buses	Coaches Standard <=18 t	64.410,4	0,87	38,27
Mopeds	50 cm³	3.370,3	1,07	54,82
Motorcycles	2-stroke >50 cm³	4.245,2	1,27	14,72
Motorcycles	4-stroke <250 cm³	5.183,2	1,50	28,11
Motorcycles	4-stroke 250 - 750 cm³	5.390,8	1,24	21,51
Motorcycles	4-stroke >750 cm³	5.437,6	1,83	17,02

II.1.4. Emission factors

TREMOVE 2.7b, the last public version, contains a beta version of the current COPERT IV methodology. Given the very minor differences between the beta and the final version, no update was made.

II.1.5. Taxes and prices

II.1.5.1. Registration & other taxes

Registration taxes and ownership taxes have been updated for TREMOVE version 3.1, in the course of the JRC-IPTS project J02/38/2007. Following tax updates were performed under this contract (quoted from Vanherle K. et al, "Modelling of the Impacts of Policies for Sustainable Use of Cars", Final report, 29/01/2009):

"

- **Registration tax (TREMOVE parameters: RRegTX)**: Since both policy simulations concern taxation, an update of the taxes in TREMOVE can be interesting for this project. Special focus is given to the registration tax as both feebate tax and scrappage subsidy will be allocated to registration tax for modeling and reporting purposes. The latest registration tax data in TREMOVE was provided in the TREMOVE 2 development program in 2003. Recent research by [Kunert, 2007] and the ACEA tax guide [ACEA, 2007] provided input for the update. For most countries, the TREMOVE data was confirmed. However, for some countries data was updated. These were mostly new member states. Registration tax values differ a lot between countries, e.g. DK has a registration tax which is on average almost equal to the purchase cost while others have no registration tax at all (e.g. DE, FR). Also, the calculation methodology can be very different; some countries apply a registration tax flat rate or as a function of vehicle cost or engine size. Some countries partly use differentiated CO_2-registration tax (like NL). To avoid problems with the feebate simulation, in these cases an average value was set as input.

- **Other taxes components (TREMOVE parameters: RINSTXfix, RINSTXrate, RFTAX_COMP, ROWNTX)**: although less important than registration tax, also ownership tax, insurance tax, fuel tax and VAT rate where revised. Only for ownership tax there were some updates needed. The same observations are valid for ownership tax as for registration tax."

II.1.5.2. LPG fitting cost

From another project, data were obtained from AEGPL (European LPG association) on LPG fitting cost. In older TREMOVE versions, the cost was set at 1,750€ for all countries. The LPG fitting cost that is used in v3.3 ranges from 600€ in Romania to 3000€ in France.

II.1.5.3. Fuel prices and taxes

In iTREN-2030, fuel prices were updated using input from the POLES model. As an added input for the current TREMOVE update, an extract from the IEA database was provided, with real pump prices up to 2008.

These updated fuel prices for gasoline, diesel and LPG were included in the baseline. For biofuels, the methodology of previous versions was continued: the end-user price of fossil and biofuels is made equal through the tax component (excise duties/subsidies) for compatible fuels (gasoline-ethanol and diesel-biodiesel).

II.2. Model update

This section describes the changes that were required to make the model compatible with the new data for road.

II.2.1. Vehicle sales logit

The vehicle sales logit was recalibrated to account for the updated vehicle fleet, and now reflects sales of the year 2005. Fuel price, discussed above, taxes, from version 3.1, and GDP, changed based on the iT-REN project (cfr. infra) were also updated in the calibration procedure.
The output was a modified set of dummies for each country.
These values were modified in table COUNTRY_PARAMETER of the input DB.

II.2.2. Model code

The previous TREMOVE version 2.7b contained a number of work-arounds to account for missing vehicle stock data for some countries. With road stock updated until 2005, these corrections were no longer needed. While most of the conditions to activate these workarounds were checked automatically during the model run, even with the new vehicle fleet data one was found to remain active. By deactivating the file *Init_Missing_Road_Stock_Data.gms*, this was rectified.

III Vehicle stock updates: rail mode with EX-TREMIS

III.1. Data update

This chapter describes the new rail transport data now integrated in TREMOVE. Largely resulting from datasets of the EX-TREMIS database, the new tables have been also built around the collection of new data for those countries not covered in EX-TREMIS, namely CH, NO, HR and TR. Data collection and gap filling methodologies have been the same of those developed in EX-TREMIS, thus using principally EUROSTAT, UIC and national statistics to build consistent time-series according to observed data of train, service and energy type distributions.

An additional effort was made in order to provide the TREMOVE model with reliable data concerning high speed (HS) rail transport The developed approach for each of the needed HS datasets is described in the next paragraphs.

The new datasets have been adapted to the model input parameters and tables, thus replacing the old input datasets. In the following, the new input tables are presented together with a description of the step-by-step process applied.

III.1.1. Tractive stock

Tractive stock consistency (in thousand units) for the time span 1980-2030 is now available in TREMOVE for the covered 29 countries[2] (reference table: T_TRAIN_FRPA_PARAMETER).

A reference Excel file named "Metadata EX-TREMIS+" has been created to show the observed/calculated cells and references for each country according to the provided distribution of the fleet, that is by train type (locomotive, railcar, high-speed train) and energy type (diesel, electric).

Consistency of high speed trains (HST) has been integrated in the new table for the whole time span according to the year of entry into service for new purchased units as well as the collected information about scrapped trains and new orders (in EX-TREMIS this units were only reported from 2005 on). UIC publication "World High Speed Rolling Stock" issued in November 2008 and available on the UIC's website, was the main reference for this exercise. In order to recalibrate the EX-TREMIS time-series, the number of HSTs has modified original passenger railcar or locomotive figures depending on the trainset formula (i.e. motor coach + trailer or locomotive + trailer).

The following steps were made in order to modify and adapt the original EX-TREMIS dataset:

1. All → new time-series for HSTs;

[2] Cyprus and Malta have no railways.

2. UK → Diesel high-speed trains are now defined as a separate category for UK due to their importance in the country's HS traffic distribution; Diesel HST were introduced in 1980 whereas Electric HST were introduced in 1989;

3. UK → consistency of Electric and Diesel Railcars and Diesel Locomotives was modified from 1995 to 2005 according to a more consistent distribution over categories; projections up to 2030 were also consistently modified;

4. DE → consistency of Electric Railcars was modified for the years 2001 and 2002.

Another task was related to the collection of data related to the 4 countries not included in EX-TREMIS: CH, NO, HR and TR (see sources in file *Metadata EXTREMIS+.xls*[3]). The projection of the number of vehicles by fuel and vehicle type for these countries was made using annual growth rates taken from TREMOVE 2.7 for the same countries. The applied growth rates are reported in the following table:

Table 16: Growth rates for the extrapolation of tractive stock data for CH, HR, NO and TR

	% 2010/2005	% 2015/2010	% 2020/2015	% 2025/2020	% 2030/2025
CH					
passenger high speed train	0.4%	0.7%	0.7%	0.5%	0.3%
passenger locomotive electric	0.4%	0.7%	0.7%	0.5%	0.3%
passenger railcar electric	0.4%	0.7%	0.7%	0.5%	0.3%
freight locomotive diesel	6.1%	-1.0%	-0.3%	0.0%	0.0%
freight locomotive electric	5.3%	-1.0%	-0.3%	-0.2%	0.0%
HR					
passenger locomotive diesel	8.7%	3.0%	3.0%	2.9%	2.7%
passenger railcar diesel	8.1%	3.0%	3.0%	2.9%	2.7%
passenger locomotive electric	8.9%	3.0%	3.0%	2.9%	2.7%
passenger railcar electric	9.2%	3.0%	3.0%	2.9%	2.7%
freight locomotive diesel	2.3%	2.2%	2.6%	1.8%	1.4%
freight locomotive electric	2.3%	2.2%	2.6%	1.8%	1.4%
NO					
passenger locomotive diesel	0.3%	0.2%	0.1%	0.1%	0.2%
passenger railcar diesel	0.3%	0.2%	0.1%	0.1%	0.2%
passenger high speed train	0.3%	0.2%	0.1%	0.1%	0.2%
passenger locomotive electric	0.3%	0.2%	0.1%	0.1%	0.2%
passenger railcar electric	0.3%	0.2%	0.1%	0.1%	0.2%
freight locomotive diesel	2.5%	0.8%	1.3%	0.5%	0.5%
freight locomotive electric	1.8%	0.8%	1.3%	0.5%	0.5%
TR					

[3] The file *Metadata EXTREMIS+.xls* contains historical summary tables (years 1980-2005) of data collected from official sources about rolling stock and train-km by train type and energy for all TREMOVE countries (Switzerland, Croatia, Norway and Turkey included).

passenger locomotive diesel	6.1%	9.9%	9.5%	8.5%	6.0%
passenger railcar diesel	7.8%	9.9%	9.5%	8.5%	6.0%
passenger locomotive electric	4.1%	9.9%	9.5%	8.5%	6.0%
passenger railcar electric	4.0%	9.9%	9.5%	8.5%	6.0%
freight locomotive diesel	3.8%	4.9%	4.6%	4.1%	3.7%
freight locomotive electric	-1.0%	4.9%	4.6%	4.1%	3.7%

A new input table was also created to split tractive stock consistency by age (T_TRAIN_FRPA_AGE_PARAMETER).

We used the rail stock AGE distribution from UIC data (2005 statistics), which consists of 5 age classes (<1970, 1970-79, 1980-89, 1990-99 and >=2000). The last class was transformed in classes 2000-2002 and post2003.

The years considered for the calculation of a per-year distribution (assuming uniform distributions within each class) are those reported in the following table:

4	10	10	10	3	3	Years
<1970	1970-1979	1980-1989	1990-1999	2000-2002	post2003	AGE classes

This distribution is consistent with the assumption of tractive stock to be scrapped every 40 years.

The age distribution is not a variable and we assume to remain constant over time.

III.1.2. Transport activity

Transport activity, in terms of performed train-km (in millions of v-km by type of train, energy an service) over the railway networks of the covered 29 countries in TREMOVE, is reported in the new input table T_TRAIN_PARAMETER (years 1980-2030).

The following steps and activities were performed:

1. Comparison of trains-km from TREMOVE 2.7 to the original EX-TREMIS database.

   As an example, the following table reports differences between EX-TREMIS and TREMOVE 2.7 concerning train-km in two years: 1995 and 2005 for the available countries. Considering the new provision of more observed data by the EX-TREMIS database, the model is now more calibrated over consistent figures over time.

Table 17: Comparison of trains-km between TREMOVE 2.7 and EX-TREMIS in 1995 and 2005

Country	1995			2005		
	1000trains-km TREMOVE 2.7	1000trains-km EX-TREMIS	% EX-TREMIS / TREMOVE 2.7	1000trains-km TREMOVE 2.7	1000trains-km EX-TREMIS	% EX-TREMIS / TREMOVE 2.7
AT	132 246	131 030	-1%	148 467	143 845	-3%
BE	88 093	88 056	0%	104 599	94 175	-10%
BG	59 730	47 578	-20%	36 166	34 823	-4%
CZ	158 665	158 771	0%	143 133	146 036	2%
DE	855 747	856 014	0%	823 768	986 686	20%
DK	58 092	57 850	0%	61 972	67 409	9%
EE	7 882	7 882	0%	9 231	8 951	-3%
ES	161 178	161 073	0%	242 942	195 301	-20%
FI	40 981	40 973	0%	54 151	48 227	-11%
FR	450 579	450 580	0%	509 022	499 259	-2%
GR	18 126	18 108	0%	17 828	17 729	-1%
HR	20 497	20 497	0%	23 955	26 064	9%
HU	93 577	93 570	0%	82 915	96 012	16%
IE	14 397	14 383	0%	17 322	18 597	7%
IT	325 149	325 047	0%	385 601	371 876	-4%
LT	16 700	16 700	0%	14 022	14 325	2%
LU	7 220	7 208	0%	6 114	7 672	25%
LV	18 870	18 870	0%	18 378	18 476	1%
NL	119 657	131 158	10%	190 810	125 250	-34%
PL	281 208	281 192	0%	256 281	207 060	-19%
PT	37 211	37 199	0%	46 186	37 675	-18%
RO	98 670	122 369	24%	67 701	97 961	45%
SE	100 343	100 345	0%	115 061	127 323	11%
SI	19 037	19 083	0%	17 198	19 759	15%
SK	64 115	64 115	0%	46 994	47 291	1%

2. Collection and calibration of new train-km figures for the countries not covered in EX-TREMIS: CH, NO, HR and TR (see sources in file *Metadata EXTREMIS+.xls*);

3. Comparison of data against TREMOVE 2.7 for CH, NO, HR and TR (see the table below);

Table 18: Comparison of a new train-km of the countries not included in the original EX-TREMIS database to TREMOVE 2.7 data in 1995 and 2005

Country	1995			2005		
	1000trains-km TREMOVE 2.7	**1000trains-km EX-TREMIS**	**% EX-TREMIS / TREMOVE 2.7**	**1000trains-km TREMOVE 2.7**	**1000trains-km EX-TREMIS**	**% EX-TREMIS / TREMOVE 2.7**
CH	7 523	116 800	1453%	7 523	165 550	2101%
NO	36 580	36 568	0%	36 580	40 628	11%
TR	41 936	43 355	3%	44 985	44 933	0%
UK	410 946	465 600	13%	541 697	590 403	9%

4. Projections of train-km by train and energy type for CH, NO, HR and TR. The estimation was made using annual mean rates taken from TREMOVE 2.7 for the same countries. Rates are reported in the following table:

Table 19: Growth rates for the extrapolation of trains-km

	% 2010/2005	**% 2015/2010**	**% 2020/2015**	**% 2025/2020**	**% 2030/2025**
CH					
freight locomotive diesel	6.40%	-1.00%	-0.30%	0.10%	0.00%
freight locomotive electric	5.60%	-1.00%	-0.30%	-0.10%	0.00%
passenger high speed train	0.40%	0.70%	0.70%	0.50%	0.30%
passenger locomotive electric	0.40%	0.70%	0.70%	0.50%	0.30%
passenger railcar electric	0.40%	0.70%	0.70%	0.50%	0.30%
HR					
passenger locomotive diesel	8.40%	3.00%	3.00%	2.90%	2.70%
passenger railcar diesel	7.80%	3.00%	3.00%	2.90%	2.70%
passenger locomotive electric	8.60%	3.00%	3.00%	2.90%	2.70%
passenger railcar electric	9.00%	3.00%	3.00%	2.90%	2.70%
freight locomotive diesel	2.30%	2.20%	2.60%	1.80%	1.40%
freight locomotive electric	2.30%	2.20%	2.60%	1.80%	1.40%
NO					
passenger locomotive diesel	0.30%	0.20%	0.10%	0.10%	0.20%
passenger railcar diesel	0.30%	0.20%	0.10%	0.10%	0.20%
passenger high speed train	0.30%	0.20%	0.10%	0.10%	0.20%
passenger locomotive electric	0.30%	0.20%	0.10%	0.10%	0.20%
passenger railcar electric	0.30%	0.20%	0.10%	0.10%	0.20%
freight locomotive diesel	2.60%	0.80%	1.30%	0.50%	0.50%
freight locomotive electric	2.00%	0.80%	1.30%	0.50%	0.50%
TR					
passenger locomotive diesel	7.40%	9.90%	9.50%	8.50%	6.00%

passenger railcar diesel	9.10%	9.90%	9.50%	8.50%	6.00%
passenger locomotive electric	5.40%	9.90%	9.50%	8.50%	6.00%
passenger railcar electric	5.30%	9.90%	9.50%	8.50%	6.00%
freight locomotive diesel	4.20%	4.90%	4.60%	4.10%	3.70%
freight locomotive electric	-0.70%	4.90%	4.60%	4.10%	3.70%

5. Passenger High Speed train-km estimation

For the new TREMOVE version the number of train-km performed by high-speed trains was required. Unfortunately, EX-TREMIS made no estimations for such a kind of traffic. A specific estimation was carried out for those countries where high-speed rail services already exist or new lines are in construction or already planned.

