



## **Assessment and improvement of methodologies used for Greenhouse Gas projections**

Annex E of the final report to DG Environment under service contract no. ENV.C.2/SER/2006/0008

*Additional information to the guidelines for transport*

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# **1 Annex E-1: Methodology for producing vehicle km statistics and average vkm for petrol and diesel cars**

Table 1 EUROSTAT statistics

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
At																
Be											75750	76980	77990	78310		
Dk			30065	30502	31376	32526	33540	34749	35663	36892	36928	36809	37673			
Fi	33430	33130	36050	35500	35400	35760	36000	36790	38080	39190	39815	40680	41675	42565	43530	
Fr	318000	324000	334000	340000	352000	350100	355000	360700	371300	382800	382900	398200	401400	404200		
De	431488	496410	509958	517823	505705	514414										
Gr																
Ie	19271		20540	21558	22894	24826	27312					27505				
It																
Lu																
Nl			83325	85336	89094	89973	89661	93081								
Pt			30300	33150	36000	38400	41250	44250	47250							
Es																
Se	59400	60500	61100	54460	55184	56279	56571	56596	57005	58573	59162	59507	60934			
uk			349216	386974	395364	405113	415568	424955	421395	442602	444406	452043	433071	470612		
Cy																
Cz				27184		26110				31181	31330	31707	33445			
Ee						3957			4763	5095	5140	5238	5430	5895	6249	
Hu																
Lv											5731	6392	6268		7486	
Lt													8626	9992	12772	
Mt																
Pl	34194	39726	42283	73100	75100	75150	80500	85350								
Sk																
Si	4749	4055	4338	4806	5221	5640	6232	6622	6660	7098	7207	7580	7820	8096	8464	

Table 2 *EUROSTAT + completed data*<sup>1</sup>

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
At	44865	46500	48675	50505	52185	53910	55350	56745	58305	60135	61455	62730	59805	60810	61635	64707
Be	63077	64807	65640	67123	69093	69871	70930	72088	73263	74769	75750	76980	77990	78310	79287	76117
Cz	27669			27184	26581	26110	29024	30838	31767	31181	31330	31707	33445	33730	35258	35575
De	398126	496410		517823	505705	514414	531959	534594	540851	549067	568044	575936	579388	584048	580619	560084
Dk	31584	31664	30065	30502	31376	32526	33540	34749	35663	36892	36928	36809	37673	37901	37821	37284
Ee	4749	4055	4338	4806	5221	5640	6232	5378	4763	5095	5140	5238	5430	5895	6249	6169
Es	182099	190312	198888	204034	208482	215738	223951	232224	243639	255737	264876	275532	284367	297279	283684	277928
Fi	33430	33130	36050	35500	35400	35760	36000	36790	38080	39190	39815	40680	41675	42565	43530	44101
Fr	318000	324000	334000	340000	352000	350100	355000	360700	371300	382800	382900	398200	401400	404200	407920	402301
Gr	31201	31938	32872	35209	37279	39636	42066	44964	48132	49298	50679	52718	55812	58746	60597	63744
Hu	19290	20087	20415	20772	21616	20614	22461	22774	21974	22340	23401	24531	25949	27399	27925	33114
Ie	19254	16598	20540	21558	22894	24826	27312	22527	23769	25210	26213	27505	28757	29950	31460	33471
It	367621	382411	394626	397603	397778	404152	402500	407694	420224	427266	433902	442624	450282	445520	434964	419370
Lt	14717	16460	9818	7694	6237	8667	9368	9457	9151	7174	5586	5615	5474	5500	5309	5269
Lu	3825	4005	4164	4343	4564	3214	3220	3636	3688	5260	5440	5620	5561	6178	6504	4506
Lv	3503	1980	2110	2216	2655	3506	4010	4557	5101	5555	5731	6392	6268	6851	7486	7334
Nl	85263	86192	83325	85336	89094	89973	89661	93081	96458	100537	103948	106975	109767	111121	113061	112934
Pl	52542	39726	42283	73100	75100	75150	80500	85350	88620	91290	98403	100586	95170	105139	111340	108533
Pt	26286	28583	30300	33150	36000	38400	41250	44250	47250	50800	54178	57031	59616	63618	67020	65177
Se	59399	60500	61100	54460	55184	56279	56571	56596	57005	58573	59162	59507	60934	60858	61411	61200
Si	4749	4055	4338	4806	5221	5640	6232	6622	6660	7098	7207	7580	7820	8096	8464	7617
Uk	375387	376076	349216	386974	395364	405113	415568	424955	421395	442602	444406	452043	461328	470612	488883	481252

