Project No 213744

SECURE
Security of Energy Considering its Uncertainty, Risk and Economic Implications

SP1 – Cooperation
Collaborative project
Small or medium-scale focused research project

DELIVERABLE No 5.8.2
Energy efficiency and security of supply of primary energy in the residential sector

Due date of deliverable: End September 2009
Actual submission date: 4^{th} December 2009

Start date of project: 1/1/2008 Duration: 39 months

Organisation name of lead contractor for this deliverable: FEEM
Contributions by OME (Section 3)

Revision: 1
(16th March 2010)

Project co-funded by the European Commission within the Seventh Framework Programme		
Dissemination level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	X
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Energy efficiency and security of supply of primary energy in the residential sector

Fondazione Eni Enrico Mattei (FEEM)

Table of contents

1. Introduction

This Deliverable follows Deliverable 5.8.1, with which it shares the same approach and methodology. For economy of space all general background information concerning energy use in the EU, the methodology applied in the empirical analyses and the database used, are provided in that Deliverable; therefore, the interested Reader is referred to that Deliverable for an overview of energy consumption and carbon emissions in Europe.

This Deliverable is in a sense a "residual" report in that it covers al what is not clearly identifiable as industrial or transport energy use. It thus covers energy efficiency for both residential demand as such, and for the so called "other sectors " (agriculture and tertiary sector). Again, due to the peculiarities of the sectors considered, it is not possible to use the same indicators of energy efficiency for all the subsectors. In particular:

- Energy intensity, that is, the ratio between energy consumption and value added, makes sense only for sectors yielding measurable economic value. Thus it will be used for the analyses of the service and agricultural sectors;
- For the residential sector, whose contribution to the welfare of the economy cannot be measured in terms of value added, an index of energy efficiency based on physical quantities is applied.

The rest of the report is organized as follows. Section 2 describes the methodology used to compute energy efficiency indexes and presents a descriptive analysis of such indicators for the EU residential sector. Section 3 (provided by OME) reviews the fuel switching and energy reduction potential in the residential sector.

Section 4 presents and discusses the results of our panel analyses, whose methodological approach was illustrated in Deliverable 5.8.1. Section 5 concludes. Annex I lists and explains the variables used in the econometric analyses.

2. Energy efficiency of the Residential Sector within the European Union

The energy intensity index cannot capture the efficiency of the residential sector, since household activities does not generate value added directly. For this sector, one needs to resort to indexes unrelated to economic values, such as the energy efficiency index. In contrast with energy intensity indicators, in fact, the energy efficiency index is based on measures of unit consumption, that is, on physical/technological measures.

Hence, it follows that the influence of economic structural changes, as well as the impact of other factors which are not directly associated to a strict definition of energy efficiency, are not considered in the construction of the indicators.

The classical energy efficiency (E.E.) index ranges between 0 and 100. A decrease in the index is to be interpreted as an improvement in energy efficiency.

The E.E. index is calculated by weighting the changes in unit consumptions (UC), according to the consumption's share of the sector they refer to. UC are defined at a more disaggregated level by relating energy consumption to an indicator of activity measured in physical terms. UC are expressed in different units, depending on the sub-sector or end-use, in order to provide the best proxy of energy efficiency. The final E.E. index is a pure number (that is, it is not expressed in terms of any unit of measure).

UC for the households sector, are not of course pure numbers, but are expressed in physical units: toe per dwelling or per m^2 for heating, toe per dwelling or per capita for water heating and cooking and kWh per dwelling or per appliance for electrical appliances as televisions, fridge, freezers, washing machines, dish washers.

Two alternative but equivalent methods can be used in order to calculate E.E. indices:

1. Weighted index

The E.E. index is calculated as a weighted average of unit consumption indices by sub-sectors. Its interpretation is easier, as the value obtained is directly linked to the variation of E.E. within each sub-sector. The idea is to calculate the variation of the weighted index of UC between a base year and year *t*, as follows:

$$\mathrm{I}_t/\mathrm{I}_0 = \left(\sum_i EC_{i,t} * \left(UC_{i,t} / UC_{i,0} \right) \right)$$

where UC_i indicates the unit consumption index of a sub-sector *i* and EC_i is the share of sub-sector *i* on total consumption. The E.E. index is then calculated by taking the data starting point as base year.

The following table illustrates the calculation of the E.E. index in a simple example of two transport modes:

Table 1:Computation of the E.E. Weighted index for two transportation modes

	Unit	1990	1991	1992	1993
Consumption					
Cars	Mtoe	135	136	140	142
Air	Mtoe	28	29	30	32
Unit Consumption					
Cars	l/100 Km	8.7	8.5	8.4	8.3
Air	Ktoe/pax	80	79	74	73
Share					
Cars		0.828	0.824	0.824	0.816
Air		0.172	0.176	0.176	0.184
Energy Efficiency Index	*It/ It-1*		0.9788	0.9787	0.9878
1990=100	*It / I0*100*	**100**	**97.9**	**95.8**	**94.6**

2. Aggregation method based on the UC effect

An alternative method to compute E.E. indices is used for the industrial sector and its sub-sectors, since it provides better information about the energy saved or the unit consumption effect (ESCU). This effect measures the influence on consumption of the variations of UC between year *t* and a base year which are due to technological changes. It is calculated by multiplying the activity production (A) by the UC difference. Thus, a variation of UC implies a reduction of the consumption and of the E.E. index.

$$\mathrm{I}_t = \frac{E_t}{E_t - ESCU_t} \qquad ESCU_t = A_t * \left(CU_t - CU_0\right)$$

Table 2. Example: calculation of the E.E. index with the aggregation method based on the ESCU (Sector: Primary Metals).