Some countries (i.e. railway operators) may own HS trainsets but have no HS dedicated lines in their network (speed >250 km/h). This is the case of Slovenia, Portugal, Norway, Czech Republic and Sweden in EX-TREMIS. According to the need of linking figures to real HS services, the estimation took into consideration the evolution of lines or section of lines upon which operation speed is higher than 250 km/h. The information concerning the lines in operation, in construction and planned, together with the year of service opening has been drawn from Barrón (2008), "*High Speed lines in the World*" – UIC High Speed Department – Updated 04 June 2008 (available on UIC's website).

When specific information concerning the year of service opening was not available for some planned lines, we assumed the new section to be built in 10 or 5 years depending on the line length, then distributing remaining km from the last year of service opening on. The evolution of High-Speed lines is therefore available for the time interval 1980-2030 as reported in the next figures for those countries for which HS lines were detected, i.e. BE, FR, DE, IT, NL, PL, PT, ES, SE, CH, TR, UK.

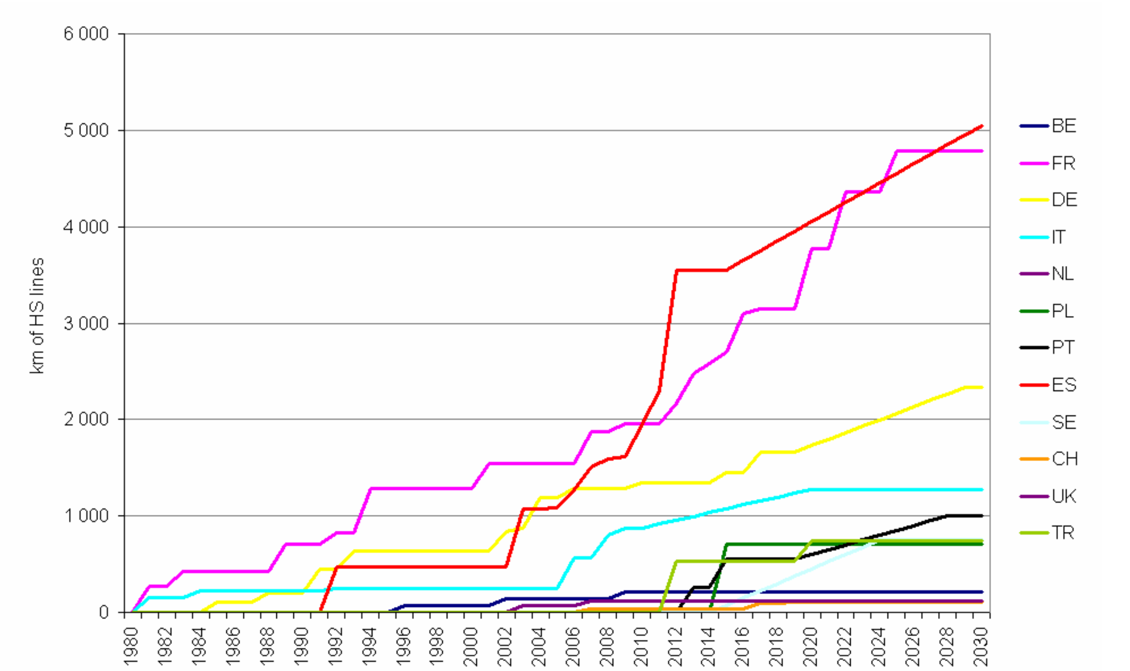

Figure 3: ***Km of HS lines (250 km/h and over) in Europe (in operation, in construction and planned) and year of service opening (UIC)***

For the estimation of High-Speed rail traffic performance we considered the development of the national High-Speed network and the trend of total passenger train-km performed on electric lines already available in EX-TREMIS. The assumption made was that the growth of High-Speed trains-km was proportional to the development of the High-Speed lines. The estimation makes reference to trains-km performed in the territory of each country. The following formula was applied for each year:

$$HS\,train\text{-}km = \frac{km\,of\;HS\,electric\;lines}{km\,of\;all\;electric\;lines} * \;passenger\;train\text{-}km\;performed\;on\;electric\;lines$$

The estimated High-Speed train-km for a given year were subtracted from the train-km performed by electric trains according to the EX-TREMIS data. In particular, 50% of estimated High-Speed train-km were subtracted from Passenger Locomotive Electric and the remaining 50% from Passenger Railcar Electric. Therefore, the total number of train-km reported in EX-TREMIS was kept unchanged. In addition, for UK, diesel and electric High-Speed rail services were separated, because of the different energy sources.

No data in terms of t-km and p-km were collected in EX-TREMIS. The new t-km and p-km ought to be calculated using load factors from TRENDS and the new table of train-km from EX-TREMIS.

III.1.3. Energy Consumption and Emission factors

Old TREMOVE Energy consumption factors (in kWh per v-km) by train type and service were provided only for electric traction and, principally, they are not a variable. So, the same factors are used over time.

By using EX-TREMIS data it is possible to have a measure of the relative rail energy efficiency/intensity of a country, which largely depends on the hauled gross weight resulting from the combination of two elements: lenght of a train and load factor. These additional information is available in EX-TREMIS through the dataset of gross hauled tonne-km (GhTkm) both for electric and diesel traction as well as differentiated by type of service (passenger and freight), which was subsequently calibrated over the number of train-km performed. In EX-TREMIS, factors are not differerentiated by distance or the specific type of service[4]. As for emission factors, the same values are assumed for all distances. For the four countries not included in EX-TREMIS, the same “donor- country” approach applied to emissions factors was used (see below).

Energy consumption factors for High-Speed trains were assumed constant over the time. Data for Germany, Spain, France and Sweden was taken from reference studies[5]. For the other countries we assumed the average value of unitary energy consumption computed on the data for the first four countries.

Time-series of energy consumption factors (in kWh per train-km) are therefore provided in a separate new input table (TRAIN_SERVICE_PARAMETER) for the time span 1980-2030.

The modified input table T_TRAIN_POLL_SERVICE_PARAMETER (years 1980-2030) contains emission factors by country, train/energy type and pollutant in grams per v-km. In the original data of

[4] For freight train: long and short distance. For passenger train: long distance, metropolitan, other urban and short distance.
[5] Jørgensen M.W., Sorenson S.C. (1997), “Methodologies for estimating air pollutant emissions from transport”, MEET Project, funded by the European Commission under the Transport RTD Programme of the 4th framework program, Department of Energy Engineering Technical University of Denmark; Andersson E., Lukaszewicz P. (2006), “Energy consumption and related air pollution for Scandinavian electric passenger trains”, Department of Aeronautical and Vehicle Engineering, Royal Institute of Technology (KTH), Stockholm

EX-TREMIS, emission factors for nine pollutants are provided: CH_4, CO, CO_2, HC, N_2O, NMVOC, NO_x, PM, SO_2. Therefore, besides the six pollutants calculated in TREMOVE 2.7 (CO, CO_2, NMVOC, NO_x, PM, SO_2) we could include three additional elements: CH_4, HC and N_2O.

The following steps and activities were performed:

1. Modification of units of original database EX-TREMIS (years 1980–2030): first of all, it was necessary to recalculate factor emissions for CO_2 from *ktonnes* to *tonnes*. After that, for all type of emissions expressed in tonnes, emission factors expressed in terms of *g/vkm* were calculated by the formula:

$$g/vkm = \frac{Emissions\ in\ tonnes\hat{}10^6}{1000trains - km * 1000}$$

2. Eliminating copy/paste detected errors in EX-TREMIS:
   - United Kingdom; 1992 (emission factors divided by 10);
   - Sweden; years 1994-1998-2000 for passenger train-locomotive diesel (emission factors divided by 10);
   - Sweden; years 1994-1996-1997-1998-1999-2000 (corrected values of emission factors of passenger train-locomotive diesel because too much high).

3. Comparison of CO_2 emission factors from TREMOVE 2.7 to the corrected EX-TREMIS database for the time interval 1995-2005.

   The following table shows differences between EX-TREMIS and TREMOVE 2.7 as far as CO_2 emission factors are concerned for the years 1995 and 2005 and for the available countries (i.e. excluding CH, NO, TR, HR).

Please note that: a) in EX-TREMIS freight trains factors take into account also shunting movements; b) emissions are estimated only for diesel trains, whereas no emission factors are provided for electric trains.

Table 20: Comparison of CO2 emission factors between TREMOVE 2.7 and EX-TREMIS in 1995 and 2005

	1995			2005		
Country	g/vkm CO2 TREMOVE 2.7	g/vkm CO2 EX-TREMIS	% EX-TREMIS / TREMOVE 2.7	g/vkm CO2 TREMOVE 2.7	g/vkm CO2 EX-TREMIS	% EX-TREMIS / TREMOVE 2.7
AT	13 699	27 407	100%	13 699	32 271	136%
BE	19 627	33 422	70%	19 627	45 476	132%
BG	23 389	30 685	31%	23 389	34 046	46%
CZ	20 555	24 593	20%	20 555	16 323	-21%
DE	19 585	26 006	33%	19 585	37 840	93%
DK	23 998	29 885	25%	23 998	30 399	27%
EE	23 389	57 243	145%	23 389	67 695	189%
ES	24 499	28 276	15%	24 499	26 790	9%
FI	19 980	21 118	6%	19 980	20 063	0%
FR	24 835	22 403	-10%	24 835	20 675	-17%
GR	20 326	24 609	21%	20 326	22 488	11%
HU	20 555	23 271	13%	20 555	26 209	28%
IE	17 286	19 674	14%	17 286	25 447	47%
IT	16 996	19 427	14%	16 996	17 230	1%
LT	23 389	60 004	157%	23 389	58 888	152%

LU	15 776	31 818	102%	15 776	24 160	53%
LV	23 389	69 584	198%	23 389	69 796	198%
NL	18 712	31 097	66%	18 712	33 108	77%
PL	20 555	24 992	22%	20 555	23 295	13%
PT	23 826	30 949	30%	23 826	28 351	19%
RO	23 389	34 575	48%	23 389	27 374	17%
SE	14 481	14 948	3%	14 481	12 814	-12%
SI	23 389	21 717	-7%	23 389	19 759	-16%
SK	23 389	22 768	-3%	23 389	19 132	-18%
UK	25 801	26 142	1%	25 801	21 111	-18%

4. For the four missing countries in EX-TREMIS, a "donor country" approach was applied to compute proxies of emission factors as follows:
   - CH: AT factors used (excluding railcar diesel as those do not exist in Switzerland);
   - NO: SE factors used;
   - HR: SI factors used;
   - TR: BG factors used.

5. Further split of emission factors based on "Service type" according to TREMOVE requirements: long distance, short distance, metropolitan, other urban. The split only consisted of replicating the same set of factors for all types of services since the same level of emissions is assumed.

III.2. Data implementation

A lot of the new rail stock data could seamlessly be implemented in the old TREMOVE structure. To fill gaps however, some parameters needed to be manipulated. In this paragraph, the data manipulation procedure is decribed for every parameter.
The change that required the most model modifications was the introduction of a new vehicle type, diesel high-speed trains (Phstdie), even if this existed only in the UK.

III.2.1. Vehicle-kilometers

Vehicle kilometres were present in the model as parameter TVKMTRENDS. New values were delivered in the same format as parameter TVKMEXTREMIS. While differences of course existed between old and new values, values were always of the same order.

III.2.2. Activity

Activity (tkm, pkm) values were not delivered by EX-TREMIS. However, as new vkm data were delivered, tkm and pkm (parameter TACTTRENDSalleng) needed to be updated accordingly. This was done by calculating load factors and occupancy rates from TREMOVE 2.7 by dividing TACTTRENDSalleng by the TVKMTRENDS parameter value, and multiplying this with the new vkm data TVKMEXTREMIS. Any gaps were filled in a pragmatic manner. The new parameter is named TACTTREXalleng, as it combines information from TRENDS and EX-TREMIS.

III.2.3. Vehicle stock

Both total stock (TSTBY) and stock split by age (TSTNBY) could be implemented into TREMOVE without modifications to the data or the input DB.

III.2.4. Fuel consumption and emissions

EX-TREMIS delivered energy consumption for electric rail and diesel rail with a time dimension. This time dimension did not exist before in TREMOVE. It was selected not to implement the energy consumption for diesel rail, as this would create additional complexity without adding much value, given that CO_2 emissions (linearly related to fuel consumption) were already being delivered by the model.

Emissions factors for CO, CO_2, NOx, PM, and SO_2 could be taken directly from EX-TREMIS input. Three new pollutants, already existent for the road mode, were added to the rail calculations: CH_4 (methane), HC (Hydrocarbons) and NMVOC (non-methane volatile organic compounds). CH_4 and NMVOC were grouped in the previous model version as VOC.