<sup>1</sup> For Lt the results are questionable due to conflicting trends in petrol consumption figures and car registration figures.

Table 3 Estimated VHKM by diesel cars

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
At	8150	6646	11051	14177	17406	20465	24428	27308	27382	31240	33320	35370	35681	37546	39019	42824
Be	20915	22914	21787	24867	27128	28184	30650	34633	36006	39070	42017	43885	46032	45822	49174	48401
Cz				13214	10949	8989	9823	11327	13497	10596	12116	10915	10559	9949	10830	11373
De				88378	102403	105616	123402	124923	128644	134248	169927	185775	190179	208821	213259	211141
Dk	4911	3559	849	1763	2571	2197	2575	2825	2945	4128	4388	4696	5223	5295	5467	5654
Ee								1887	1400	1859	1854	1289	1765	2352	2803	2620
Es	32082	34757	33388	46947	46969	65785	64137	73766	83804	96344	111393	121351	133270	148099	139166	140612
Fi	2688	2683	5918	7619	7037	7852	9077	9046	10722	11966	13437	13771	13928	14459	14588	15293
Fr	23466	39130	50956	72192	97789	108176	121276	131070	145939	157200	166263	183214	192413	205646	216609	221293
Gr	-6194	-6249	-6114	-4144	-2567	-1220	-1257	13	1176	1189	1204	1233	1283	1326	1351	1404
Hu	-1158	1859	3570	3836	5043	4559	7340	7494	5739	6370	8047	8861	10338	10704	10794	13042
Ie	5374	2537	5644	7153	8125	9331	10900	4901	4103	3802	3437	3665	4114	5148	5754	6182
It	123434	123838	115708	111218	105970	102155	97323	99779	107833	116673	137938	148830	161653	165643	168982	169889
Lt																
Lu										1554	1888	2126	2253	2692	3026	2232
Lv										868	1064	1448	1368	1917	2474	2379
Nl	24544	25883	21419	21007	23210	22427	21214	24932	27297	30067	34867	35809	36930	37429	39137	39432
Pl											22892	29317	27620	39898	46549	47028
Pt							7083	10132	11817	14752	17159	21897	22308	27165	31667	31347
Se	7038	7570	7672	4518	5010	5368	6325	7254	8824	9934	10897	10697	10918	10875	11908	11881
Si										1520	1391	1712	2154	2519	3410	2589
Uk						71112	74720	84996	86346	105959	111951	123727	131313	152474	174756	177320

## 1.1 Methodology to complete EUROSTAT statistics: data

### 1.1.1 Country specific data

Private cars

- EUROSTAT vehicle km statistics;
- EUROSTAT car registration statistics for petrol cars and diesel cars;
- petrol and diesel consumption statistics from CRF reporting.

Transport by trucks

- ton-km and vehicle km statistics from EUROSTAT.

### 1.1.2 Common data

- time dependent default average fleet energy consumption per km for petrol cars and gasoline cars

## 1.2 Methodology to complete EUROSTAT statistics: assumptions

In the published vehicle km statistics (see Table 1) it is empirically observed that increases in vehicle km statistics are mainly explained by increasing car registrations. In symbols:

$$(AKMP * NP + AKMD * ND) / (NP + ND) = Vhkm / (NP+ND) \approx constant (1)$$

AKMP: Average KM driven by petrol car

AKMD: Average KM driven by diesel car

NP: number of petrol cars

ND: number of diesel cars

Depending on the availability of historical Vhkm statistics in Table 1, this constant has been derived in two different ways:

- Average value period (1999-2004) if Vhkm are available in that period
- An estimate (A) obtained by an expert judgment methodology (see below) (ex. 15000 km /year)

These estimates is used to replace values when Vhkm statistics are missing.