	Unit	1990	1991
Production	Mt	25	30
Unit Consumption	Toe/t	0.0076	0.070
Consumption	Mtoe	1.9	2.1
Energy Efficiency Index	Base year 1990=100	**100**	**92**

$$ESCU_t = A_t * \left(CU_t - CU_0\right) = 30*(0.070-0.076) = -0.18$$

$$\mathrm{I}_t = \frac{E_t}{E_t - ESCU_t} = \frac{2.1}{(2.1+0.18)} = 92$$

In this Section energy efficiency indexes are computed for the households sector. The time-span covered by the available data does not allow us to verify how energy efficiency has improved in the decades before 1980 and after 2004.
Table 3 shows the percentage change in the energy efficiency index in the EU-15 and Norway between 1980-2004 by considering separately the sub-samples 1980-1992 and 1993-2004. That is, it shows whether in the residential sector significant changes have occurred.
The resulting ranking of these countries does not illustrate necessarily the more or less "virtuous" countries in terms of energy efficiency: only the countries that had the more significant changes are reported. That is, these tables show only the countries that have been able to benefit from their potential of energy efficiency improvement.
Since data are not available for all EU15 countries, we are not able to depict an overall description of the improvements in energy efficiency for the household sector. However, statistical evidence suggests that the most significant improvements in the energy efficiency of the household sector have been achieved by countries like Portugal and Norway. As it can be seen from this table, in Portugal, the increases in energy efficiency in the two sub-samples have been 12.9 and 42.4 percentage points, respectively. In Norway, improvements have been more impressive. Although in Norway, during the 1980-1992 period, energy efficiency has decreased by 15.8 percent, this country was able to raise energy efficiency standards. Consequently, during the 1992-2004 period, energy efficiency has increased by, approximately, 11.7 percent.

Table 3: Percentage Change of Energy Efficiency in the EU-15 Countries and Norway, 1980-2004. Household sector.

HOUSEHOLD (% change in EE Index over period)

1980 - 2004			1980 - 1992		1992 - 2004	
PT	-49.8%		-31.7%	DK	PT	-42.4%
DK	-43.4%		-18.0%	SE	DK	-17.2%
SE	-28.5%		-12.9%	PT	AT	-16.3%
AT	-24.9%		-10.3%	AT	SE	-12.8%
FR	-17.1%		-10.0%	FR	NO	-11.7%
FI	-16.1%	Median	-7.9%	FI	FI	-8.9%
DE	-10.5%		-6.9%	UK	DE	-8.5%
UK	-8.7%		-2.2%	DE	FR	-7.9%
IT	-4.2%		0.5%	IT	IT	-4.7%
NO	2.2%		15.8%	NO	UK	-1.9%
ES	142.7%		40.5%	ES	ES	72.7%
BE	n / a		n / a	BE	BE	n / a
EL	n / a		n / a	EL	EL	n / a
IE	n / a		n / a	IE	IE	n / a
LU	n / a		n / a	LU	LU	n / a
NL	n / a		n / a	NL	NL	n / a
Average =	-5.3%		-3.9%			-5.4%
Median =	-16.1%		-7.9%			-8.9%
St. Dev =	0.516		0.188			0.280
Minimum =	-49.8%		-31.7%			-42.4%
Maximum =	142.7%		40.5%			72.7%

Notes: Countries are ordered according to their energy intensity. Arrows show significant movements between quartiles over time. Source: Authors' calculations on Odyssee (ENERDATA) data.

This reversal in the general trend has been argued to be due to the policies introduced by these countries in order to boost energy savings and energy conservation. The lesson that can be drawn from the experience of these countries, is that the implementation of these policies is feasible, not only in countries with high indexes of economic and social development like Norway, but also in countries that have to do efforts in order to reduce the gap they have with respect to the rest of Europe (such as Portugal).

Table 3 illustrates how large is the potential for improvement for the energy efficiency of the household sector for the less performing countries such as Italy, where the improvement in energy efficiency achieved by this sector has been equal only to 25 percent of the median change, and, approximately, a tenth of the improvement that more efficient countries (namely, Portugal and Denmark) have registered over the same period.

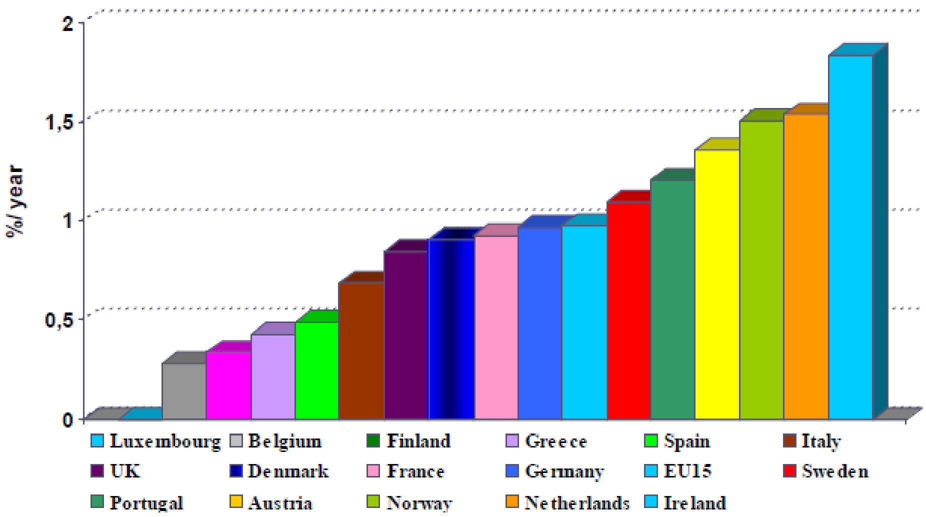
3. Energy saving potentials in the residential sector[1]

Looking at the IEA studies on energy efficiency, in the residential sector, the average energy consumption per dwelling in the EU-15 reached in 2004 between 1.1 and 2.3 toe per year, with an European average of 1.7 toe per year. This average energy consumption in 2004 was slight below its 1990 level. The changes in the average energy consumption per household result from a mix of different factor that have countervailing influence:

- Genuine energy efficiency improvements brought about by more efficient new buildings and appliances and by most energy substitutions tend to lower energy consumption
- Larger dwellings, more appliances, increased heating are driving energy demand upwards.

Energy efficiency improved by 11% (0.9% per year) in the household sector between 1990 and 2004. Most of the progress was achieved before 1996. Large appliances experienced the biggest energy efficiency improvements: 20% since 1990 (1.5% per year). In most countries, energy efficiency increased by around 1% per year, which corresponds to the target of the European Energy Efficiency Directive.

