Assessment and improvement of methodologies used for Greenhouse Gas projections

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Additional information guidelines service sector

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1 Annex D -1: Correction for heating degree days

1.1 Statistical relationship between HDD and energy use of the service sector

Econometrically we can observe a log-linear relationship between the fuel use for space heating & sanitary hot water (SHW) and the heating degree days. This relationship is explained in Annex D-3.

The resulting, statistical significant elasticity for different MS have been listed in Table 1. These values express the % average increase/decrease of the service energy consumption for an increase/decrease of 1% for the number of degree days.

Table 1 Energy use of service sector for heating and SHW: heating degree days elasticity for selected EU MS

Member State	**HDD elasticity**
At	0.42
Be	0.14
Cz	0.52
De	0.20
Dk	0.27
Ee	0.92
Es	0.04
Fi	0.29
Fr	0.26
Gr	0.06
Hu	0.26
Ie	0.27
It	0.19
Lt	0.43
Lv	0.43
Nl	0.38
Pl	0.30
Pt	0.01
Se	0.04
Uk	0.28
Sk	0.24
Si	0.07
Average value	**0.27**

These figures are all smaller than 1%, which implies that changes of the outside temperature are not completely translated into a higher/smaller energy use. Furthermore, the resulted average elasticity are – obviously - smaller than that of the residential sector.

1.2 Temperature corrections of historical figures

Fluctuation of degree days is an important parameter explaining short term fluctuations of energy consumption for heating. In order to determine (changes in) trends in historical energy consumptions (other than temperature), it is recommended to calibrate the historical figures to normal temperature calibrated historical energy uses, by means of the following formula:

$$Xcal_t = Xhist_t * CF_t \text{ with: } CF_t = [\, HDD_n / HDD_t \,]^{\tau}$$

With: τ = HDD elasticity value, taken from Table 1 or a default value;
$Xcal_t$ = normal temperature calibrated historical energy use for heating and SHW in year t;
$Xhist_t$ = historical observation for heating and SHW in year t;
CF_t = correction factor year t;
HDD_t = observed degree days in year t;
HDD_n = long term average degree days (e.g. average of 1990-2005).

1.3 Errors in historical figures of fuel consumption

Historical figures of fuel consumption are mostly based on purchase number. These purchases of fuel do not completely reflect the real consumption of fuels in one year, because (voluntary and involuntary) yearly stock movements should be considered too. In general, the following equation holds true on a yearly basis:

consumption = purchases - changes in stocks hold by service sector

An increase in stocks is likely to be followed by a decrease in stocks in the following year. Therefore, it might be useful to plot a three yearly moving average of the historical energy consumption (corrected for HDD) for all fuels:

$$Xcal_{t,av} = average\ (Xcal_{t-1}, X\ cal_{t}, X\ cal_{t+1})$$

1.4 Heating Degree Days assumptions in GHG projections

GHG projections are explicitly or implicitly based on expectations of degree days. Preferably, the energy projections for heating and SHW depart from an average value over a longer period, for instance the average value of 1990-2005.

1.5 Summary

How to handle heating degree days in the projections of the energy consumption for space heating and SHW?

- First of all, the historical energy consumptions for heating & SHW must be corrected for HDD. Therefore, the historical observations can be calibrated to normal temperature calibrated historical observations by means of HDD elasticity.

- Secondly, a three yearly moving average of the calibrated historical consumptions is recommended to correct for the discrepancy between fuel stocks and fuel consumption.
- As a result, a time series of calibrated historical fuel consumption will be obtained which can be used for the projections.

Concerning the projections, these are preferably based on the average HDD over a longer period (e.g. 1990-2005).

2 Annex D-2: Correlation GDP/number of employees and energy consumption for heating and SHW

2.1 Statistical relationship between GDP and energy use for heating and SHW

Econometrically we can observe a log-linear relationship between the fuel use for space heating & sanitary hot water (SHW) and the GDP. This relationship is explained in Annex D-3.

The resulting, statistical significant GDP elasticity for different MS have been listed in Table 2. These values express the % average increase/decrease of the tertiary energy consumption for an increase/decrease of 1% for the GDP.

Table 2 Energy use for heating and SHW: GDP elasticity for selected EU MS

Member State	**GDP elasticity**
At	1.11
Be	0.27
Cz	0.57
De	0.20
Dk	0.24
Es	1.06
Fi	0.38
Fr	0.30
Gr	0.58
Hu	0.34
Ie	0.59
It	0.90
Lt	0.75
Lv	0.81
Nl	0.35
Uk	0.19
Pt	1.08
Se	0.20

Member State	GDP elasticity
Ee	0.20
Pl	0.20
Sk	0.25
Si	0.11
Average value	**0.49**

2.2 Statistical relationship between total number of employees and energy use for heating and SHW

Econometrically we can observe a log-linear relationship between the fuel use for space heating & sanitary hot water (SHW) and the total number of employees in the service sector. This relationship is explained in Annex D-3.

The resulting employee elasticity for different MS have been listed in Table 3. Given the fact that employee data of a too short time period are used in this analysis, the employee elasticity can not be considered as statistical significant.

Table 3 Energy use for heating and SHW: employee elasticity for selected EU MS

Member State	GDP elasticity
At	2.40
Be	-0.50
Cz	1.34
De	-0.38
Dk	0.49
Es	0.89
Fi	0.38
Fr	0.07
Gr	0.53
Hu	1.16
Ie	0.80
It	0.29
Lt	1.12
Lv	0.92
Nl	0.39
Uk	-0.08
Pt	0.83
Se	-0.26
Ee	1.09
Pl	0.87
Sk	-0.09
Si	0.35
Average value	**0.57**

The values of the East-European countries are higher than those of the other MS. So, these countries have a good correlation between the number of employees and the energy use for heating.