III.3. Model update

For renamed parameters mentioned above, changes were made throughout the model code. As stated before, the most complex update was the inclusion of a new train type. Apart from adding this type to the set definitions, the allocation of activity to the new type was not straightforward. GAMS file *Allocate_Train_Kms.gms* was updated to reflect the extra option as part of the final step, where the activity is split over diesel locomotives, electric locomotives and high speed trains (now both diesel and electric).

IV Other data updates

One of the main features of this update was changing the model baseyear from 1995 to 2005, including a change of model currency from EURO 2000 to EURO 2005.

This chapter describes all updates that were not made based on the FLEETS and EX-TREMIS projects.

IV.1. Inland waterway transport

Inland waterway emission factors were updated based on TML's EMMOSS model. This model was developed to project emissions for Flanders. However, inland waterway transport is very much oriented towards long distance, international transport, meaning that emissions factors could be extrapolated to the rest of Europe as well.

Both emission factors and fuel consumption values were not only updated, but a time dimension was also added. As a consequence, the table IWVEH_POLL_PARAMETER in the input DB became obsolete and was replaced by table T_IWVEH_POLL_PARAMETER. For fuel consumption, the parameter IWCONSFfuel was moved from IWVEH_PARAMETER to T_IWVEH_PARAMETER.
Accordingly, adaptations were made to the vehicle stock module GAMS files.

IV.2. Monetary values

All parameters representing a monetary value were updated to reflect the baseyear change from 2000 to 2005. The value to be used for the extract was the change in HICP (Harmonised Index of Consumer Prices) for the European Union.

Table 21: Eurostat HICP extract (EU)

Year	Rate (BY 2005)	Rate (BY 2000)
1995	82.80	91.79
1996	84.61	93.79
1997	85.94	95.27
1998	86.87	96.30
1999	87.85	97.38
2000	90.21	100.00
2001	92.19	102.19
2002	94.11	104.32
2003	95.95	106.36
2004	97.88	108.50
2005	100.00	110.85
2006	102.20	113.29
2007	104.59	115.94
2008	108.42	120.19

Baseyear 2000 monetary values would thus be 10.85% lower than baseyear 2005 monetary values. For simplicity, a factor of 1.1 was applied to all monetary data in Euro 2000 to obtain Euro 2005. Modified parameters in the TREMOVE Input Database are:

- Table CATEGORY_PARAMETER:
    - ACCIDENTCOST
    - NOISECOST
    - WEARMARGCOST
- Table COUNTRY_PARAMETER
    - RPCS_INCREASE_GSI
    - RPCS_INCREASE_TPMS
- Table T_AIRDIST_ALTITUDE_POLL_SET_MEC_PARAMETER
    - AIRPOLLCOSTUNIT
- Table T_CATEGORY_PARAMETER
    - RLABOURC
    - RLABOURTX
- Table T_CATEGORY_ROAD_PERIOD_PARAMETER
    - NETWORKTAX
    - ACCIDENTMARGCOST
- Table T_GENERAL_PARAMETER
    - IWFCOST
    - IWFTAX
- Table T_PARAMETER
    - RLOGITGDP
- Table T_POLL_REGION_SET_MEC_PARAMETER
    - POLLCOSTUNIT
- Table T_POLL_SET_MEC_PARAMETER
    - LC_POLLCOSTUNIT
- Table T_VEHICLE_PARAMETER
    - RINSTXfix
    - RPCS_BASE
    - RREGTX
- Table T_VEHICLE_TECH_PARAMETER
    - ROWNTX

Accordingly, some tables were edited in the Demand input database as well, i.e. those including monetary values:

- Table vot
- Table MPtariff

IV.3. Demand module

While the vehicle stock module allows for different baseyears for different countries in terms of road and rail stock, the demand module structure is more rigid. As a complete set of data is now available for all years in the period 1995-2005, the procedure for model years (as performed in *demandcalibnext.gms*) is now in fact obsolete for those years. Instead, the procedure in *demandcalibinit.gms* is repeated for those years.

The file is however slightly modified as *demandcalibinitafter.gms*. As a result, it is no longer possible to simulate policy for those years, which is not needed in any case. The historic data are still reflected in the output.
The same data structure modification was used for the demand simulation files.
A slight decrease in model run time is obtained this way, as well as a guaranteed correct starting point for simulation after the model baseyear of 2005, as any rounding errors before 2005 are eliminated this way.

According changes where made in the vehicle stock module to refer to these new files. Files that were modified are:

- Run_TREMOVE.gms
- Calibrate_CES_Tree_BY.gms
- Calculate_Transport_Demand_BY.gms

V Scenario development

It was decided that this TREMOVE update would follow the scenarios of iTREN-2030, so as to assure a maximal level of compatibility between the models used by the European Commission's different directorates. In iTREN, 2 scenarios were set-up: a "reference" scenario, only including current policy ("frozen 2008"); and an "integrated" scenario, including all relevant and likely policies between the present time and 2030. The former will be the basis of the "Baseline" scenario, while the latter will be the "Alternative baseline" in accordance to the requirements of this TREMOVE update project.

This report goes into a bit more detail on model updates specific to TREMOVE, but for all policies that were evaluated through one of the other iTREN-2030 models, we refer to the iTREN deliverables. Some parts of the sections below are quoted from these reports.

V.1. Baseline scenario

The Reference Scenario of iTREN, TREMOVE's "Baseline" can be briefly characterised as follows:

- in terms of pricing and taxation the scattered and unbalanced level of charges and taxes across countries and modes is maintained, the opportunities for harmonisation provided by the several EC directives is not taken by most member states.
- The TEN-T networks are slowly implemented following TEN-Connect project framework. No acceleration of implementation is expected.
- Climate gas emissions trading is not extended to transport sectors and for others remains at the Kyoto Protocol.
- The regulation in road emission standards is not transferred to other modes, in particular to rail and air.
- Although the development of LPG and CNG vehicles and fuel supply will increase, new vehicle concepts will not largely enter the market.

In general, this scenario is a "Frozen-2008" group of policies, containing all legislation in place at the end of 2008.

Table 22 below summarises the policy measures included in the Reference/Baseline Scenario.

Table 22: Policies & measures considered in the Reference /Baseline Scenario

	Road	**Rail**	**Aviation**	**Shipping**
Transport pricing and taxation	Distance-based motorway charges for HGVs	-	-	-
Transport Investment	TEN network as implemented in TEN-Connect project			
Energy	CO2 emission targets agreed by Kyoto Protocol and implemented in national allocation plans (NAP I + II). Existing national regulations e.g. phasing-out of nuclear energy for some countries and quotas for renewables incl. biofuels. Share of renewable energy in the electricity production. Energy Efficiency improvements, reduction of final energy consumption e.g. in buildings.			
Environment, Fleet	Voluntary CO2 reduction target for cars LPG / CNG / E85 adaptation and infrastructure Euro-V for HGVs / Euro-VI for cars	Emission standards for diesel trains (UIC Stage IIIA)	ICAO Chapters 3 (emissions) and 4 (noise)	-

In the sections below, some more detail is provided on the scenario construction as this was done in iTREN. As stated before, we refer to the iTREN deliverables for a more detailed description.

V.1.1. Transport demand

Transport demand is partly based on underlying assumptions on GDP evolution.
Overall GDP growth in Western Europe is based on historical long run growth rates of around 1.5% per year, which is the main determinant of the overall EU rate. The EU12 countries are expected to successfully enter into an economic catch-up process, which implies that their growth rates are higher than the rates of Western Europe and reach an average annual growth rate of about +3% until 2030. In total the GDP in EU27 increases by about 38% between 2010 and 2030. The connection between GDP growth and overall transport demand evolution is made in the ASTRA model. The output of ASTRA was then fed into TRANS-TOOLS

TRANS-TOOLS then added a number of policy assumptions, based on TEN-Connect, with a number of corrections, a.o. for slow modes and local traffic.

Table 23 and Table 24 summarise the overall growth assumptions for transport demand.

Table 23: Passenger traffic growth rates by mode for EU15, EU12 and EU27

	AIR			**ROAD**			**RAIL**		
	2005-2020	**2020-2030**	**2005-2030**	**2005-2020**	**2020-2030**	**2005-2030**	**2005-2020**	**2020-2030**	**2005-2030**
EU15	1.3%	1.0%	1.2%	1.0%	0.8%	0.9%	0.8%	0.8%	0.8%
EU12	2.4%	1.5%	2.0%	1.2%	1.4%	1.3%	0.2%	0.2%	0.2%
EU27	1.4%	1.0%	1.2%	1.0%	0.8%	0.9%	0.7%	0.7%	0.7%

Table 24: Freight traffic growth rates by mode for EU15, EU12 and EU27

	ROAD			RAIL			INLAND WATER-WAYS			MARITIME		
	2005-2020	**2020-2030**	**2005-2030**	**2005-2020**	**2020-2030**	**2005-2030**	**2005-2020**	**2020-2030**	**2005-2030**	**2005-2020**	**2020-2030**	**2005-2030**
EU15	1.1%	0.8%	1.0%	1.2%	0.8%	1.1%	1.1%	0.5%	0.9%	1.1%	0.6%	0.9%
EU12	3.1%	2.2%	2.7%	4.7%	2.9%	4.0%	4.5%	2.6%	3.7%	4.5%	2.3%	3.6%
EU27	1.5%	1.1%	1.3%	2.7%	1.8%	2.3%	1.6%	0.9%	1.3%	1.4%	0.8%	1.2%

V.1.2. Fuel prices

With respect to prices of energy resources, the world primary energy prices are estimated to remain on high levels until 2030. Crude oil price rose recently from prices around 20 €/bbl to more than 100 €/bbl and declined thereafter due to the economic crisis. It is assumed that the crude oil price will increase and remain in a range of 70 to 85 €/bbl between 2010 and 2030. Prices for natural gas can be expected to increase at the lower growth rates as the price of crude oil. The price of coal is estimated to increase on a very low rate due to ample amount of coal reserves.

With regard to transport fuels, the trend of high fossil fuel prices is expected to continue. In this way, the price of gasoline might be in the range of 1.00 €/l to 1.30 €/l, while diesel remains slightly lower than gasoline. CNG follows in principle the same trends, while the price of hydrogen might decrease slightly through improvements in the production technologies. The price of electricity is also expected to rise slightly until 2020 and might keep then this level.

In the baseline scenario fuel prices are expected to develop as shown in Figure 4 (where the relative development of prices including taxes, as the unweighted average price index over the EU 27 countries is reported). Oil based fuels increased strongly between 1990 and 2007-8, where they reached a peak. Current prices have fallen sharply because of the recession in 2008-2009, but world demand for oil-based fuels is expected to continue to grow in the medium term, such that prices can be expected to at least regain the levels of 2007-8. This is shown in the assumed prices in 2020 and 2030 as being at a similar level to 2010.

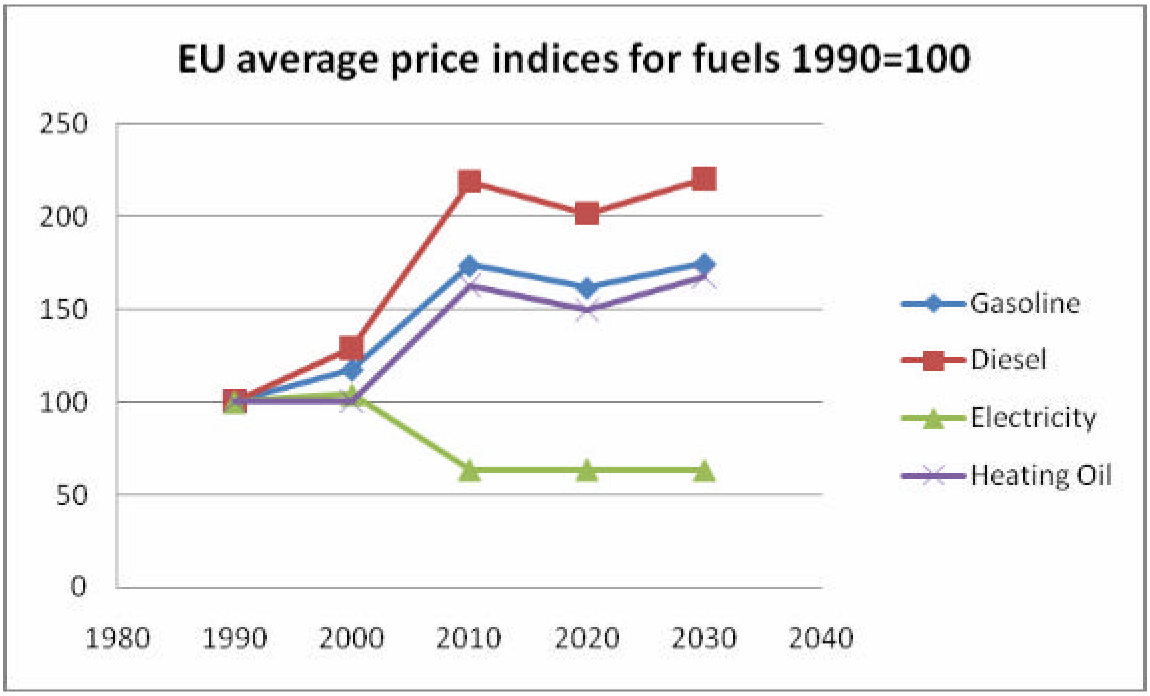

Figure 4: Fuel prices trend

Increasing transport performances especially of air, road freight and road passenger transport lead to an overall increase of final energy demand of 17%.

V.1.3. Vehicle stock

Vehicle stock in the new TREMOVE baselines will build on the updated historic data collected in FLEETS, and will maintain the mechanism for stock evolution based on the nested logit purchase decision model. Any new technologies in the future stock have been based on the output of ASTRA.

V.1.4. Transport emissions

Apart from the relevant assumptions in the sections above, some additional ones are also included in the baseline scenario.

On average, no further car fuel efficiency improvements will happen after 2006. However, as a weight increase is expected in the 2009-2012 period, technological improvements are needed to keep the average CO_2 emission at 140g/km. The related 2009-2012 fuel efficiency changes by car type, are also derived from data and projections reported in the TNO CO2CAR Task A study. Also the purchase cost increases related to these fuel efficiency improvements are taken from the TNO report.

The baseline scenario does not include any further changes in fuel efficiency of new cars beyond 2012. For all other road vehicles the 1995-2009 base case fuel efficiency increases were initially taken from the Auto Oil II programme, in which an agreement on improvement estimates has been reached with the manufacturers' representatives. After 2009 no further increases in fuel efficiency were assumed, as this assumption is needed for a correct assessment of post 2009 EU policies on CO_2 emissions of road vehicles.