Figure 1 Energy Efficiency trends by country between 1990 and 2004 in the household sector



(*source: ODYSSEE*)

The EU has been very active in setting up a legal framework for energy efficiency. In Europe, most countries have taken a particularly active role in responding to, and transposing, energy efficiency-related Directives across all sectors from the European Commission. This activity included preparing the National Energy Efficiency Action Plans – under the Energy Services Directive (2006). In the residential sector, the

[1] This Section has been prepared by OME

members have been active in transposing and recasting the Energy Performance of Buildings Directive (2002) and extending the energy efficiency and labeling requirements for energy-using products and electrical appliances through transposing the Eco-Design and labeling Directives (1992, updated in 2008). The following examples present some case of implementation of measures to promote energy efficiency in the residential sector.
In Italy, in the recent past, the administration has made a number of amendments to energy efficiency policy. The country started a White Certificates Scheme in January 2005, and this scheme[2] was then amended by an Inter-ministerial Decree, and its duration extended from 2009 to 2014. Italy has been particularly proactive in providing financial support for energy efficiency. The 2008-2011 Economic and Financial Programming Document recently approved by the Italian Government provides for the pursuit and extension of fiscal measures to encourage energy efficiency of buildings and energy use equipment. Also, articles 351 and 352 of Budget Law 2007 included funding of 15 million € for 2007-2009 to underwrite a provision allowing a tax deduction worth 55% of the total amount of 2007 expenditures for the implementation of projects to enhance the energy efficiency of buildings.

Other European countries have set up similar policies, such as the United Kingdom, where the Energy Efficiency Commitment (2002-2005) programme required that all electricity and gas suppliers with 15,000 or more domestic customers must achieve a combined energy saving of 62 TWh by 2005 by assisting their customers to take energy-efficiency measures in their homes: suppliers must achieve at least half of their energy savings in households on income-related benefits and tax credits.

In France, the aggregate energy intensity decreased by around 1.1% from 1990-2005. This decrease was made up of a 0.6% decline due to improved energy efficiency and a 0.5% decline due to changes in economic activity and structure. France has also developed innovative financing products for the residential sector since 2007, when in partnership with banks low-interest loans for residential energy conservation projects were offered, financed through a special tax-free savings account.

3.1. Space heating

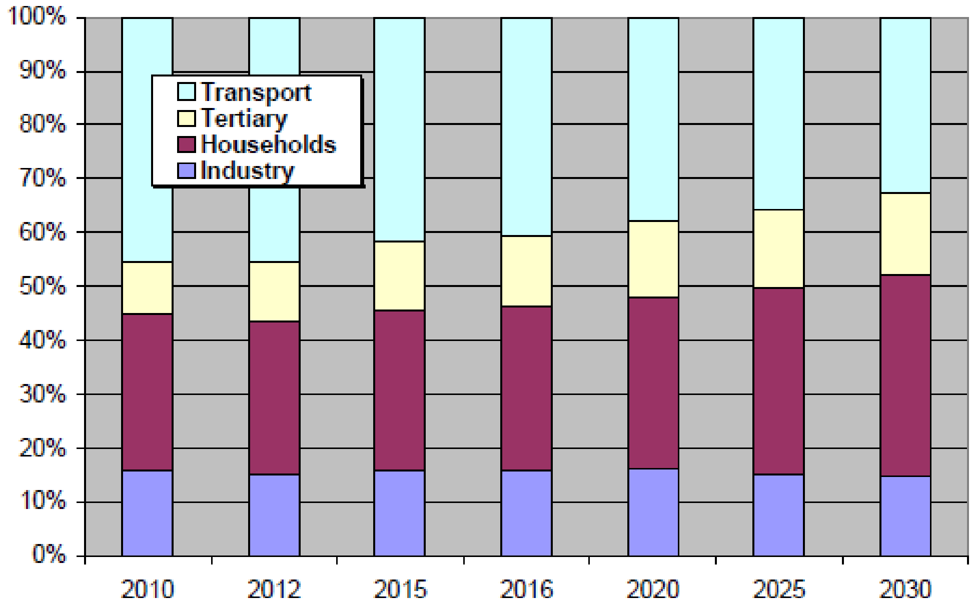
Space heating represents 68% of the households' energy final consumption in the EU-15 in 2004. In the southern European countries, this share is much lower than in the northern European countries (40% of the households' final energy consumption in Spain or in Portugal, 60% in the United Kingdom, 75% in Germany and in the Netherlands). The average amount of energy used per dwelling for space heating has not really decreased in the EU-15 since 1990: in 2004 it was only below its 1990 level. (source: ODYSSEE)

Appliances

2 A white certificate is an instrument issued by an authorized body guaranteeing that a specified amount of energy savings has been achieved. In most applications, the white certificates are tradable and combined with an obligation to achieve a certain target of energy savings.

According to the study of the European Commission published in March 2009 on Energy Savings Potentials[3], electrical appliances in the residential sector have the largest potential at the short term (2010) for improving its energy efficiency.

Figure 2: Sectoral contributions to the Energy savings potentials over time in relative terms.



(Source: Study on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries, Final Report, 2009)

Few measures concern the use of electricity in buildings, although the consumption of electricity for households appliances is steadily increasing. Electricity consumption in buildings is, growing at an average rate of 1.5% per year according to the ODYSSEE database. Electrical and electronic appliances represent 14% of household's final energy consumption and 62% of their electricity consumption in 2007.

Several European directives have been adopted during the 1990's in order to lay down minimal standards concerning energy efficiency. When they were implemented within the member states, the share of energy consumption of large household appliances[4] in the total electricity consumption of this sector was limited (54% in 1990, 45% in 2006). For example, refrigerators in the United Kingdom have decreased their energy consumption by 21% between 1995 and 2000. During the same period, freezers in the United Kingdom have decreased by about 25% their average electricity consumption. In general, large appliances display the best improvements in terms of energy efficiency in the residential sector in Europe.

3 *Study on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries*, Final Report, 2009

4 Large household appliances include : refrigerators and freezers, washing machines, dishwashers, hoods, microwave ovens, cooking appliances such as hobs, ovens, air conditioners

The share of the small household appliances consumption in the residential sector's total electricity consumption has on the contrary increased (38% of the specific total electricity consumption in 2006, and 27% in 1990).

Although the energy efficiency of large household appliances improved on average by 20% between 1990 and 2004, in the same time, the average consumption per household decreased of only 2% because the household appliances penetration rate grew up, thus counterbalancing the best part of improvements in technical efficiency (a clear example of the so called *rebound effect*) .