AKMP is calculated from petrol consumption (CRF data) using the default average fleet energy consumption for petrol cars and a scaling factor C expressing the country specific petrol relative efficiency which is primarily determined by the composition of the petrol car fleet. The methodology for the determination of the scaling factor C is described below.

$$AKMP = C * Petrol\ consumption / default\ average\ fleet\ energy\ consumption\ for\ petrol\ cars$$

$$AKMD = (Vhkm - AKMP * NP) / ND$$

- Diesel consumption for cars is calculated from the default average fuel consumption per km for diesel cars.

- Diesel consumption for other transport is calculated as the remaining diesel consumption.

### **1.3 Methodology for the determination of the country specific relative energy efficiency parameter C and the average Vhkm driven by cars A**

Basically we use a combination of maximum likelihood estimation and expert judgment. Maximum likelihood estimations are used to get a first guess of the parameters. Final acceptance of the parameters is basically based on expert judgment and validation of two additional theoretical considerations.

Two additional assumptions are introduced for the maximum likelihood specification:

- The average kilometer driven by diesel cars (AKMD) should be more or less stable between 1999 and 2005. Two cases are considered. First, if total v hkm are known, then AKMD is calculated as a difference and its value is only sensitive for the parameter C. Second, if recent v hkm statistics are not available, then an additional estimate A is required. Then AKMD is sensitive to the assumption of A too.
- Transport of goods is the main source for other diesel consumption. Average per ton km diesel consumption (fuel-tonkm) is approximated by diesel consumption for other transport divided by ton km. This variable should not fluctuate too much between 1999 and 2005.

Theoretical considerations to judge the validity of the parameter estimations:

- $AKMD > AKMP$   
Average km driven by diesel cars is higher than for petrol cars. In MS with an increasing share of diesel cars we often observe a small decrease in AKMD and AKMP. This can be explained by a shift from petrol cars to diesel cars.
- $0.8 < C < 1.2$   
For MS with many small petrol cars we expect a  $C > 1$  whereas for MS with many big petrol cars we expect  $c < 1$ .

Maximum likelihood specification:

Different specifications have been used, including only the first additional assumption, only the second one, or both simultaneously.

- The first additional assumption is translated in the following way:  $(AKMD/(\text{average } AKMD)-1)$  is normally distributed between 1999 and 2005 with mean 0 and variance  $\sigma^2$ . Stability in AKMD means minimum  $\sigma^2$ . We minimize the sum of the squared terms.
- The second additional assumption is translated in a similar way.

In practice, the first assumption appeared to be the more useful one. The second assumption (stable fuel-consumption per ton-km) had to be released frequently because of the impact of international transport on fuel sales and vehicle km statistics.



*Table 4 Average year km, petrol relative efficiency estimates, and average yearly km driven by petrol cars and diesel cars, results*