[6] This assumption is needed to enable the assessment of the effects of further agreements with the car industry (the current voluntary agreement includes an option to discuss further reductions up to 120g CO_2/km on the longer term.

V.1.5. Overview

On top of the demand input from TRANS-TOOLS, these trends were implemented in the baseline for TREMOVE:

Table 25 Policies in baseline scenario

Sector	Content	Period	Level
Emission	Fuel quality directives	1994, 1996, 2000, 2005, 2009-2030	Base: CEN
Emission	NEC directives	2004-2030	Based on directive 2001/81/EC
Emission	Eco driving by driver training and GSI	2008-2030	Assumed similar % of new sold road vehicles with GSI, % fuel consumption reduction, % of vehicle purchase cost increase
Vehicle	Euro V for HDV	2012-2030	Euro V
Vehicle	LPG, CNG cars	2008-2030	
Vehicle	Euro 5, 6 for cars	2009, 2014	NOx, PM target
Vehicle	Euro 5, 6 for LDV	2010, 2015	NOx, PM targets
Emission	Yearly 1% Improvement of HDT fuel efficiency (CO_2 emission)	1997-2030	ACEA suggestion

V.2. Alternative baseline scenario

The alternative baseline scenario builds on the standard baseline, but adds a number of critical evolutions/ policy assumptions. Again, to guarantee compatibility between the assumptions of the EC's DG's dealing with transport issues, the policy selection made within the consortium of iTREN-2030, a DG TREN project, for their "Integrated" scenario, will be equal to that of the alternative baseline for this project. The evolutions/policies have been selected based on two criteria:

- Relevance: policies that really make a difference.
- Likeliness: policies that bear a high probability to become implemented between now and 2025. The point of time 2025 was chosen as the impact of policies often appears with some lags, and commencing latest in 2025 all policies should have some time to take effect.

In brief, the alternative baseline covers all "major and likely" policies as was the situation at the end of 2008.

V.2.1. Transport demand

Via the same mechanism as for the "frozen" baseline, GDP plays an important role in demand volumes. The biggest difference between both scenarios is the modelling of the economic crisis of 2008-2009 and its consequences in following years. Most West-European countries see a rather steep decrease of GDP growth, also in the later modelling years. After the initial period of crisis, growth does remain positive. Effects are usually more moderate in the developing economies of the East, certainly in those later years. The direct effect on TREMOVE is on the vehicle sales logit, where parameter RLOGITPGDP is modified to reflect the new GDP.

The GDP change also impacted transport demand significantly. The effects on demand have been calculated by the ASTRA model and served as an input to the alternative baseline of TREMOVE in a direct and an indirect manner. Indirectly, GDP changes play a role in TREMOVE by causing higher or lower transport demand. The same GDP change values from ASTRA served as an input to TRANS-TOOLS, which then delivered its new demand baseline to TREMOVE.

Passenger-km growth rates for EU-27 are:

Passenger Mode	2005-2010	2010-2020	2020-2030	2010-2030
Car	-1.20%	1.70%	0.50%	1.10%
Bus	1.30%	-0.90%	-0.20%	-0.60%
Train	2.70%	0.80%	0.90%	0.90%
Air	-1.60%	2.20%	0.40%	1.30%
Non-motorised	0.80%	1.20%	1.10%	1.20%
Total	-0.60%	1.40%	0.50%	1.00%

Freight tkm growth rates for EU-27 are:

Freight Mode	2005-2010	2010-2020	2020-2030	2010-2030
Van	1.30%	0.90%	0.90%	0.90%
Truck	0.10%	2.80%	1.00%	1.90%
Train	0.90%	2.30%	0.90%	1.60%
Ship (Intra-EU)	-1.80%	4.30%	0.90%	2.60%
IWW	-0.60%	2.30%	0.70%	1.50%
Total	-0.10%	2.80%	1.00%	1.90%

We refer to iTREN-2030, deliverable 5 for a precise description of the effects.

V.2.2. Fuel prices

Fuel resource cost evolutions were calculated in iTREN-2030 with the POLES model, and was an exogenous input to TREMOVE.
For fuel tax, the assumption was made that fuel tax harmonisation will gradually take effect over the coming years. Their combined effect on transport demand was used as an input to transport demand calculations in TRANS-TOOLS.
The combined effect of fuel resource cost and fuel tax plays a role in the vehicle sales logit. Hence, the implementation of these changes into TREMOVE for future years was a part of the scenario construction

V.2.3. Modelling sequence

The major effects estimated by the other iTREN models (ASTRA, POLES and TRANS-TOOLS) were described above. All of those effects were input to an intermediate transport baseline for the integrated scenario. To come to the final transport baseline, a number of policies still needed to be added in TREMOVE, and their effects on transport demand would then produce a final baseline, with all relevant and likely policies included.

So, following modelling sequence with relevance to TREMOVE was used:

1. Model all background policies with POLES (fuel cost) and ASTRA (GDP)
2. Use their output as input to TRANS-TOOLS for the intermediate transport baseline
3. Use TRANS-TOOLS (transport demand in vkm/tkm/pkm), ASTRA (GDP) and POLES (fuel prices) output as input to TREMOVE intermediate transport baseline
4. Model policies on fleet and emissions as a scenario run with TREMOVE and intermediate baseline
5. Transport demand output of scenario run is then the final transport demand baseline, so scenario run output of demand is transformed into input
6. All scenario run parameters are included in the baseline, together with final transport demand

V.2.4. Major policies and trends in alternative baseline

On top of the policies already modelled in the baseline, Table 26 shows which other trends and policies were implemented for the iTREN-2030 project, Integrated scenario. As stated before, the first three on the list were already calculated with other models and were part of the intermediate transport baseline. Effects of the other policies were calculated with TREMOVE.

Table 26 iTREN-2030 integrated scenario, policies in TREMOVE

Sector	Content	Period	Level	Implementation
Transport	New demand from VACLAV	Whole		Based on change from the "REF with crisis" given by VACLAV
Transport	New GDP from VACLAV/ASTRA	Whole		Based on change from the "REF with crisis "given by VACLAV
Transport	Harmonisation of fuel prices (resources cost, excise duty, vat)	whole	POLES level	Input from POLES
Transport	User charging trucks implemented as road charges on interurban network (not only motorway)	2020-2030	Country based values, depending on Greening transport package proposal	updating NETWORKTAX by adding charges on RURAL road using values from table 5-3
Transport	User charges cars implemented as road charges on interurban network (not only motorway)	2025-2030	Country based values based on truck charges and ratio between car and truck marginal costs	updating NETWORKTAX by adding charges on RURAL and MOTORW roads using values from table 5-4
Transport	City tolls	2025-2030	0.3927€/vkm for peak period (pk)	updating NETWORKTAX by adding charges on METROP road using given values (5 euros/trip or 0.357 €/vkm) for pk
Transport	Liberalisation: 3rd railway package (gradual opening up of int. rail services to competition)	2010-2030	-2% of rail passenger costs (source: quantification in the ASSSESS)	Change (-2%) through TAXSIMULATION ("PTRAIN",period,lo,T, run)
Vehicle	Binding CO_2 emission targets for cars	2009-2030	2012-135 2015-130 2020 to 2030-105 *supplementary measures (LRRT, LVL,...) are applied so that the targets decrease furthermore by 10 gr/km to reach: 2012-125 2015-120 2020 to 2030-95 MAC starting 2010 for small gasoline and small CNG cars	Will be implemented: by technical measures in cars and supplementary measures: LRRT, LVL, GSI, MAC Between 2012 and 2020: Extra strong downsizing without learning is assumed.
Vehicle	Binding CO_2 emission targets for LDV	2009-2030	LDV: 2012-181 2016-175 2020 to 2030-135	Will be implemented by technical measures in LDV Between 2009-2012: Package-1 (Policy Measure report TREMOVE) is assumed Between 2012-2020: Extra strong downsizing without learning is assumed.

In the following paragraphs, we will discuss how these policies were implemented in the scenario run and the alternative baseline input database.

V.2.4.1. Road charging for trucks and cars

Road charging is an important policy in the context of internalising external costs of transport in the EU.

While most countries already apply some form of road charging for trucks on motorways (it has been modelled in TREMOVE from 2005 onwards), measures are expected to also include the rest of the inter-urban road network from 2020 onwards. Additionally, a similar system will be set up for passenger cars from 2025 onwards. The level of taxation is based on estimates of external costs from the GRACE project, with the level of the tax being set equal to that of the estimate. No distinction was made between vehicle size classes. Table 27 displays the values that were used for trucks on rural roads. Motorway charges were not changed.

Table 27 NETWORKTAX value for trucks on rural roads (for OP, congestion is not counted)

Country	Pollution	Noise	Congestion	Total	OP	PK
AT	0.0396	0.00143	0.0495	0.0902	0.04103	0.09053
BE	0.0341	0.00143	0.0495	0.0858	0.03553	0.08503
BG	0.0649	0.00143	0.0495	0.1166	0.06633	0.11583
CY	0.0517	0.00143	0.0495	0.1034	0.05313	0.10263
CZ	0.0495	0.00143	0.0495	0.1001	0.05093	0.10043
DE	0.0374	0.00143	0.0495	0.0891	0.03883	0.08833
DK	0.0275	0.00143	0.0495	0.0781	0.02893	0.07843
EE	0.0517	0.00143	0.0495	0.1034	0.05313	0.10263
EL	0.0473	0.00143	0.0495	0.0979	0.04873	0.09823
ES	0.0407	0.00143	0.0495	0.0913	0.04213	0.09163
FI	0.0374	0.00143	0.0495	0.0891	0.03883	0.08833
FR	0.0363	0.00143	0.0495	0.088	0.03773	0.08723
HU	0.0572	0.00143	0.0495	0.1089	0.05863	0.10813
IE	0.0451	0.00143	0.0495	0.0968	0.04653	0.09603
IT	0.0374	0.00143	0.0495	0.088	0.03883	0.08833
LT	0.0517	0.00143	0.0495	0.1034	0.05313	0.10263
LU	0.0308	0.00143	0.0495	0.0814	0.03223	0.08173
LV	0.0539	0.00143	0.0495	0.1045	0.05533	0.10483
MT	0.0517	0.00143	0.0495	0.1023	0.05313	0.10263
NL	0.022	0.00143	0.0495	0.0726	0.02343	0.07293
PL	0.0561	0.00143	0.0495	0.1067	0.05753	0.10703
PT	0.0495	0.00143	0.0495	0.1001	0.05093	0.10043
RO	0.0649	0.00143	0.0495	0.1166	0.06633	0.11583
SE	0.0352	0.00143	0.0495	0.0869	0.03663	0.08613
SI	0.0528	0.00143	0.0495	0.1034	0.05423	0.10373
SK	0.044	0.00143	0.0495	0.0946	0.04543	0.09493
UK	0.0297	0.00143	0.0495	0.0814	0.03113	0.08063

Table 28 NETWORKTAX value for cars on rural roads and motorways (for OP, congestion is not counted)

Country	Pollution	Noise	Congestion	Total	OP	PK
AT	0.00385	0.00077	0.0253	0.0297	0.00462	0.02992
BE	0.00385	0.00077	0.0253	0.0297	0.00462	0.02992
BG	0.00341	0.00077	0.0253	0.0297	0.00418	0.02948
CY	0.00264	0.00077	0.0253	0.0286	0.00341	0.02871
CZ	0.00253	0.00077	0.0253	0.0286	0.0033	0.0286

DE	0.00253	0.00077	0.0253	0.0286	0.0033	0.0286
DK	0.00165	0.00077	0.0253	0.0275	0.00242	0.02772
EE	0.00264	0.00077	0.0253	0.0286	0.00341	0.02871
EL	0.00352	0.00077	0.0253	0.0297	0.00429	0.02959
ES	0.00341	0.00077	0.0253	0.0297	0.00418	0.02948
FI	0.00011	0.00077	0.0253	0.0264	0.00088	0.02618
FR	0.00286	0.00077	0.0253	0.0286	0.00363	0.02893
HU	0.00187	0.00077	0.0253	0.0275	0.00264	0.02794
IE	0.0022	0.00077	0.0253	0.0286	0.00297	0.02827
IT	0.00308	0.00077	0.0253	0.0286	0.00385	0.02915
LT	0.00264	0.00077	0.0253	0.0286	0.00341	0.02871
LU	0.0033	0.00077	0.0253	0.0297	0.00407	0.02937
LV	0.00275	0.00077	0.0253	0.0286	0.00352	0.02882
MT	0.00264	0.00077	0.0253	0.0286	0.00341	0.02871
NL	0.0022	0.00077	0.0253	0.0286	0.00297	0.02827
PL	0.00187	0.00077	0.0253	0.0275	0.00264	0.02794
PT	0.00319	0.00077	0.0253	0.0297	0.00396	0.02926
RO	0.00341	0.00077	0.0253	0.0297	0.00418	0.02948
SE	0.00154	0.00077	0.0253	0.0275	0.00231	0.02761
SI	0.00176	0.00077	0.0253	0.0275	0.00253	0.02783
SK	0.0022	0.00077	0.0253	0.0286	0.00297	0.02827
UK	0.00154	0.00077	0.0253	0.0275	0.00231	0.02761

V.2.4.2. City tolls

City tolls are an additional form of road charging that was implemented. However, within iTREN it was set up in a rather limited scope: only in the metropolitan area, and only for passenger cars. The charge was set at 5.5€ per trip in the metropolitan area. Accounting for average trip length (12 or 14 km, depending on the country), the city toll measure was included in the package of policies as a NETWORKTAX as well.

V.2.4.3. Rail liberalisation

The market for railway freight has been liberalised for some time, yet domestic passenger rail has remained the sole business of one usually state-controlled operator. With the adoption of the third railway package in 2007, the EC has cleared the path to open the passenger rail market for all willing participants from 2010 on. While the position of the incumbent service provider is likely to remain dominant in most to all member states, some competition is to be expected, namely from other national operators expanding their services to other countries. As monopolistic prices tend to be higher than prices within a competitive market, a price decrease can be expected. However, as competition is expected to remain moderate in most cases, no steep price drops (at least on average) should be expected.

In the TREMOVE v.3.3 alternative baseline, a 2% discount on user prices is estimated compared to the scenario without liberalisation. This is implemented in TREMOVE through a 2% decrease of the MPTariff value in the Demand input database.