For instance, the technical improvements concerning computer and TV-set screens did not lead to energy savings because of their steadily growing sizes. Televisions have undergone a rapid transformation in recent years as flat-screen technology replaces bulkier traditional screens. Spurred on by falling retail prices, consumers continue to purchase televisions with larger screens for primary use, while often keeping existing televisions. Consequently, the number of televisions is growing in most countries. Televisions are also switched on for longer periods of time, although they may not be watched. Increased use of games consoles and program-recording devices have tended to extend viewing hours. These developments are leading to increases in energy use of approximately 5% per year, which will cause the global energy consumption of televisions to nearly triple by 2030 if current trends continue.

3.2. European policies concerning the energy efficiency of appliances

The policies implemented for appliances in the EU are specific to each step of the product's life cycle:

– During conception: set-up of standards, subsidies for research and development, agreements with the manufacturers
– During the commercialization: calls for tenders concerning more efficient products and technologies with specified criteria;
– During the buying phase: communication, labeling, subsidies.

Over the last 14 years, the Energy Labeling Directive (92/75/EEC) has proven a very effective policy instrument, leading to a significant improvement of the energy efficiency of the household appliances in the EU. The "A-G" label displayed on appliances such as washing machines, dishwashers, refrigerators or ovens has provided consumers information at the point of sales about energy consumption and hence the running costs of the product, thus steering the demand towards the best-performers. The European Commission aims to extend the scope of the Directive to energy-using products used in the industrial and commercial sectors and to other energy-related products which have an impact on energy consumption during use.

If fully implemented, the proposal is expected to result in energy savings corresponding to 27 Mtoe annually by 2020 or translates into the annual abatement of 80 Mt of CO_2 emissions (based on savings from commercial heating and refrigeration appliances and windows alone).

The Eco-design directive aims to integrate environmental standards as soon as possible during the design and the conception of the product, as well as applying a "life cycle" approach in the designing stage of the product. The Commission has adopted in December 2008 the eco-design regulation to reduce standby energy consumption of all household and office products. This regulation aims to cut the standby electricity consumption by almost 75% by 2020. The standby consumption of new products has to be less than 1-2 W as of 2010 and less than 0.5-1 W in 2013. The aim is to reduce by 2020 73% of the electricity consumption in "off mode" for those appliances within the EU. Currently, the electricity consumption of appliances when they are in "off mode" is around 50 TWh per year, which is more than 10% of the French total electricity consumption. The European Commission aims to reduce the energy consumption of electrical household appliances and of office products. In Europe, minimum efficiency standards for several types of appliances and products will be introduced in the next few years. These standards will be set by EU regulations that are to be based on the Eco-Design Directive (2005/32/EC). At this stage, the EU Commission has plans for proposing such standards for 19 product groups.

3.3.Lighting

Phasing out globally incandescent lamps are the first priority for energy-efficient lighting policy. Globally incandescent lamps are estimated to have accounted for 970 TWh of the worldwide final electricity consumption in 2005 (IEA, 2006). In the hypothetical case that all these lamps were to be replaced by compact fluorescent lamps, cumulatively this would reduce global net lighting costs by USD 1.3 trillion from 2008 to 2030, and avoid 6.4 $GtCO_2$ emissions at negative abatement cost. In Europe, lighting is by far the major end-use category in tertiary sector consumption, responsible for about 175 TWh or 26% of total electricity consumption in the tertiary sector (source: European Commission). Within the household's consumption, in 2004, the share of lighting energy consumption reached 14% (source: ODYSSEE).

A study of the European Commission[5] considers four different scenarios to assess the additional potential of energy efficiency for lighting:

– Autonomous Progress Scenario APS (which comprises autonomous progress and earlier policies such as the labeling Directives for electric appliances but excluding the success of important recent policies which are not yet fully implemented such as the

5 *Study on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries,* Final Report, march 2009, Directorate-General Energy and Transport

EU Performance Directive for Buildings and the CO_2 standards for cars and light duty commercial vehicles);

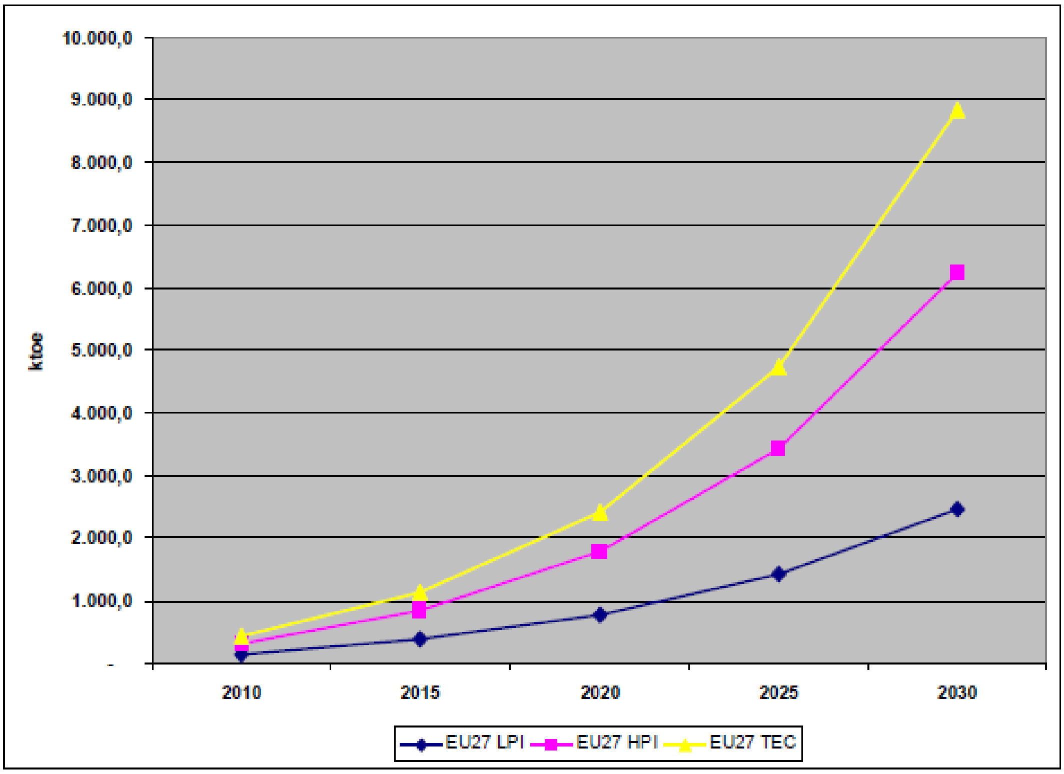
– Low Policy Intensity Scenario LPI, which implies continued high barriers to energy efficiency, a low policy effort to overcome the barriers and high discount rates for investments in energy efficiency);

– High Policy Intensity Scenario HPI (which implies removing barriers to energy efficiency, a high policy effort to overcome the barriers and low discount rates for investments, options are economic on a life cycle basis);

– Technical Scenario (TEC, includes also more expensive but still fairly realistic options; no exotic technologies).