3 Annex D-3: Econometrical estimation of HDD, GDP and employee elasticity

3.1 HDD and GDP elasticity

The regression analysis to determine the HDD and GDP elasticity of each member state is based on the following equation:

$$Log(energy\ use) = \alpha_0 + \alpha_{GDP} * (1-\lambda) * log(GDP) + \alpha_{HDD} * log(HDD)$$
for year x in member state y

With: energy use = fuel use of member state y in year x
α_0 = scaling parameter (regression constant);
α_{GDP} = long term GDP elasticity
λ= system dynamics parameter - α_{GDP} * (1-λ) represents the short tem income elasticity;
GDP =Gross Domestic Product year x;
α_{HDD} = HDD elasticity;
HDD = number of heating degree days in year x.

The required statistics for this analysis are based on Eurostat data of 1990 to 2005. Table 4 presents the results from this regression analysis. The first row contains the point estimates, the second row the standard errors (se) of the point estimates. Grey zones mean that this parameter could not be estimated accurately for this country. As a consequence it is fixed at 0.2 or zero.

Table 4 Energy use for heating and SHW: statistical parameters of the regression analysis to determine HDD and GDP elasticity

Member State		α_0	α_{GDP}	α_{HDD}	λ	*ser*	*R^2*	*DW*
at		-1.532	1.112	0.421	0.549	2.1%	97%	1.945
	se	1.070	0.128	0.083	0.210			
be		4.192	0.271	0.139	0.565	3.0%	74%	2.342
	se	2.146	0.263	0.108	0.288			
cz		1.655	0.570	0.520	0.475	9.9%	54%	0.405
	se	10.162	1.287	0.496	1.292			
dk		4.251	0.237	0.269	0.477	1.1%	90%	1.707
	se	2.404	0.059	0.307	0.042			
de		1.398	0.200	0.198	0.876	1.2%	83%	1.082
	se	1.178		0.035	0.104			

Member State		α_0	α_{GDP}	α_{HDD}	λ	*ser*	*R²*	*DW*
ee		0.805	0.200	0.923	0.606	6.4%	58%	2.163
	se	1.150		0.333	0.223			
es		0.383	1.060	0.041	0.203	1.5%	99%	1.936
	se	0.461	0.035	0.046	0.186			
fi		6.565	0.380	0.290	0.000	2.1%	88%	1.773
	se	1.935	0.046	0.182				
fr		2.854	0.298	0.264	0.689	1.4%	87%	1.377
	se	2.610	0.158	0.048	0.321			
gr		3.066	0.576	0.058	0.505	2.1%	97%	2.190
	se	2.105	0.063	0.099	0.289			
hu		4.980	0.336	0.264	0.345	2.0%	88%	1.797
	se	1.265	0.065	0.080	0.119			
ie		2.618	0.587	0.268	0.358	2.0%	99%	1.850
	se	0.886	0.029	0.154	0.179			
it		1.427	0.899	0.187	0.037	1.3%	96%	2.086
	se	0.980	0.055	0.053	0.261			
lt		0.506	0.750	0.426	0.719	1.2%	85%	1.954
	se	1.888	0.615	0.510	0.095			
lv		0.282	0.812	0.429	0.783	3.2%	97%	1.987
	se	0.535	0.253	0.142	0.041			
nl		6.853	0.353	0.379	0.000	0.1%	94%	1.872
	se	0.565	0.026	0.041				
pl		1.508	0.200	0.304	0.844	3.9%	82%	2.234
	se	1.387		0.151	0.140			
pt		0.656	1.075	0.011	0.177	3.6%	96%	2.489
	se	0.870	0.088	0.068	0.255			
se		4.150	0.000	0.040	0.691	2.9%	65%	2.290
	se	2.021		0.142	0.149			
si		1.354	0.107	0.066	0.870	4.8%	90%	1.597
	se	1.093	1.237	0.143	0.212			
sk		5.137	0.248	0.241	0.386	4.4%	23%	0.996
	se	3.135	0.192	0.187	0.251			
uk		4.789	0.192	0.283	0.546	1.4%	74%	1.787
	se	2.836	0.070	0.077	0.270			
Average			**0.476**	**0.274**				

It should be remarked that the above mentioned elasticity can change when another reference period than 1990-2005 is used, when the data are expressed in a different kind of HDD than 18-15, … It is also strong dependent on the data quality. Therefore, it is recommended to check if the resulting elasticity reflects the historical energy uses quite well. This requires a good understanding of the historical energy statistics.

3.2 Employee elasticity

The regression analysis to determine the employee elasticity of each member state is based on the following equation:

$$Log(energy\ use) = \alpha_0 + \alpha_{employee} * log(employee) + \alpha_{HDD} * log(HDD)$$
$$for\ year\ x\ in\ member\ state\ y$$

With: energy use = fuel use of member state y in year x
α_0 = scaling parameter (regression constant);
$\alpha_{employee}$ = employee elasticity;
Employee = number of employees of year x;
α_{HDD} = HDD elasticity;
HDD = number of heating degree days in year x.

The required statistics for this analysis are based on Eurostat data of 1999 to 2005. 1990-2005 is a too small reference period to perform an accurate statistical analysis. So, the resulting employee elasticity (Table 3) is not statistical significant.