V.2.4.4. CO_2 in cars and light duty vehicles

CO_2 legislation in the past few years has taken the form of both voluntary and mandatory targets. In the policy package included in TREMOVE 3.3 alternative baseline, a clear 2020 target was put forward. As a fleet average (per constructor), the passenger car target for new vehicle sales was set at 95g/km (intermediate targets were assumed: 135g by 2012, 130g by 2015). Driving cycle improvements are meant to reach 105g/km, with the additional 10g coming from other improvements (Low rolling resistance tires, low viscosity liquids, etc.). For LDV, the goal is 135g/km (intermediate: 181g by 2012, 175 by 2016).
After 2020, no further improvements were assumed.

The question is then how this target on the driving cycle would be reached. The reports "Assessment of options for CO_2 legislation for light commercial vehicles" (AEA, CE Delft, TNO, Öko Institut, 25/11/2009) and "Assessment with respect to long term CO_2 emission targets for passenger cars and vans" (AEA, CE Delft, TNO, Öko Institut, 07/2009) estimated cost effects of different targets under different technological and cost evolution assumptions. In agreement with the EC, it was selected to use the option "extra strong downsizing – no learning" for both cars and light duty vehicles.

The CO_2 improvements (as a percentage compared to 2002 average emissions) were included in the model through the parameter RFACTORACEA, while the cost increases were (also as a percentage of average vehicle cost) implemented through RPCS_INCREASE_2012.

V.3. Validation of scenarios

V.3.1. Demand

Demand levels (tkm, pkm, vkm) have been checked with the statistics reported in the publication "EU Energy and Transport in Figures – Statistical pocketbook 2009" (ETiF, from now on) in iTREN Deliverable 4. Text below is quoted from that (not yet finalised) report:

V.3.1.1. "Passenger transport

Table 5-6 reports the comparison of mode shares for available modes. Air transport is not considered in both tables since ETiF provides air passengers-km only for the EU27 as a whole (the published data is 527 billion pass-km compared to 442 billion pass-km in the iTREN-2030 reference scenario where intercontinental demand is not modelled, however).
The tables show that iTREN-2030 Reference scenario is quite close to ETiF for all the aggregations considered, with the largest discrepancy being largely below 10%.

Table V-29: Passenger land* transport activity in the year 2005: comparison between iTREN-2030 and ETiF (Billion pkms)

Region Code	Region Name	iTREN-2030	ETiF
EU27	EU27 countries	5,757	5,523
EU15	EU15 countries	5,076	4,831
EU12	EU12 countries	680	692
BIG 4	DE, FR, UK, IT	3,668	3,500
Southern EU	ES, EL, PT, CY, MT	667	623
Northern EU	AT, DK, IE, FI, BE LU, NL, SE	749	717
Eastern EU	BG, CZ, EE, LV, LT, HU, PL, RO, SL, SK	672	684
Non-EU	HR, NO, CH, TK	n.a.	394

Source: iTREN-2030 – Energy and Transport in Figure – Statistical Pocketbook 2009
* Car, bus and train/tram only

Table V-30: Passenger land* modes split in the year 2005: comparison between iTREN-2030 and ETiF (% based on pkm)

Region Code	iTREN-2030			ETiF		
	Car	Bus	Train	Car	Bus	Train
EU27	81%	11%	8%	82%	10%	8%
EU15	83%	9%	8%	83%	9%	8%
EU12	66%	21%	13%	74%	16%	10%
BIG 4	84%	8%	8%	84%	7%	8%
Southern EU	82%	14%	5%	80%	14%	6%
Northern EU	81%	11%	8%	82%	10%	9%
Eastern EU	67%	20%	13%	74%	16%	11%
Non-EU	n.a.	n.a.	n.a.	67%	26%	7%

Source: iTREN-2030 – Energy and Transport in Figure – Statistical Pocketbook 2009

* Car, bus and train/tram only

V.3.1.2. Freight demand

Table 5-7 and 5-8 report comparisons of total freight demand (tonnes-km) of land modes and, respectively, of mode shares. Maritime is not included in the comparisons because ETiF reports just a share of total maritime activity.

Table V-31: Freight transport activity on the national territory in the year 2005: comparison between iTREN-2030 and ETiF (Billion tkms)

Region Code	Region Name	iTREN-2030	ETiF
EU27	EU27 countries	2,677	2,353
EU15	EU15 countries	2,150	1,878
EU12	EU12 countries	527	475
BIG 4	DE, FR, UK, IT	1,323	1,149
Southern EU	ES, EL, PT, CY, MT	382	323
Northern EU	AT, DK, IE, FI, BE LU, NL, SE	445	405
Eastern EU	BG, CZ, EE, LV, LT, HU, PL, RO, SL, SK	527	474
Non-EU	HR, NO, CH, TK	110	232

Source: iTREN-2030 – Energy and Transport in Figure – Statistical Pocketbook 2009

Table V-32: Freight mode split on the national territory in the year 2005: comparison between iTREN-2030 and ETiF (% based on tkm)

	iTREN-2030			ETiF		
Region code	Road	Rail	IWW	Road	Rail	IWW
EU27	78%	17%	5%	77%	18%	6%
EU15	81%	13%	5%	79%	14%	7%
EU12	67%	30%	3%	66%	32%	3%
BIG 4	80%	15%	5%	78%	16%	6%
Southern EU	95%	5%	0%	95%	5%	0%
Northern EU	73%	16%	11%	70%	17%	13%
Eastern EU	67%	30%	3%	65%	32%	3%
Non-EU	78%	22%	0%	88%	11%	0%

Source: iTREN-2030 – Energy and Transport in Figure – Statistical Pocketbook 2009

Even if the discrepancies are a bit larger than for passengers, the iTREN-2030 reference scenario data at the year 2005 is well comparable to ETiF statistics in all regions and also the different mode shares are well reflected in the iTREN-2030 results."

V.3.1.3. Review

a. Passenger transport

a.1. EU27

The EU27 difference in total pkm (for categories within TREMOVE) goes from 15.55% in 1995 to 8.59% in 2005 (TREMOVE is higher). Total reported numbers in statistics amount to 5.247 million pkm in 1995 to 6.201 million pkm in 2005.
In both relative and absolute difference, busses are most important (420 mio pkm in 1995, 350 in 2005). In absolute numbers, cars are second, with a difference of 350 (1995) to 290 (2005) million pkm. Excellent for two-wheel vehicles and metros, all categories have a higher value in TREMOVE.

a.2. Country level

On a country level, car statistics for Germany are fairly accurate (difference always below 2%). The UK and France are within reasonable ranges as well (below 10%), whereas Italy and Spain, of the big countries, show large to very large discrepancies (for IT, TREMOVE is between 25 and 30% too low, while ES is around 100% overestimated) between the iTREN baseline and statistics.
The aggregate difference for other EU27 countries goes from 16% in 1995 to 3% in 2005, so the match does improve over the years. Large differences between countries still exist though.

For busses, most countries show TREMOVE overestimating demand by about 100%. For a few smaller MS, there is however an underestimation.

In the big countries, rail estimates are about 10-20% higher in iTREN/TREMOVE. Only in France, there is slight underestimate, while UK pkm are 50-60% too high.

b. Freight transport

For freight transport, comparison is a bit more difficult due to a difference in methodology. While TREMOVE reports activity on a country's network, DG TREN statistics contain freight activity for vehicles registered in a certain country. While domestic transport does make up the majority of total freight, especially in the bigger countries, this makes a comparison on a country level very difficult. Hence, we will only discuss the overall EU27 values here.

Road freight in the EU 27 is substantially overestimated by iTREN/TREMOVE, but like for passenger transport, the difference with DG TREN statistics decreases through the years. In 1995, TREMOVE reports values that are 37% higher, while the difference is reduced to 16% by 2005.

For rail freight, TREMOVE first underestimates demand by about 14%, but it evolves to an overestimate of 8% in 2005. For IWW, TREMOVE underestimates demand by between 2 and 13%.

c. Assessment

While the iTREN consortium has deemed the baseline above as suitable, relatively large discrepancies still exist between statistics and TREMOVE output. As it was agreed that this TREMOVE update project would follow the iTREN baseline, and a new transport baseline is currently being developed by JRC/IPTS for DG MOVE (formerly DG TREN), we believe it is not necessary adapt TREMOVE v3.3 to ETiF data at this point, but include DG MOVE's new baseline when it becomes available. This will result in TREMOVE v3.4.

V.3.2. Emissions

A consequence of demand data not being in line with statistics is that vehicle emissions will also diverge. More specifically, fuel sales volume or total CO_2 emissions can not be used for calibration purposes, at least not on an absolute scale. Relative fuel sales (gasoline vs. diesel) have been made to closely follow real shares. For five of the EU's biggest countries (Germany, France, Italy, Spain and the UK), a separate calibration was performed, as the share of tank tourism (or differences between fuel consumed and fuel sold in general) in those countries is expected to be limited in the total. For the rest of the EU27, overall fuel sales were calibrated together.

The parameter used to calibrate fuel consumption was the emission of new vehicles in a given year. While this was delivered by the FLEETS project, they were always intended to be the tool for calibration.

Sales shares in statistics are as follows (data source: Eurostat):

Table 33 Fuel sales shares from statistics

SHARES	***Statistics***										
Gasoline	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
DE	57.08%	57.31%	56.71%	55.76%	53.95%	52.55%	52.04%	51.01%	50.49%	48.95%	47.77%
ES	43.03%	43.21%	42.17%	38.61%	36.30%	33.60%	31.83%	29.94%	27.96%	25.83%	23.82%
FR	38.23%	38.97%	37.31%	35.68%	35.83%	32.81%	31.48%	30.62%	28.94%	27.41%	25.93%
IT	54.24%	54.65%	54.11%	53.19%	51.69%	49.32%	47.39%	45.30%	43.37%	39.86%	37.39%
UK	62.00%	60.94%	59.77%	59.06%	59.30%	57.63%	56.04%	55.14%	52.93%	51.28%	49.08%
Rest EU	56.13%	53.20%	52.36%	51.11%	50.72%	48.71%	46.49%	45.77%	43.73%	42.03%	39.98%
Total EU27	**53.15%**	**52.37%**	**51.43%**	**49.99%**	**49.19%**	**46.94%**	**45.27%**	**44.15%**	**42.36%**	**40.41%**	**38.45%**
Diesel	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
DE	42.92%	42.69%	43.29%	44.24%	46.05%	47.45%	47.96%	48.99%	49.51%	51.05%	52.23%
ES	56.97%	56.79%	57.83%	61.39%	63.70%	66.40%	68.17%	70.06%	72.04%	74.17%	76.18%
FR	61.77%	61.03%	62.69%	64.32%	64.17%	67.19%	68.52%	69.38%	71.06%	72.59%	74.07%
IT	45.76%	45.35%	45.89%	46.81%	48.31%	50.68%	52.61%	54.70%	56.63%	60.14%	62.61%
UK	38.00%	39.06%	40.23%	40.94%	40.70%	42.37%	43.96%	44.86%	47.07%	48.72%	50.92%
Rest EU	43.87%	46.80%	47.64%	48.89%	49.28%	51.29%	53.51%	54.23%	56.27%	57.97%	60.02%
Total EU27	**46.85%**	**47.63%**	**48.57%**	**50.01%**	**50.81%**	**53.06%**	**54.73%**	**55.85%**	**57.64%**	**59.59%**	**61.55%**

This corresponds to these absolute values:

Table 34 Fuel sales from statistics

ABSOLUTE	*Statistics*										
Gasoline	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
DE	29,894	29,776	30,001	30,056	30,025	28,581	27,724	26,970	25,625	24,768	22,946
ES	8,534	9,093	8,970	9,007	8,928	8,524	8,481	8,206	8,040	7,714	7,260
FR	13,889	14,736	14,370	14,184	14,216	13,448	13,067	12,602	11,801	11,199	10,473
IT	16,853	17,030	17,132	17,880	17,565	16,678	16,348	15,981	15,398	14,465	13,453
UK	21,953	22,409	22,252	21,848	22,597	21,603	20,933	20,808	19,918	19,484	18,731
Rest EU	35,768	36,417	36,557	36,926	37,429	36,041	36,165	36,552	36,609	36,744	35,519
Total EU27	**126,891**	**129,461**	**129,282**	**129,901**	**130,760**	**124,875**	**122,718**	**121,119**	**117,391**	**114,374**	**108,382**
Diesel											
DE	22,479	22,180	22,900	23,851	25,633	25,805	25,548	25,907	25,130	25,833	25,089
ES	11,300	11,950	12,300	14,322	15,670	16,847	18,165	19,199	20,712	22,155	23,216
FR	22,444	23,077	24,150	25,573	25,457	27,539	28,438	28,558	28,975	29,657	29,918
IT	14,220	14,132	14,531	15,737	16,417	17,137	18,149	19,297	20,107	21,826	22,527
UK	13,457	14,365	14,976	15,143	15,508	15,881	16,418	16,926	17,712	18,514	19,436
Rest EU	27,955	32,042	33,260	35,320	36,363	37,949	41,632	43,301	47,105	50,670	53,314
Total EU27	**111,855**	**117,746**	**122,117**	**129,946**	**135,048**	**141,158**	**148,350**	**153,188**	**159,741**	**168,655**	**173,500**

With original mileage values, the results obtained showed a much higher share of gasoline consumption than in statistics.

This was corrected by lowering the mileage of gasoline vehicles for those vehicle categories that have vehicle types using both fuels. These are CAR (with diesel: PCDB, PCDM and PCDS and gasoline: PCGB, PCGM and PCGS), VAN (Diesel: VAND and gasoline: VANG) and LDT (diesel: LTD and gasoline: LTG). Changing mileages for other vehicle categories does not change the outcome of the fuel consumptions calculations.

More precisely, mileages for diesel vehicles were generally increased, while gasoline mileages were decreased. For most countries; the increase for diesel mileages compared to FLEETS values was between 5% and 15%, with the UK the exception at over 20%. Combined with a decrease of gasoline mileage of between 10% and 30%, the numbers obtained for TREMOVE v.3.3 after calibration are shown in Table 35 and Table 36.