This study highlights a high potential for improving energy efficiency from lighting in the residential sector, as illustrated in Figure 3:

Figure 3 Additional Energy Efficiency potential from Lighting by scenarios (EU-27, compared to the Autonomous Progress Scenario)



Source: European Commission, DG TREN

The European Commission's draft regulation "implementing Directive 2005/32/EC with regard to eco-design requirements for non-directional household lamps" aims at progressively phasing out incandescent bulbs between 2009 and 2012. It is estimated that the EU will save around 40 TWh and 15 Mt CO_2 per year.

Following its commitment under the European Union Energy Services Directive, Germany's 2007 National Energy Efficiency Action Plan aims to achieve 9% energy efficiency improvement between 2007 and 2016, incorporating a target of 933 PJ, with an interim target of 510 PJ for 2010. In the area of lighting, Germany, like other EU countries, has an established comparative energy label for household lamps and plans to develop new standards for office, residential and outdoor lighting products under the EU Eco-Design Directive.

By 2011, the United Kingdom aims to outreach the European directive in setting up minimal standards for energy efficiency concerning 21 products especially in the lighting sector.

4. Panel analysis of energy efficiency and energy security: Results

In this Section we illustrate the result of the panel analyses, whose methodology and dataset has been described in Sections 4 and 5 of Deliverable 5.8.1.

As mentioned there, our aim is to check whether the implementation of energy efficiency policies has had an effect in EU (EU15+Norway) countries on indicators of energy efficiency, carbon efficiency and security of supply. In particular we are interested in checking whether some policies had a sort of “double dividend” by having a positive effect on more than one of these indicators. Besides policy dummies, we also look at the effect of the macro drivers (GDP, prices, R&D, etc.)

In this Section we analyse such effects for the European residential sector (in Subsection 4.1) and for the consumption sectors usually grouped under the “other sectors” label in energy statistics, that is the tertiary sector and agriculture(in Subsection 4.2). As explained before, to assess energy efficiency we need to resort to different indicators according to whether the sector under scrutiny contributes to the officially recorded production of value added or not. Thus we will look to energy intensity for the “other sectors” and to a physical indicator of energy efficiency for the residential sector. For the same reasons it will not be possible to assess the carbon intensity of the residential sector, but we look at (per capita) emissions. The regressions’ results are reported in Table 4. Subsection 4.3 discusses briefly these results.

Table 4 Econometric Results of the Energy Intensity, Energy Security and Carbon Intensity Indicators

				Dependent variables								
				energy intensity/efficiency		**energy security**				**carbon intensity/emissions**		
			Unit	eioth	eehouody	esoth	esagter	eshou1	eshou2	cioth	ciagter	co2hou
Coefficients		Energy Price	US$/unit	-	-1.46	-0.01	-0.01	-	-0.01	-0.001	-	-0.01
		GDPppp	US$	-0.03	40.26	0.60	0.44	-11.68	0.36	-0.033	-0.06	0.38
		R&D	mio_pps	0.01	-	-	-	14.47		-	0.03	-0.20
		Share Industry	%	-	-	-	-	-		-	-	-
		Energy Production	ktoe	-	-	-	-	-		-	-	-
	Household Policy Variables	Hh01		-	-7.22	-	-	-		-	-	-
		Hh02		-	-12.03	-	-	-		-	-	-
		Hh03		-	-	-	-	-		-	-	-0.159
		Hh04		-0.007	-	-	-	-		-0.0254	-	-
		Hh05		-	-	-	-	-		-	-	-0.049
		Hh06		-0.010	-	-	-	-	-0.125	-	-	-0.11
		Hh07		-0.007	-	-0.1729	-	-		-	-	-
		Hh08		-	-	-	-	-		-0.008	-	-
		Hh11		-0.006	-19.28	-	-	-		-	-	-
		Hh12		-0.008	-14.64	-0.08	-	-5.2255		-0.008	-	-0.072
	Tertiary Policy Variables	Te02		-	-	-0.09	-	-		-	-	-
		Te06		-	-	-0.18	-	-		-	-	-
		Te07		-	-	-	-	-		-	-0.007	-
		Te08		-	-	-0.17	-0.156	-		-	-	-
		Te09		-	-	-	-	-		-0.015	-	-
		Te10		-	-	-	-	-		-	-0.005	-
	Cross-Cutting Policy Variables	Cc01		-	-16.712	-	-	-3.95		-0.0136	-	-
		Cc03		-	-16.513	-	-	-		-	-	-
		Cc04		-	-	-	-0.113	-		-	-	-0.097
		Cc07		-0.0081	-	-	-	-		-0.009	-	-0.074
R-square				0.67	0.46	0.47	0.37	0.3	0.3	0.76	0.55	0.46

Notes:
Eioth: energy intensity index other sectors (residential+tertiary+agriculture)
Eehouody: energy efficiency index - residential sector (Odyssee), 1980-2004
Esoth: energy security index - other sectors (proxy:Gas import/gas consumption)
Esagter: energy security index - agriculture+tertiary (proxy:Gas import/gas consumption)
Eshou1=energy security index - residential sector (proxy:Total GAS consumption/GDP)
Eshou2=energy security index - residential sector (proxy:Gas import/gas consumption)
Cioth: carbon intensity index - other sectors (residential+tertiary+agriculture)
Ciagter: carbon intesity index - agriculture+tertiary

4.1. Panel analyses of energy polices in the EU for the residential sector

The energy efficiency in the household sector appears to be improved by the application of a number of policies, both sector- and non sector- specific. In particular, mandatory standards for buildings and regulation for heating systems and hot water systems have proven effective, along with cooperative measures and cross cutting policies with sector-specific characteristics. Cross cutting policies such as the implementation of fiscal measures and general programs to improve energy efficiency or promote renewables also had a positive effect.