	avg-km -2005 A	petrol - rel eff C	Averg km petrol	Averg km diesel	Share diesel
At	15.00	1.00	10.80	18.66	0.53
Be	16.55	1.00	12.09	20.97	0.50
Dk	19.89	1.15	18.55	33.28	0.09
Fi	18.91	1.08	14.07	53.12	0.12
Fr	13.79	1.03	11.80	15.95	0.48
De	12.98	0.93	10.22	23.41	0.20
Gr	18.00	1.00	17.75	48.00	0.01
Ie	19.87	1.00	18.88	25.83	0.14
It	14.00	1.20	11.20	22.09	0.26
Lu	20.00	1.00	18.48	21.82	0.45
Nl	16.72	1.14	12.99	36.05	0.16
Pt	10.30	1.20	7.85	15.51	0.32
Es	15.18	1.18	11.94	20.63	0.39
Se	14.94	0.87	12.67	57.84	0.05
Uk	17.90	1.03	14.29	33.44	0.20
Cz	9.12	0.76	7.60	15.73	0.19
Ee	12.57	0.80	8.53	34.35	0.16
Hu	9.92	0.80	7.0700	26.16	0.15
Lv	10.56	0.94	8.73	18.54	0.19
Lt	4.03	1.00	4.03		0.00
Pl	10.00	1.00	6.90	24.25	0.18
Sk	10.08	1.00	10.08		0.00
Si	10.03	0.50	7.35	20.44	0.20

## **2 Annex E-2: private transport income and price elasticity**

Table 5 presents the results from a regression analysis to determine GDP and price elasticity. The first row contains the point estimates. The second row contains the standard errors of the point estimates. The price for fuel is a weighted average of petrol and diesel price. The weights are the respective numbers of petrol and diesel cars.

Alf1: GDP elasticity

Alf2: Price elasticity

Alf0: Scaling parameters (regression constant)

Lam: System dynamics parameter  $\text{Alf1} \cdot (1 - \text{Lam})$  represents the short term income elasticity

ser: Standard error of regression  
 r<sup>2</sup>: R squared statistic  
 DW: Durban Watson

Table 5 Vehicle km GDP and price elasticity estimates

MS	alf 0	alf 1	alf2	lam	ser	R2	DW	sample
At	2.498 1.329	0.709 0.108			0.021	0.84	1.67	1991-2005
Be	1.561 0.886	0.295 0.787	-0.072 -0.066	0.807 0.316	0.014	0.96	1.78	1991-2005
Dk	0.597 0.667	0.794 0.089		0.411 0.210	0.020	0.95	1.62	1991-2005
Fi	0.941 0.389	0.685 0.108	-0.070 0.028	0.697 0.206	0.042	1.00	2.00	1997-2005
Fr	1.445 0.441	0.768 0.074	-0.389 0.029	0.367 0.174	0.011	0.98	2.47	1991-2005
De	-19.943 8.140	2.456 0.659	-0.357 0.241		0.022	0.78	1.63	1994-2005
Gr	-0.020 0.611	0.985 0.419	-0.078 0.606	0.894	0.019	0.99	1.85	1991-2005
le	1.826 2.440	0.682 0.396	-0.486 0.447	0.689 0.277	0.105	0.72	1.93	1991-2005
It	2.290 1.310	0.853 0.126	-0.154 0.082		0.019	0.87	0.74	1991-2005
Nl	-0.664 0.631	0.937 0.175	-0.041 0.116	0.622 0.137	0.013	0.99	1.55	1994-2005
Pt	4.422 1.642	0.626 0.095	-0.445 0.118	0.296 0.267	0.016	0.92	2.61	1994-2005
Es	0.225 0.618	1.037 0.097	-0.227 0.132	0.113 0.077	0.024	0.98	1.38	1991-2005
Se	5.090 1.485	0.423 0.042	-0.100 0.044	0.211	0.063	0.98	1.88	1996-2005
Gb	2.217 1.838	0.808 0.167	-0.058 0.076		0.029	0.92	2.13	1991-2005
Cz	1.628 0.891	0.709 0.142		0.415 0.121	0.019	0.93	2.24	1996-2005
Ee	4.160 0.539	0.530 0.064			0.030	0.92	2.19	1998-2005
Hu	-3.571 1.686	1.509 0.630		0.401 0.512	0.040	0.94	2.13	1996-2005
Lv	1.154 0.648	0.605 0.410		0.683 0.200	0.042	0.97	2.84	1996-2005
Lt								

MS	alf 0	alf 1	alf2	lam	ser	R2	DW	sample
PI	0.549	0.923			0.028	0.94	2.49	1996-2005
	0.996	0.084						