Table 35 Fuel consumption shares from TREMOVE 3.3

SHARES	***TREMOVE***										
Gasoline	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*200*
DE	58.45%	58.77%	58.66%	58.44%	57.39%	55.55%	54.99%	53.71%	52.87%	51.12%	49.94%
ES	45.11%	44.31%	42.69%	39.03%	36.41%	33.55%	31.55%	29.33%	27.42%	25.23%	23.21%
FR	40.54%	40.75%	38.99%	37.33%	37.24%	34.23%	32.75%	31.65%	29.84%	28.11%	26.53%
IT	55.19%	55.15%	54.31%	53.16%	52.08%	49.65%	47.85%	45.77%	43.67%	40.00%	37.49%
UK	64.18%	63.23%	62.62%	62.17%	62.42%	61.10%	59.87%	58.71%	56.49%	54.47%	52.20%
Rest EU	55.47%	53.61%	52.79%	51.75%	51.16%	49.47%	47.72%	46.87%	45.19%	43.46%	41.58%
Total EU27	**54.15%**	**53.50%**	**52.62%**	**51.45%**	**50.70%**	**48.62%**	**47.18%**	**45.87%**	**44.15%**	**42.10%**	**40.21%**
Diesel											
DE	41.55%	41.23%	41.34%	41.56%	42.61%	44.45%	45.01%	46.29%	47.13%	48.88%	50.06%
ES	54.89%	55.69%	57.31%	60.97%	63.59%	66.45%	68.45%	70.67%	72.58%	74.77%	76.79%
FR	59.46%	59.25%	61.01%	62.67%	62.76%	65.77%	67.25%	68.35%	70.16%	71.89%	73.47%
IT	44.81%	44.85%	45.69%	46.84%	47.92%	50.35%	52.15%	54.23%	56.33%	60.00%	62.51%
UK	35.82%	36.77%	37.38%	37.83%	37.58%	38.90%	40.13%	41.29%	43.51%	45.53%	47.80%
Rest EU	44.53%	46.39%	47.21%	48.25%	48.84%	50.53%	52.28%	53.13%	54.81%	56.54%	58.42%
Total EU27	**45.85%**	**46.50%**	**47.38%**	**48.55%**	**49.30%**	**51.38%**	**52.82%**	**54.13%**	**55.85%**	**57.90%**	**59.79%**

Absolute values:

Table 36 Fuel consumption from TREMOVE 3.3

ABSOLUTE	***TREMOVE***										
Gasoline	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*200*
DE	30,212	30,524	30,483	30,367	29,765	28,674	28,356	27,667	27,209	26,252	25,55
ES	12,138	12,083	11,818	10,954	10,332	9,660	9,200	8,644	8,174	7,583	6,90
FR	15,214	15,475	14,935	14,413	14,468	13,377	12,834	12,477	11,815	11,188	10,65
IT	15,165	15,325	15,192	14,978	14,755	14,120	13,626	13,084	12,554	11,528	10,80
UK	26,593	26,554	26,610	26,818	27,139	26,836	26,522	26,231	25,418	24,659	23,23
Rest EU	37,143	36,291	36,171	35,887	35,846	35,008	34,059	33,894	33,067	32,156	31,11
Total EU27	**136,466**	**136,253**	**135,209**	**133,418**	**132,305**	**127,676**	**124,597**	**121,998**	**118,236**	**113,366**	**108,26**
Diesel											
DE	21,476	21,417	21,478	21,600	22,097	22,946	23,211	23,842	24,254	25,101	25,61
ES	14,772	15,187	15,867	17,109	18,044	19,132	19,964	20,828	21,630	22,475	22,84
FR	22,318	22,501	23,366	24,198	24,383	25,706	26,356	26,950	27,780	28,612	29,51
IT	12,313	12,463	12,782	13,199	13,578	14,321	14,848	15,500	16,196	17,291	18,02
UK	14,842	15,441	15,887	16,321	16,339	17,085	17,777	18,448	19,576	20,615	21,27
Rest EU	29,814	31,402	32,347	33,459	34,223	35,759	37,315	38,425	40,106	41,835	43,72
Total EU27	**115,536**	**118,412**	**121,727**	**125,886**	**128,662**	**134,950**	**139,470**	**143,992**	**149,542**	**155,929**	**160,98**

For the EU27, sales shares are within less than 2% of the actual values (down from almost 7% with original mileage values).
In absolute terms, differences are larger. However, while demand in TREMOVE (iTREN) is generally higher than reported by statistics, overall fuel sales are below their statistical value. This has a number of possible causes:

1. Demand values for similar categories are distorted. This could mainly apply to the different HDT categories. For example, more demand (vkm) for HDT4 and less for HDT3 will increase fuel consumption.
2. Vehicle stock values with different vehicle types within a category are distorted. When more small cars are in the fleet relative to big cars, average fuel consumption for that category will decrease.
3. Mileage values (RMILnew) within fuel type classes are distorted. As reported, the recalibration phase only changed the relative mileages between fuel type classes, not between the size classes within fuel type classes, as this would create a more or less random process. It could well be that mileages for big diesels are relatively low compared to those for small diesels (as delivered by FLEETS), but this can not be verified.
4. Emission factors are incorrect.

Probably, factors 1-3 are the main causes for the anomaly, as emission factors (cause 4) were left unchanged for this version. When a new demand baseline is produced (e.g. for TREMOVE 3.4 as mentioned supra), this will eliminate the first cause. To deal with causes2 and 3, a careful review of vehicle stock input values would be advisable in light of the results produced by TREMOVE 3.3.

V.4. Output comparison of TREMOVE 3.3 with TREMOVE 2.7b

In this paragraph, the output (pivot tables) of TREMOVE 3.3 and the previous public version, TREMOVE 2.7b, are compared. The focus is on the total for all countries.

V.4.1. Demand

The most remarkable change in pkm is noted in the "metro and tram" category, which goes from a range of 50 000 - 70 000 to only 2 000 - 3 000. The decrease is similar in all countries and is most likely due to the fact that TRANS-TOOLS, the base demand input in TREMOVE 3.3, does not cover the local traffic very well. "Motorcycle" also sees a decrease, but to a lesser extent (10-20%). The biggest growth is in bus transport. However, TREMOVE 2.7b already showed a decrease in volume from 2020 on. In TREMOVE 3.3, this trend already starts in 1995. For plane, TREMOVE 2.7b shows a large growth in pkm demand. In the new release, the 1995 level is significantly higher, while the 2030 value is slightly lower; the growth rate is only 76%, compared to 260% in TREMOVE 2.7b. While car volumes are very similar in both versions, the newest has a slightly lower increase in total pkm level.

In terms of road tkm, a similar trend occurs as with plane pkm: initial demand in 1995 is lower (around 33%) in the old version, but higher in 2030 (about 12%). Also, the split between the truck types changes: trucks between 16 and 32 tonnes have a much larger share in TREMOVE 3.3 compared to TREMOVE 2.7b. Additionally, rail freight starts off at a similar level in both versions, but sees a much bigger growth in TREMOVE 3.3 (+100% in 3.3 vs. +25% in 2.7b). Not much changes in IWW freight.

The occupancy rate of most vehicles is about the same, leaving the ratio between pkm and vkm intact. Only for busses and vans, the OR is slightly higher in the new version.

Load factors of heavy duty trucks are higher in the new version, up to 50% higher even. There is however no longer a growth in LF as in TREMOVE 2.7b, but a drop. The opposite is true for freight trains. Inland ships do not change much.

V.4.2. Stock

Most of the values for passenger vehicle stock evolution are relatively similar in both versions: some categories are slightly lower, others are somewhat higher. In freight road stock, greater differences occur. There is much higher stock of light duty vehicles in version 3.3 (almost 3 times higher), a much lower stock of HDT1, HDT2 is more or less the same, HDT3 is only about half of the value in 2.7b and HDT4 is 80-100% higher in version 3.3. This of course only builds on the values that served as an input.

V.4.3. Emissions

Overall CO_2 emissions are at a similar level between the old and new version in the later years. In historic years, version 2.7b has a lower total. The share of different vehicle categories does change completely between TREMOVE 2.7b and TREMOVE 3.3. Notably in cars, overall CO2 exhaust emissions increase by about 115 million tonnes (around 15%) in 2030 from 2.7b to 3.3. the differences is almost completely compensated by the lower emissions of road freight modes, namely HDT3 and HDT4.

VI Sensitivity analysis

VI.1. Parameter definition

Sensitivity runs are conducted with an agreed set of parameters. As was requested in the ToR, the variables that are used are fuel/energy prices and economic activity in terms of GDP. For fuel prices, the effect would be checked of fuel prices that are double (2x) or half (0.5x) those present in either baseline. For GDP, it would be checked if growth rate (so not GDP itself) would be double or half. For each variable, the envisioned higher/lower levels are reached by 2030, starting their increase or decrease from 2011 on (so over 20 years).

	Double Prices of Fuels	Half Prices of Fuels
Activity Expansion (Double Growth) (population, GDP, v-km, t-km, p-km)	Sensitivity A	Sensitivity B
Activity Tightening (Half Growth) (population, GDP, v-km, t-km, p-km)	Sensitivity C	Sensitivity D

As described before, GDP influences TREMOVE in 2 ways: directly through the vehicle sales logit (RLOGITPGDP) and indirectly through transport demand.

While the direct impact is very straightforward to program, the indirect effect was evaluated based on runs of the ASTRA model.

VI.1.1. GDP effect on transport demand

The growth of Gross Domestic Product is one key element in the trend of transport demand and, therefore, of fuel consumption and emissions. At the same time, forecasting the future level of GDP in several countries and in the long term is more than a challenging exercise as demonstrated by the fact that even two-three years projections issued by international organisations often prove themselves to be substantially wrong and need to be continuously adjusted. The current phase of the global economy adds further uncertainty on the future trends. For those reasons, GDP growth has been chosen as one variable for the sensitivity runs.

However, the TREMOVE model does not use GDP as a direct input. Therefore, the assumptions concerning alternative growth rates of GDP have to be translated into an indirect input for TREMOVE. Since transport demand is highly correlated to GDP and since transport demand is a major input for TREMOVE, it has been chosen to translate the assumptions concerning GDP growth into assumptions concerning the level of transport demand. This way to proceed has required two steps:

- To estimate a quantitative relationship between the GDP growth rate and the level of demand;
- To define the assumptions concerning alternative GDP growth rates.

In theory, the first step could be addressed by looking at past time series of transport demand and GDP, however this line is actually hard to follow. The reason is that observed transport demand is the effect of several factors and not only of GDP. Even if looking just at the overall demand, other influencing variables are e.g. the cost of the energy, the organisation of the logistical chain, the economic integration between different areas, the development of foreign trade, etc. When the analysis is carried out on demand segments (e.g. demand by different mode of transport) other factors become relevant. For instance, the growth of air transport in the last years have been fundamentally driven by a new supply model (budget carriers) rather than by the GDP growth. All in all, in order to capture the only effect of GDP growth on demand by using observed data, quite a sophisticated econometric analysis would be needed, but this task could have not been completed within the scope of this project.

A simpler approach has been followed. For the HOP! project, several model runs were made using the System Dynamics model ASTRA[7]. The results of these runs provide (among other results) forecasts of GDP and transport demand on a yearly basis until 2050. In some of these runs and for some years, the only difference is the GDP growth, all other elements (e.g. fuel price, transport policies) being the same. Therefore, by comparing transport demand and GDP growth in these conditions, it has been possible to estimate a relationship between the two elements. The analysis has been carried out separately for different demand segments defined according to:

- Passenger/freight;
- Mode of transport;
- long and short distance;
- Country groups.

Country groups have been analysed instead of single countries, because the demand and economy trends in any single country are partially dependent on specific calibration parameters in ASTRA and therefore results could be biased. By grouping countries, the impact of such parameters is minimised.

The outcome of the analysis has been a set of ratios between GDP growth and demand growth for a given demand segment (e.g. car demand for short distance trips in Central-West Europe countries). In order to use these parameters for the definition of the transport demand for the sensitivity analysis, the assumptions concerning alternative GDP growth had to be defined. It has been decided to adopt two alternative scenarios:

- In one scenario the economic growth is halved with respect to the reference trend;
- In the other scenario the economic growth is two times faster than in the reference trend.

Both these two assumptions keep the GDP growth rates in a realistic range and, at the same time, change the reference scenario enough to allow a clear understanding of the impact of these elements on the model results.

Thus, the ratios between economic growth and demand growth have been applied to the two alternative set of values for the GDP growth to estimate the overall changes of the amount of demand for each segment at the year 2030. This information has been provided to TREMOVE as input, an example is shown in Table 37 below. Since the demand is the same in the base year, an interpolation has been made to compute the differences year by year as needed by TREMOVE.

[7] See Annex I

Table 37 Example of GDP change impact on transport demand

Passenger transport demand by mode, distance and European region	Demand changes in the year 2030 if average growth rate of GDP	
	decreased 50%	increased 100%
Central West Europe: AUT, BLX, GER, FRA, NLD, CHE		
PKM SHORT CAR	-6%	15%
PKM SHORT PUBLIC MODES	-5%	5%
PKM LONG CAR	-8%	19%
PKM LONG PUBLIC MODES	-16%	36%
PKM LONG AIR	-21%	57%

The full list changes that were implemented can be found in Annex II.

VI.1.2. Fuel price

Ex-tax fuel price is readily available as parameter within TREMOVE and can be manipulated with ease.

VI.2. Performing the runs

The changes in GDP have their effect in an exogenous manner. The changes discussed above were implemented as a modification the demand input database.
On top of that, a modification was made to the vehicle stock input parameter RLOGITPGDP. While this only directly influences the sales logit procedure, it can have consequences on fleet composition and fuel consumption. As this parameter can not be changed between simulation and basecase runs, it was set as an input of the basecase as well (i.e. the value in the input DB was modified).

Fuel price changes were introduced as a scenario run, with the RFCOSTCOMP parameter value being doubled or halved from 2011 on. Note that these values do not necessarily reflect a realistic evolution, but are introduced for the sake of the sensitivity analysis alone.

A total of 8 extra runs were performed, 4 for each baseline.

VI.3. Analysis of the runs

As demand changes resulting from the change in GDP are exogenous, we refer to Annex II for the comparison between the (alternative) baseline's basecase (BC) and the new BC's. This paragraph will discuss the main differences between the BC runs and the scenario runs, with a focus on the evolution in fleet (as a result of both fuel price and GDP variation) and demand (as a result of fuel price variation). As a corollary, any trends in evolution of emissions will also be evaluated.

VI.3.1. TREMOVE baseline

VI.3.1.1. High GDP growth

a. High fuel prices

A first important conclusion is that all modes that rely on fossil or biofuel see a relatively large decrease in demand. For 2030, with the exception of busses (-0.65%) and planes (-2.5%), all passenger modes see a decrease of between 4 and 7%. Due to the income effect, rail modes (train and metro/tram) and slow mode also see a minor decrease in overall demand (less than 1%). Freight road modes by "small" vehicles

(LDT, HDT1, HDT2) decrease by around 3%. HDT3 and HDT4 demand drops by around 5.3% in 2030 compared to the basecase. Non-road freight however sees an increase of 0.3% (both freight trains and inland ships).
Also noteworthy in terms of demand is that EU15 countries experience less of drop than EU12 countries.