As to the macro variables, electricity price has a beneficial effect on this indicator, confirming that the share of household energy use which is not related to transport, mainly has to do with electrical appliances and lighting. On the other hand, increasing per capita income appears to be bad news for energy efficiency. This is probably linked to the well known high income elasticity of the demand of electrical appliances. Note that the same variable had a beneficial effect the aggregate[6]. There the efficiency gains due to shifts in the productive structure towards a less energy intensive setting, typical of richer economies may have prevailed and counterbalanced this detrimental one, specific of the household sector.

Carbon emissions. Energy prices and GDP per capita have an analogous effect as on energy efficiency: price increases improve the performance of this indicator and higher income worsens it. R&D expenditures have a small beneficial effect.

Residential policies improve this indicator, but with the exception of cross-cutting with sector-specific characteristics, they are different from those influencing the energy efficiency indicator: building regulations, legislative/informative measures, and grants or subsidies to promote energy efficiency. Again, some cross cutting policies are effective, in particular those related to financial measures.

If we look at the effect on **energy security** of policies aimed at energy efficiency in the residential sector and general cross cutting measures only the results are quite disappointing. Relying only on this family of policies has little or no effect on most energy security indicators. Only a couple of gas-related indicators of energy security appear to respond positively to these policies. In particular, the ratio of gas consumption and GDP turns out to decrease in presence of general support to energy efficiency and renewables, climate policies, and those cross cutting policies that have a more specific focus on households. Increasing income per capita appear to promote diversification of fuel use, while R&D's effect is detrimental in this case. Energy prices do not appear to be playing a significant role.

Note that these results are not directly comparable with those for the "other sector" below because the indicator chosen as energy security proxy is different. The other energy security indicator displaying some responsiveness to this family of policies is in fact the same proxy as for the "other sectors" (the ratio of gas imports to gas consumption); however in this case we obtained less significant results. In particular, in this case only grants and subsidies to promote energy efficiency in the residential sector had a significant beneficial impact. Macro variables behave as they do in the analogous

[6] see Deliverable 5.8.1, Section 6.1

regressions for the "other sectors" policies described below: increasing energy prices improve this indicator and increasing per capita GDP worsens it.

4.2. Panel analyses of energy polices in the EU for the "other sectors"

"Other Sectors" is a general aggregate used in energy balances that includes the residential sector , the tertiary sector and agriculture. It is not always easy to disentangle these three components.

Energy intensity is in this case measurable, since two out of three of its components do produce statistically recorded value added. It is however an upward biased measure, because there is nothing in the denominator related to the household sector. Nevertheless, this measure of energy efficiency seems to be sensitive to policies targeted at the residential sector: mandatory standards for electrical appliances, grants, subsidies or soft loans to encourage energy efficiency at home, along with cooperative measures and cross cutting policies with sector-specific characteristics have proven effective. Notice that these are not exactly the same set of household policies and measures that have a beneficial effect on the energy efficiency indicator, although some overlapping is present; this may be a side effect of the bias just highlighted. Measures aimed at the tertiary sector does not seem to influence this indicator, while general cross cutting policies have positive effects (again not the same policies as in the energy efficiency case).

Also the behaviour of macro variables is rather different: this time increasing energy prices have no effect on this indicator, while GDP per capita slightly improves it and R&D worsens it.

As to **carbon intensity and carbon emissions**, one notices a difference between this aggregate and the pure household per capita emissions. In fact for the more general aggregate, (i.e. carbon intensity in the "other sectors"), mandatory standards for electrical appliances, tax exemption and tax reduction, as well as cross cutting measures with sector specific characteristics are effective. Of the tertiary sector policies, cooperative measures only are effective. General cross-cutting measures in particular those aimed at improving energy efficiency or mitigating climate change or policies schemes to support renewable energy are also beneficial. Again increasing energy prices improve this indicator, this time, also GDP per capita improves this indicator. This is understandable as carbon intensity by construction gets lower as GDP increases.

Finally we also checked the different impact of policies of the subsectors on carbon intensity by disentangling the impact of policies aimed at the tertiary sector from those aimed at the household sector on the carbon intensity of the value generating subsectors (tertiary and agriculture). We found again sector-specific measures that work: fiscal support measures such tax exemptions or reductions for energy efficiency improving inputs and cross cutting measures with a focus on the tertiary or agricultural sectors. GDP per capita displays the same beneficial effect noted for the "other sector" aggregate while R&D quite surprisingly worsens this indicator.

To assess the sector's **energy security**, we look at both the joint effect of the policies aimed at the three subsectors together and the effect of these policies separately. More specifically we consider the effect of policies aimed at energy efficiency in the "other sectors" to see if these policies have an effect on the ratio of gas imports to total gas consumption. In terms of macro variables, in this case energy prices appear to improve this indicator, while GDP per capita worsens it.

In terms of policy variables, we found that soft loans to the household sectors and crosscutting measures with a residential focus do improve this indicator. Note that the same policy variables had a beneficial impact on the energy intensity of this aggregate. Also a number of policies aimed at the tertiary sector improve this dimension of energy security: soft loans for energy efficiency, renewable energy and CHP, regulations for building equipment and policy promoting information and education in energy efficiency. These policy, however had no effect on energy efficiency or energy intensity for this aggregate. No general cross cutting policy displays an effect. The effect of tertiary policy variable is not robust to the specification of the model: if we test only the policies aimed at the tertiary sector, and cross cutting policies, we find that only policies promoting information and training in energy efficiency issues and cross-cutting financial measures have a significant effect.