The shift in overall stock per category is more or less proportional to the shift in demand. When drilling down to vehicle type, more interesting trends are revealed. By 2030, a clear shift towards small(er) and/or diesel cars occurs, while big gasolines go down 25% compared to the basecase.in the categories that have both diesel and gasoline, the share of diesel vehicles increases by about 1.5%, while gasolines decrease by 14-18% for all 31 TREMOVE countries.

b. Low fuel prices

As could be expected, demand trends are about the opposite as in the previous case. The same groups can be identified: the increase in fossiel/biofuel powered passenger modes is between 2 and 3%. Other passenger modes (including busses) have only a minor increase (due to the income effect) between 0 and 1%, with air again somewhat exceptional (increase of 1.29%) Light freight road transport increases by 1.5-2%, with heavy transport at 3% in the plus. Rail and IWW are expected to decrease marginally (-0.15%)

For stock, the same opposite trend shows: a shift towards larger gasoline vehicles occurs for all categories with multiple types. The overall vehicle fleet grows by about 2.3%, while CO_2 emissions grow by 3%.

VI.3.1.2. Low GDP growth

a. High fuel prices

In demand, trends are almost identical to those with high GDP growth and high fuel prices, as only fuel price really externally influences demand.

In stock, it becomes obvious that the influence of GDP in vehicle choice (sales logit) is of much smaller importance than that of fuel price. This is demonstrated by the fact that the shift towards small(er) and/or diesel cars is almost identical (in%) to that with high GDP growth. Overall CO_2 emissions of transport (as calculated by TREMOVE) are about 20% lower with lower GDP growth though.

b. Low fuel prices

The trends in this run are largely a combination of the two previous ones, in terms of evolution of demand, stock and emissions.

VI.3.2. TREMOVE alternative baseline

VI.3.2.1. High GDP growth

a. High fuel prices

Relative demand evolution is completely similar to that of the standard baseline.
In the evolution of vehicle stock, the trend towards smaller diesel cars still exists, but the effects are not as large. This is likely due to the policy of fuel tax harmonisation, which closed the gap between diesel and gasoline end-user prices. Due to the high fuel prices, the demand for small, fuel-efficient cars is still present (large diesels decrease by 12%, large gasolines by 14%, small diesel increase by 6%, small gasolines only decrease 1.5%). Still, it is clear the share of diesel in the fleet increases, only to a lesser extent than in the standard baseline – which also had a higher GDP (this also limits the growth of diesels).

b. Low fuel prices
With low fuel prices, passenger transport demand increases by about 1.5% in total (cars: 1.7%). Freight transport evolves the same way.

In stock, only small diesels are less represented in the fleet compared to the basecase run. All other car types see an increase in their numbers, especially big cars.

VI.3.2.2. Low GDP growth

a. High fuel prices
The relevant effects reported above are generally combined here. In these most unfavourable circumstances for transport development, overall demand drops by 3% in pkm and 4% in tkm compared to the basecase. Compared to the alternative baseline (outside of the sensitivity analysis), overall demand for passenger transport went down by almost 12%. In freight, it is a decrease of more than 24%.

b. Low fuel prices
The effects discussed before apply here. With low GDP growth and low fuel prices, combined with fuel tax harmonisation, the share of gasolines and of big cars in the fleet increases. CO_2 emissions are 2.3% higher than in the basecase run.

VI.4. Conclusion of sensitivity analysis

The influence of GDP on demand was calculated exogenously. When changing GDP as an internal parameter (to the vehicle sales logit), the effect on demand evolution is almost non-existent (demand doesn't change by more than 0.2% for any category). The effect on vehicle stock is very moderate as well. When comparing the output of a "high GDP growth" scenario with a "low GSP growth" scenario for the 31 TREMOVE countries, the difference in effect of GDP on relative fleet evolution is never greater than 0.5%, except for CNG cars. This is mainly due to the very small changes in EU15 countries, which have a high GDP already. In countries with a lower than average GDP, as many of the EU12 countries, the effect is bigger. This is in line with common logic, as income is more of a limiting factor in vehicle choice there.
To summarise: the internal effect of a GDP growth change is relatively small, but more important in countries with a lower than average initial GDP.

Changing fuel has a substantial impact on demand levels, particularly for car, van and trucks above 16 tonnes. It is remarkable that the effect of a high fuel price is larger in absolute terms than that of a fuel price decrease (vkm: high fuel -3.32%, low fuel +1.73 in the TREMOVE alternative baseline with high GDP growth; other cases show a similar trend). In vehicle stock, the trend is very much alike: in case of high fuel prices, the vehicle types that are expected to go down (big, gasoline) go down more than they go up in the case of low fuel prices. For vehicle types that expect an increase (small, diesel), the opposite is true: they go up more in case of high fuel prices than they decrease in case of low fuel prices.
The main conclusion that can be drawn from the analysis is that the effect of a fuel price increase is more significant than that of a fuel price decrease.

VII TREMOVE Maritime model

The main TREMOVE model covers four modes: road, rail, inland waterways and air, and allows for policy modelling on relevant parameters.
While the main model works on a country-by-country basis, maritime transport is more often than not an international form of transport, outside individual countries' borders. Therefore, a separate model was developed to model emissions of this transport mode. For information on this model's history and development, we refer to the TREMOVE website (www.TREMOVE.org).
The maritime model was also updated in this project.

VII.1. Model updates

Following updates took place:

- Extension of the time scope of the model to 2030
- Update of activity data (callings and vkm)
- Update of emission factors for NOx, SOx and PM taking into account new MARPOL regulation
  - For NOx
    - From 2010 all ships (new and existing) compliant with TIER I
    - From 2011 TIER II for all new ships
    - From 2016 TIER III for all new ships operating in ECA's (emission controlled area)
  - For SOx
    - From 2010 on 1.0%S fuel equivalent in SECA's (sulphur emission controlled area)
    - From 2015 on 0.1%S fuel equivalent in SECA's
    - From 2020 on 0.5%S fuel equivalent in non SECA's
    - (EU regulation; 0.1%S in ports from 2010 was already taken into account in previous version)

VII.1.1. Extend the model to 2030

All calculations have been extended to 2030 (previously, this was 2020).

VII.1.2. Update of activity data

TREMOVE maritime used vkms and port callings provided by ENTEC for the year 2000. It then applied growth percentages to these data. We did not change the approach.

The activity growth figures have been updated based on the growth figures for the maritime activity in the EXTREMIS project. Until 2005, Extremis provides figures based on statistics/historical data. After 2005, the figures are based on a prognosis.

For this reason, the activity data fluctuate much more between 1995 and 2005 than they did in the previous TREMOVE maritime version. The previous TREMOVE version also used a similar growth figure before and after the year 2000. After 2005, actual activity figures increase more gradually as it concerns a prognose, not measured data.

VII.1.3. Update of emission factors

We included the different above mentioned MARPOL emission regulations in the TREMOVE maritime model.
To take into account emission regulation applicable outside (S)ECA, we calculated detailed reduction factors. Reduction factors are calculated depending on engine (SSD-slow speed diesel, MSD-medium speed diesel, HSD-high speed diesel, GT-gas turbine, ST-steam turbine) fuel type (Gas oil, Medium derived oil, Residual oil), main engine ore auxiliary engine and activity (sea, maneuvering, berth). For the (S)ECA's, reduction factors have been applied on emissions per country or per sea (not on emission factors).

For the NOx emission factors, the ENTEC emission factors we used in the previous version were the starting point. On the emission factors, we applied the following operations.

From 2010 the emissions are limited to the TIER I emission limit. (MARPOL implementation) We adapted emission factors to take this into account. As a consequence, a downward step is seen in the emissions in 2010. The TIER I emission factor was calculated was based on the assumption that 4% of the ships were responsible for the reduction in the emission factor between 2000 and 2001. These 4% of ships were new TIER I ships. We assumed 4% as ENTEC assumed a fixed renewal of 4% of the year, or a fleet renewal after 25 years at a fixed replacement rate.
From 2011, TIER II ships are introduced. We calculated an average emission factor for the ships of the fleet by making a weighted average of emission factors of TIER I and TIER II. The weights of TIER I and TIER II ships come from the Flemish EMMOSS model which includes a detailed vehicle stock data base.

From 2016, TIER III ships are introduced. We assume they only reduce emissions in ECA's. We applied a reduction factor of 75% to all activities in ECA's, sailing, maneuvering and berth.

For the SOx emission factors, the emission factors used in the previous TREMOVE version have been adapted from 2020 on to take into account the reduction in sulphur content from 2.7%S to 0.5%S. Also PM emission have been adapted, those emission factors have been reduced. For the SECA's, reduction factors have been applied on country or sea emissions (not on emission factors).

We remind that the reductions for EU 0.1%S fuel in ports regulation from 2010 on have only been applied on the activity "berth", not on the activity maneuvering.

VII.2. Validation

Following validation checks were performed:

- Compare with previous TREMOVE results
- Compare with EU wide NOx emissions in 2020 from IIASA and Kris EU database.
- Verify whether evolutions in emissions of SOx and NOx in ECA's, non-ECA's and for sea and calling activity are logic.

All checks were within normal ranges.

Annex I: The results from HOP! as the input to TREMOVE

Elasticity of transport demand with respect to fuel price increase

This note reports the simulated impacts of different fuel prices on the transport demand based on the results of HOP! scenarios. In the HOP! project, alternative scenarios were simulated with the ASTRA model. Scenarios were differentiated for energy price and for other elements. Results are discussed in two sections: first, the short term impact of increased fuel prices in 2012 with respect to base scenario is presented, then the dynamic long term impact based on annual growth rates of fuel prices and of transport demand, computed for the time period 2010-2050, is reported.

VII.1. Short term impact on the transport demand of different fuel prices

VII.1.1. Methodological remarks

The responsiveness of transport demand to the different level of fuel prices were analysed ex-post on the basis on HOP! results for a specific time interval (i.e. 2010-2012).

The choice of this specific time period was made because of two mainly reasons:

1. In the HOP! scenarios, fuel prices and transport demand, change at any year and from scenario to scenario. A difference between scenarios at a given time depends on a different trend of each scenario from the base year to the time considered. Until year 2010, all scenarios (included baseline) have the same trend and all start to response mainly to changes of fuel price in this year. The choice of this year as starting one of our analysis allow us to not take in consideration a trend of fuel prices and of transport demand of previous years as there aren't significant differences.
2. The HOP! scenarios are different from each other for more than just fuel prices, mostly after year 2014. Thus, changes in the transport demand are caused by others factors such as the investments size, fuel taxes etc. For this reason, to avoid misleading interpretation, period after 2014 was excluded from analysis. Detailed description of the HOP! scenarios can be found at the end of this note.

To quantify a response of demand to fuel price two elements have been considered:

- differences of fuel prices in each of the nine scenarios with respect to starting level of the price in the baseline,
- differences of passenger-km (car, air) or of tonne-km (truck) in each of the nine scenarios with respect to the baseline.

Then the formula to calculate elasticity was applied:

$$e = \frac{\%\ change\ in\ \ demand}{\%\ change\ in\ \ price}$$

For identifying differences between European countries, the analysis was carried out separately for two groups of countries i.e. EU15 and EU12.

Three modes, car, air and truck has been considered because the user cost of other modes (public transport, rail, maritime) is only slightly dependent on energy prices in ASTRA since tariffs are regulated or market conditions play a much larger role (e.g. for maritime)
According to the mode of transport, a different price index has been considered:

- for car passenger demand, the mean price of gasoline and diesel was used, calculated separately for EU15 and EU12 countries,
- for air passenger demand, the price of kerosene was used. Air fuel price is not different by country in ASTRA,
- for truck freight demand, diesel price, was considered, calculated separately for EU15 and EU12 countries.

VII.1.2. Results of the analysis

Table 38 shows the sensitiveness of car demand (passenger-km) with respect to different level of prices for EU15 and EU12.

Table 38: The response of car passenger demand to fuel price – initial impact

Scenario	Car EU15			Car EU12		
	fuel* price change 2012/2010	**demand change 2012/2010**	*e*	**fuel* price change 2012/2010**	**demand change 2012/2010**	*e*
150 Smooth	4%	-0.4%	-0.11	3%	-0.2%	-0.07
220 Smooth	10%	-2.3%	-0.22	9%	-2.2%	-0.24
150 Early	88%	-16.5%	-0.19	77%	-12.3%	-0.16
600 Early	189%	-22.5%	-0.12	167%	-17.0%	-0.10
800 Early	211%	-23.5%	-0.11	187%	-17.9%	-0.10

* - mean of Gasoline and Diesel price

The table shows that the elasticity of car demand with respect to different changes of fuel price is variable according to the size of the price shock, but the relation is not linear. Indeed, elasticity tends to be quite limited for small price increase, it becomes higher (but still well below 1) when the price change is larger, but it returns to smaller values for big price shocks. Given this behaviour, the tests reveal that until price change is limited, only a marginal reduction of car demand is expected. Only when price shock becomes significant (i.e. price is almost doubled) demand reduction is noticeable. At the same time, most of car demand gives up before that price increase reaches dramatic level. In other words, when price is as much as 80% higher than the reference, demand reduction is almost as large as when price increases by 200%.

The differences between EU15 and EU12 are very limited and are not significant.

Table 39 reports results for the air passenger demand. The same behaviour as for car can be identified: very low elasticity for marginal price changes, then higher elasticity for significant price shocks and rela-

tively minor additional air demand losses when price increase is huge. Also the same insignificance of the difference between EU15 and EU12 is found.
Finally, Table 40reports the summary of the reaction of truck demand (tonnes-km) with respect to different level of prices for EU15 and EU12.