4.3. Discussion

In general, the fit of the econometric models analysed in this Deliverable is reasonable, (R-square ranging from 0.3 to 0.76), but on average lower than what noted for the overall economy and industry model of Deliverable 5.8.1. It is quite striking that energy efficiency policies aimed at the residential, tertiary and agricultural sector have very little effectiveness in improving energy security. However, there is an important difference between policies aimed at the household sectors and those aimed at the two remaining sectors: the former are all effective both on energy security and on energy intensity or efficiency, while none of the latter show this overlapping of areas of effectiveness. Cross cutting policies, which are very relevant in terms of multi dimensional effectiveness in the aggregate case (see Deliverable 5.8.1) play a less relevant role in the sectors examined in this Deliverable: only general programmes related to energy efficiency, climate change mitigation and renewable energy have this double beneficial effect, and only in terms of the ratio of gas consumption and GDP and household energy efficiency.

5. Conclusions

In this second Deliverable of SECURE's WP5.8 we have explored the relationships between energy efficiency and energy security, for the residential and for the tertiary and agricultural sectors in the EU 15 and Norway.

To this purpose we have provided a descriptive analysis of a few energy efficiency indicators and of the energy potentials in these sectors. As mentioned in the concluding Section of Deliverable 5.8.1, the distinguishing feature of this WP, is its original econometric approach applied to a dataset of policies and measures in the EU whereby panel analysis methods are used to assess the effect of such policies on energy efficiency, carbon efficiency and energy security.

The descriptive analysis of Sections 2 and 3 have highlighted a substantial effort of the EU both at the community and at the state level in improving energy efficiency in the residential sector. Varying results in terms of performance and speed across countries are noticeable, but they are difficult to assess in terms of pure energy efficiency due to the intrinsic cross-country incomparability of the index, that by construction mainly allows to track energy efficiency progress of a given country across time, but cannot tell us within any given pair of countries, which one has ever been more efficient than the other. Surely there has been since the 90's a growing policy activity in this area in the EU. While it has surely led to a number of success stories in terms of unit efficiency (take for instance the energy efficiency labeling for electrical appliances or the mandatory standards for lighting), their ultimate effectiveness has been limited by a significant presence of the rebound effect in the residential sector.

Thus, as noted in Deliverable 5.8.1, the significant commitment both at the EU level and at the national level, to put in practice policies and measures to promote energy efficiency is unquestionable. A more effective coordination among member states inspired by a shared strategy in the field of energy policy is what we found still missing in this landscape. This is a quantum leap whose urgency is clearly felt, and the recent developments in the EU energy policy appear as serious if not completely successful attempts to build it.
The resulting picture of converging but dishomogeneous policy efforts is an ideal field of application for panel analysis of the effectiveness of these policies both in terms of their original target and in terms of their co-benefits for energy security.
The general analysis on the economy as a whole performed in Deliverable 5.8.1 showed that quite a number of policies had a beneficial impacts on energy efficiency and carbon efficiency, but only general cross-cutting policies have proven also useful to improve the performance of aggregate energy security indicators. We noted in that Deliverable that in a more general perspective, it is the policy mix rather this or that policy in insulation that has been all in all, quite effective.

As to the main focus of this Deliverable, unfortunately, what said above about general indicators is still as good as it gets. In fact, restricting our analysis to the residential sector, the tertiary sector and the agricultural sector does not lead to sharper or more encouraging conclusions in terms of co-benefits on energy security of energy efficiency policies.

In fact it turns out that energy efficiency policies aimed at the residential, tertiary and agricultural sector have very little effectiveness in improving energy security. This is particularly true for the policies aimed at the “other” economic sectors: no overlapping between security and on energy intensity or efficiency is indicated as statistically significant, and this in general holds also for general cross cutting policies.

The same caveats as those pointed out in Deliverable 5.8.1 apply here: the analysis performed here could in principle be extended and refined, in particular if better data could allow us to look at more countries, and to use continuous, instead of binary, policy variables: such data, and long enough time series of energy indicators for new accession countries were not available or available for a decade or less of observations. The qualitative nature of the MURE database prevented us to assess the role of the intensity of the policy effort deployed (in terms for instance of the funds earmarked for a given policy or the financial impact of a given tax).

The analysis of the role of energy efficiency will continue in Deliverable 5.8.3, focused on district heating, and in Deliverable 5.8.4, focused on transport.

References

ADEME (2008), "L'efficacité énergétique dans l'Union Européenne: panorama des politiques et des bonnes pratiques", Paris, France.

CONFINDUSTRIA (2008) "Efficienza energetica in Italia. Tendenze e prospettive", Mimeo.

EUROPA Gateway to the European Union (2008), Synthèse du Plan d'action pour l'efficacité énergétique de l'Union Européenne (2007-2012)", Brussels, Belgium.

European Commission (2006) "Green Paper "Energy", COM(2006) 105 final. Brussels, Belgium.

European Commission (2009), "Study on the Energy Savings Potentials in the EU Member States, Candidate Countries and EEA Countries", Brussels, Belgium.

Geller H., P. Harrington, A.Rosenfeld, S. Tanishima and F. Unander (2006) "Policies for Increasing energy Efficiency: thirty years of experience in OECD countries" *Energy Policy*, 34, p.556-573

Greening, L.A. and Green, D.L., (1998). "Energy use, technical efficiency, and rebound effect: review of the literature". Conference Proceedings, Vol I. In: , 21st Annual International Conference of IAEE, Quebec, Canada, pp. 321–330.

IEA (2006), "Light's Labour's Lost – Policies for Energy Efficiency Lighting", Press Release, Paris, France.

IEA (2008), "Energy Efficiency Policy recommendations", Paris, France.

IEA (2008), "Energy Efficiency Requirements in Building Codes, Energy Policies for New Buildings", Information Paper, in support of the G8 Plan of Action, Paris, France.

IEA (2009), "Progress with implementing energy efficiency policies in the G8, Paris", France.

ISIS (2008), "MURE II Project. Best Available Technologies in Housing. Italian case study", Rome, Italy.

Markandya, A., Pedroso-Galinato, S. and Streimikiene, D., (2006). "Energy intensity in transition economies: Is there convergence towards the EU average?" Energy Economics 28, 121-145.

Odyssee (2007), "Evaluation of Energy Efficiency in the EU-15: indicators and policies", ADEME/IEEA, Paris, France.

Schipper, L., Meyers, S., Howarth, R., (1993), "Energy intensities in OECD countries: an historical analysis". International Journal of Global Energy Issues 5(2/3/4), 76}89.

Tipping, P., Antonelli R., Boonekamp, P., Donkelaar Kroon M., Longstaff T. McLeod K., Srinivasan G., Tigchelaar C. (2006) "Impact Assessment on the Future Action Plan for Energy Efficiency" (CLWP: 2006/TREN/032), ECN, The Netherlands (http://www.ecn.nl/docs/library/report/2006/e06041.pdf)

Trégouët, R. (2008), "L'efficacité énergétique: un enjeu économique et écologique majeur pour la France et l'Europe", www.enerzine.com.

Annex I – Data Dictionary

Variable	Description
Country	EU15 countries + NO
Year	1980 – 2006
EIfin EIind EIoth EItra	Energy intensity index; Final (all sectors) Energy intensity index; Industry sector Energy intensity index; Other sectors Energy intensity index; Transport sectors
EEhouOdy	Energy efficiency index; Residential sector; 1980-2004, Odyssee data
EEtraOdy	Energy efficiency index; Transport sector; 1980-2004, Odyssee data.
ESfin1	Energy security index (Total Imports/TPES); Final (all sectors)
ESfin2	Energy security index (Total Oil Consumption/GDP); Final (all sectors)
ESind1	Energy security index (Total Oil Consumption/GDP); Industry sector
ESind2	Energy security index (Total Gas Consumption/GDP); Industry sector
ESoth	Energy security index (Gas Import/Gas Consumption); Other sectors
ESagter	Energy security index (Gas Import/Gas Consumption); Agriculture & Tertiary sectors
EShou	Energy security index (Total GAS Consumption/GDP); Residential sector
EStra	Energy security index; Transport sectors;
CIfin CIind CIoth CIagter Citra CO2hou PReleHH PReleIND PRdiesel ShINDwdi R&Dpps GDPppsCur EnProdWdi	Carbon intensity index; Final (all sectors) Carbon intensity index; Industry sector Carbon intensity index; Other sectors Carbon intensity index; Agriculture & Tertiary sectors Carbon intensity index; Transport sectors Per capita CO_2 emissions; Residential sector Price in US$ of electricity residential (incl. taxes); Total Price (US$/unit) Price in US$ of electricity industry (incl. taxes); Total Price (US$/unit) Price in US$ of diesel (incl. taxes); Total Price (US$/unit), Household Industry, value added (% of GDP) (NV.IND.TOTL.ZS) WDI Total intramural R&D expenditure (GERD). Millions of PPS (Purchasing Power Standard). All sectors. EUROSTAT GDP per capita, PPP (current international $) (NY.GDP.PCAP.PP.CD), WDI Energy production (kt of oil equivalent) (EG.EGY.PROD.KT.OE), WDI
PMhhT1 PMhhT2 PMhhT3 PMhhT4 PMhhT5 PMhhT6 PMhhT7	P&Ms Household sector - Mandatory Standards for Buildings P&Ms Household sector - Regulation for Heating Systems and hot water systems P&Ms Household sector - Other Regulation in the Field of Buildings P&Ms Household sector - Mandatory Standards for Electrical Appliances P&Ms Household sector - Legislative/Informative P&Ms Household sector - Grants / Subsidies P&Ms Household sector - Loans/Others

PMhhT8	P&Ms Household sector – Tax Exemption / Reduction
PMhhT9	P&Ms Household sector – Tariffs
PMhhT10	P&Ms Household sector - Information/Education
PMhhT11	P&Ms Household sector - Co-operative Measures
PMhhT12	P&Ms Household sector - Cross-cutting with sector-specific characteristics
PMtrT1	P&Ms Transport sector - Mandatory Standards for Vehicles
PMtrT2	P&Ms Transport sector - Legislative/Informative
PMtrT3	P&Ms Transport sector - Grants / Subsidies
PMtrT4	P&Ms Transport sector – Tolls
PMtrT5	P&Ms Transport sector - Taxation (other than eco-tax)
PMtrT6	P&Ms Transport sector - Tax Exemption / Reduction / Accelerated Depreciation
PMtrT7	P&Ms Transport sector - Information/Education/Training
PMtrT8	P&Ms Transport sector - Co-operative Measures
PMtrT9	P&Ms Transport sector – Infrastructure
PMtrT10	P&Ms Transport sector – Social Planning/Organisational
PMtrT11	P&Ms Transport sector - Cross-cutting with sector-specific characteristics
PMinT1	P&Ms Industry sector - Mandatory Demand Side Management
PMinT2	P&Ms Industry sector - Other Mandatory Standards
PMinT3	P&Ms Industry sector - Legislative/Informative
PMinT4	P&Ms Industry sector - Grants / Subsidies
PMinT5	P&Ms Industry sector - Soft Loans for Energy Efficiency, Renewable and CHP
PMinT6	P&Ms Industry sector - Fiscal/Tariffs
PMinT7	P&Ms Industry sector - New Market-based Instruments
PMinT8	P&Ms Industry sector - Information/Education/Training
PMinT9	P&Ms Industry sector - Co-operative Measures
PMinT10	P&Ms Industry sector - Cross-cutting with sector-specific characteristics
PMteT1	P&Ms Tertiary sector - Mandatory Standards for Buildings
PMteT2	P&Ms Tertiary sector - Regulation for Building Equipment
PMteT3	P&Ms Tertiary sector - Other Regulation in the Field of Buildings
PMteT4	P&Ms Tertiary sector - Legislative/Informative
PMteT5	P&Ms Tertiary sector - Grants / Subsidies
PMteT6	P&Ms Tertiary sector - Soft Loans for Energy Efficiency, Renewable and CHP
PMteT7	P&Ms Tertiary sector - Tax Exemption / Reduction
PMteT8	P&Ms Tertiary sector - Information/Education/Training
PMteT9	P&Ms Tertiary sector - Co-operative Measures
PMteT10	P&Ms Tertiary sector - Cross-cutting with sector-specific characteristics
PMccT1	P&Ms Cross-cutting - General Energy Efficiency / Climate Change / Renewable Programmes
PMccT2	P&Ms Cross-cutting - Legislative/Normative Measures
PMccT3	P&Ms Cross-cutting - Fiscal Measures/Tariffs
PMccT4	P&Ms Cross-cutting - Financial Measures

PMccT5	P&Ms Cross-cutting - Co-operative Measures
PMccT6	P&Ms Cross-cutting - Market-based Instruments
PMccT7	P&Ms Cross-cutting - Non-classified Measure Types