Table 39: The response of air passenger demand to fuel price – initial impact

Scenario	fuel* price change 2012/2010	Air EU15		Air EU12	
		demand change 2012/2010	*e*	Demand change 2012/2010	*e*
150 Smooth	7%	-0.2%	-0.03	-0.3%	-0.04
220 Smooth	19%	-4.8%	-0.25	-3.4%	-0.18
150 Early	161%	-29.7%	-0.18	-20.4%	-0.13
600 Early	345%	-43.0%	-0.12	-28.9%	-0.08
800 Early	385%	-45.5%	-0.12	-30.4%	-0.08

* - Kerosene price

Table 40: The response of truck freight demand to fuel price – initial impact

Scenario	Truck EU15			Truck EU12		
	fuel* price change 2012/2010	demand change 2012/2010	*e*	fuel* price change 2012/2010	demand change 2012/2010	*e*
150 Smooth	3%	-0.6%	-0.19	3%	-3.9%	-1.35
220 Smooth	10%	-2.3%	-0.24	9%	-3.8%	-0.45
150 Early	84%	-9.5%	-0.11	74%	-3.3%	-0.04
600 Early	184%	-9.9%	-0.05	162%	-13.5%	-0.08
800 Early	207%	-9.7%	-0.05	182%	-16.5%	-0.09

* - Diesel price

It is quite apparent that road freight demand is very rigid. Looking at EU15 countries, elasticity is in line with that of car demand for small fuel price changes, but it becomes very low for large price shocks. One should consider that fuel price is major share of truck costs, but still less than 50%, so a given change of fuel price corresponds to quite a lower change of total transport costs.

For EU15, the behaviour of road freight demand looks similar to car and air demand: huge price shocks (e.g. +200%) do not reduce demand much more than large price increases (e.g. +80%). In particular, demand is even not really further reduced in case of the largest price step. This result can be partially spurious, due to modelling reasons, but it is not totally implausible. It should be taken into account that demand reaction is taken from different scenarios, where fuel price is assumed to increase in a different size in the same period of time. Where demand can shift from trucks to alternative modes (shift is virtually impossible for short distance demand for instance) an increase of fuel price of 80% is probably large enough to give rise to the modal change. Furthermore, the ASTRA model takes into account, even roughly, capacity of alternative modes and accommodate a large number of tonnes-km on e.g. rail can be difficult (shifting 10% of road tonnes-km demand corresponds to increase rail tonnes-km of 40%).

For EU12 results are different. Truck demand is changed of the same amount for whatever price change from 3% to 74%. This is equivalent to a very high elasticity for the scenario where energy price changes is tiny and to a very small elasticity for the scenario where the fuel price change is large. This outcome is not very convincing and it is most likely caused by some unrecognized impact due to non-price elements. Results for the two most extreme scenarios are more realistic and show that the elasticity is larger than for EU15, which is plausible since rail freight still play a significant role in Eastern EU countries.

VII.2. Dynamic long term impact on the transport demand of different fuel prices

To quantify the impact of different trends of fuel price on transport demand over the whole period of simulation, the two following elements have been compared for the HOP! scenarios:

- the annual average growth rate of fuels[8] prices for the time period 2010-2050,
- the annual average growth rate of specific demand category in different scenarios for the time period 2010-2050.

From this analysis the two HOP! scenarios assuming extreme fuel prices have been excluded because the trend of energy price and demand is oscillating and therefore annual average growth rates are unreliable measures of what happens in the forecasting period.

Table 41 reports the results of the analysis for car passenger demand. A clear negative correlation exist between the growth rate of fuel price and the growth rate of car demand. In the reference scenario the average growth is of 1.5% per year (in real terms) and demand is expected to growth at a pace of 0.3% per year in the EU15 and of 0.52% per year in EU12. In alternative scenarios price growth rate is always above 2% per year and growth rate of demand is therefore reduced.

In EU15, when price growth rate is slightly more than 2% per year, demand growth rates is lowered to about 0.17-0.20% per year. When fuel price growth rate is larger than 2.5% per year, demand growth rate is further reduced to 0.10-0.15% per year. This means that a half percentage point more of fuel price growth is able to reduce of about 30% the growth rate of car demand and one percentage point more can halve the growth of car demand. It should be considered that the difference between 1.5% per annum and 2.5% per annum over 40 years means that price would increase of 150% instead of 80%.

In EU12 the impact is lower. When fuel price annual growth rate is around 2% the demand growth rates falls from 0.52% to about 0.45%, i.e. only 15% less. For price growth rates of 2.5% or more, demand growth rate is nearly 0.3% per year, i.e. 40% lower than in the reference scenario. This lower elasticity is motivated by a stronger underlying trend due to motorisation. It should be noted that HOP! scenarios forecasts that a faster growth of energy prices do not give rise to a lower economic growth and therefore the disposable income is increasing, especially in EU12 countries, thus sustaining motorisation trend and partially offsetting fuel price growth.

[8] The same fuels types mentioned in section 1 have been considered.

Table 41: Growth rates of car passenger demand and fuel price in alternative scenarios

Scenario	**Car EU15**		**Car EU12**	
	Price growth* 2010-2050	**Demand growth** 2010-2050**	**Price growth* 2010-2050**	**Demand growth** 2010-2050**
Ref 70	1.5%	0.30%	1.5%	0.52%
150 Smooth	2.4%	0.13%	2.4%	0.39%
150 Smooth no invest	2.8%	0.12%	2.9%	0.25%
150 Smooth reduced tax	2.3%	0.17%	2.4%	0.43%
150 Smooth carbon tax	2.5%	0.12%	2.5%	0.37%
150 Early	2.1%	0.21%	2.1%	0.50%
150 Late	2.2%	0.17%	2.3%	0.42%
220 Smooth	2.8%	0.10%	2.9%	0.34%

* annual average growth rate of mean value of Gasoline and Diesel price

** annual average growth rate

Table 42 shows the response of air passenger demand both in EU15 and EU12. Apparently, air demand is more sensitive than car demand. Interestingly, this difference did not appear for short term price changes (see section 1). So simulations results suggest that even if in the shorter terms air demand is no more elastic to energy price than car demand, in the longer term it is. This difference can be at least partially explained with diverse assumptions about the efficiency improvements: in ASTRA it is assumed that cars can benefit of larger energy efficiency gains, while for aircrafts unitary fuel consumption does not change much over time. So the relevance of energy price become larger and larger for air and this explains the higher elasticity in the longer term.

It can be noted that in those scenarios where air fuel price is supposed to grow faster, air demand is forecasted to be stagnating or even slightly decreasing in reaction. We are talking of average rates, so this result does not mean that air demand is steadily decreasing. Rather, it is in those years when fuel price reaches quite high values that air demand goes down so that at the end of the simulation period (2050) it is below the value at the reference year.

As for car, the impact is larger in EU15 than in EU12. In the reference scenario the growth rate is similar in the two areas, but it is higher in EU12 when energy price increases faster. Again, it is the more robust economic growth forecasted in the Eastern Europe countries that explain this difference.

Table 42: Growth rates of air passenger demand and fuel price in alternative scenarios

Scenario	Price growth* 2010-2050	Air EU15	Air EU12
		Demand growth** 2010-2050	Demand growth** 2010-2050
Ref 70	1.7%	0.63%	0.60%
150 Smooth	2.5%	0.09%	0.33%
150 Smooth no invest	3.5%	-0.27%	-0.04%
150 Smooth reduced tax	2.5%	0.14%	0.36%
150 Smooth carbon tax	2.4%	0.07%	0.31%
150 Early	2.2%	0.32%	0.48%
150 Late	2.3%	0.19%	0.38%
220 Smooth	3.0%	-0.12%	0.16%

* - annual growth rate of Kerosene price

** annual average growth rate

Finally, in Table 43 the growth rates of road freight performance under different trend of fuel (diesel) price. It is quite clear that road transport demand trend is only poorly affected by the energy price. Growth rates remain similar, even if for the EU15, at the end of the simulation the difference between alternative scenarios and the reference is of 50% more tonnes-km instead of 70%. For EU12 the reduction is small also at the end of the period and the impact of fuel price is basically negligible. This rigidity is explained by the economic growth as major driver of freight transport demand and by the fact that road is foreseen to remain the dominant transport alternative in the freight sector.

Table 43: Growth rates of road freight demand and fuel price in alternative scenarios

Scenario	Truck EU15		Truck EU12	
	Price growth* 2010-2050	Demand growth 2010-2050	Price growth* 2010-2050	Demand growth 2010-2050
Ref 70	1.7%	1.38%	1.6%	2.63%
150 Smooth	2.9%	1.06%	2.8%	2.40%
150 Smooth no invest	3.1%	1.03%	2.9%	2.43%
150 Smooth reduced tax	2.9%	1.07%	2.8%	2.41%
150 Smooth carbon tax	3.0%	1.06%	3.0%	2.40%
150 Early	2.6%	1.11%	2.5%	2.33%
150 Late	2.7%	1.11%	2.6%	2.35%
220 Smooth	3.4%	1.06%	3.4%	2.38%

* - annual growth rate of Diesel price

VII.3. The ten major HOP! modelling scenarios

Table 44: HOP! scenarios

Scenario name	Oil price in 2020 (€2000/bbl)	Investment size	Investment target	Fuel taxes	Price growth path
Ref 70	70	Low	Efficiency & New Sources	EU directives	Stable
150 Smooth	150	High	Efficiency & New Sources	EU directives	Smooth rise
150 Smooth no invest	150	Low	Neither	EU directives	Smooth rise
150 Smooth reduced tax	150	High	Efficiency & New Sources	Reduced Tax	Smooth rise
150 Smooth carbon tax	150	High	Efficiency & New Sources	Carbon Tax	Smooth rise
150 Early	150	High	Efficiency & New Sources	EU directives	Early Step
150 Late	150	High	Efficiency & New Sources	EU directives	Late Step
220 Smooth	220	Very High	Efficiency & New Sources	EU directives	Smooth rise
600 Early	600	High	Efficiency & New Sources	EU directives	Early Step
800 Early	800	High	Efficiency & New Sources	EU directives	Early Step

Source: up-front definition of HOP! scenarios

- The scenario *Ref 70* (Reference Scenario) assumes high amounts of oil reserves and can be seen as an optimistic scenario. It reaches an oil price of about 70 $€_{2000}$/bbl in 2020, smoothly rising to 140 $€_{2000}$/bbl by 2050. Investment in energy efficiency and alternative energy sources follows common trend. Taxation takes the current excise duties plus the changes through the diesel directive into account.
- The scenario *150 Smooth* assumes a smoothly increasing oil price which reaches a level of 150 $€_{2000}$/bbl in 2020. This leads to increased investment in energy efficiency as well as in alternative sources. The other HOP! scenarios vary one or more parameters to investigate the impacts of specific economic responses to high oil prices: the scenario *150 Smooth no invest* assumes that the level of investments remain more or less the same as in the reference scenario (*Ref 70*).
- *150 Smooth reduced tax* and *150 Smooth carbon tax* vary the taxation level: they simulate a tax reduction with the purpose to limit the increase of transport costs and a carbon taxation additional to *Ref 70* scenario aiming at higher tax revenues to compensate higher governmental investments.
- *150 Early* and *150 Late* vary the way oil prices increase: this could happen either in an early step between 2010-2013, which enables to look at the impacts of a short-term steep rise of high oil prices, and with a late step to look at the impacts if we assume a moderate oil price development, which suddenly turns out to be false.
- *220 Smooth* investigates a higher oil price than *150 Smooth* (> 220 €/bbl in 2020).

- Two variants of scenario *150 Early* explore the impacts of extraordinarily high oil prices reached with a step in the year 2020. *600 Early* assumes a price of 600 €/bbl in 2020, while *800 Early* assumes a price of 800 €/bbl in 2020.

Annex II: GDP impact on demand

This annex contains the assumptions on transport demand from GDP changes (doubled or halved), as used in the sensitivity runs. They are based on output of ASTRA.

assenger transport demand y mode, distance and Euro-pean region	Demand changes if average growth rate of GDP in year 2030:	
	decreased 50%	increased 100%
ntral West Europe: AUT, BLX, GER, FRA, NLD, CHE		
M SHORT CAR	-6%	15%
M SHORT PUBLIC MODES	-5%	5%
M LONG CAR	-8%	19%
M LONG PUBLIC MODES	-16%	36%
M LONG AIR	-21%	57%
rth Europe: FIN, SWE, DNK, NOR, GBR, IRL, LTU, EST, LAT		
M SHORT CAR	-5%	13%
M SHORT PUBLIC MODES	-11%	17%
M LONG CAR	-12%	37%
M LONG PUBLIC MODES	-26%	60%
M LONG AIR	-26%	68%
rth East Europe : SVK, POL, CZE		
M SHORT CAR	-19%	31%
M SHORT PUBLIC MODES	-4%	4%
M LONG CAR	-14%	45%
M LONG PUBLIC MODES	-6%	12%
M LONG AIR	-23%	64%
uth East Europe: CYP, BLG, HUN, ROM, SLO, GRC		
M SHORT CAR	-12%	22%
M SHORT PUBLIC MODES	-1%	1%
M LONG CAR	-11%	31%
M LONG PUBLIC MODES	-18%	45%
M LONG AIR	-21%	56%
uth West Europe: ESP, ITA, PRT, MLT		
M SHORT CAR	-11%	21%
M SHORT PUBLIC MODES	-1%	1%
M LONG CAR	-8%	20%
M LONG PUBLIC MODES	-11%	25%
M LONG AIR	-12%	33%

Freight transport demand by mode, distance and European region	Demand changes if average growth rate of GDP in year 2030:	
	decreased 50%	increased 100%
Central West Europe: AUT, BLX, GER, FRA, NLD, CHE		
TKM SHORT ROAD	-17%	43%
TKM SHORT RAIL	-16%	34%
TKM LONG ROAD	-17%	43%
TKM LONG RAIL	-17%	40%
TKM LONG SHIP	-20%	48%
North Europe: FIN, SWE, DNK, NOR, GBR, IRL, LTU, EST, LAT		
TKM SHORT ROAD	-15%	38%
TKM SHORT RAIL	-13%	26%
TKM LONG ROAD	-28%	98%
TKM LONG RAIL	-32%	100%
TKM LONG SHIP	-32%	100%
North East Europe: SVK, POL, CZE		
TKM SHORT ROAD	-23%	60%
TKM SHORT RAIL	-24%	90%
TKM LONG ROAD	-38%	121%
TKM LONG RAIL	-43%	120%
TKM LONG SHIP	-43%	120%
South East Europe: CYP, BLG, HUN, ROM, SLO, GRC		
TKM SHORT ROAD	-19%	47%
TKM SHORT RAIL	-12%	31%
TKM LONG ROAD	-25%	83%
TKM LONG RAIL	-31%	93%
TKM LONG SHIP	-34%	100%
South West Europe: ESP, ITA, PRT, MLT		
TKM SHORT ROAD	-23%	60%
TKM SHORT RAIL	-13%	44%
TKM LONG ROAD	-19%	55%
TKM LONG RAIL	-25%	70%
TKM LONG SHIP	-23%	58%