SAVING AND ENERGY EFFICIENCY ACTION PLAN

2011-2020

ANNEXED DOCUMENT

METHODOLOGY FOR CALCULATING THE SAVINGS DERIVED FROM THE 2005-2007 AND 2008-2012 ENERGY EFFICIENCY ACTIONS PLANS
ANALYSIS OF RESULTS

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CONTENTS

I. EXECUTIVE SUMMARY

1. Calculation of 2010's savings. Objective and methodology

Objective

Directive 2006/32/EC from the European Parliament and Council of 5 April 2006 concerning the efficiency of the final use of energy and energy services sets out, in its article 14, that Member States shall present a second Energy Efficiency Action Plan before 30 June 2011. Said Action Plan shall include an analysis and evaluation of the previous Plan, that is to say, the 2008-2012 Action Plan (first Action Plan under the effects of Directive 2006/32/EC), as well as the results of the energy saving objectives set out in article 4 for the third year of the application of the Directive.

This Annex comprises the calculation and quantification methodology relative to the energy savings achieved in 2010 with respect to reference years 2007 and 2004. The calculation of savings taking 2007 as a reference enables a valuation to be made of the progress in terms of the achievement of saving objectives in Spain for 2016 and 2020. Additionally, the calculation of savings using 2004 as a base year enables evaluation of the results from the 2005-2007 Action Plan, approved in the context of the *2004- 2012 Saving and Energy Efficiency Strategy in Spain (E4)*.

The scope of the study carried out covers the savings achieved in each of the sectors described in the 2005-2007 and 2008-2012 Action Plans, through the saving and energy efficiency measures developed in the period sustained by different mechanisms and implemented through specific actions. These actions are normally associated with policy initiatives complemented by public support (direct subsidies and fiscal incentives etc.) that have made changes in consumption patterns possible as well as the adoption of new, more efficient technologies.

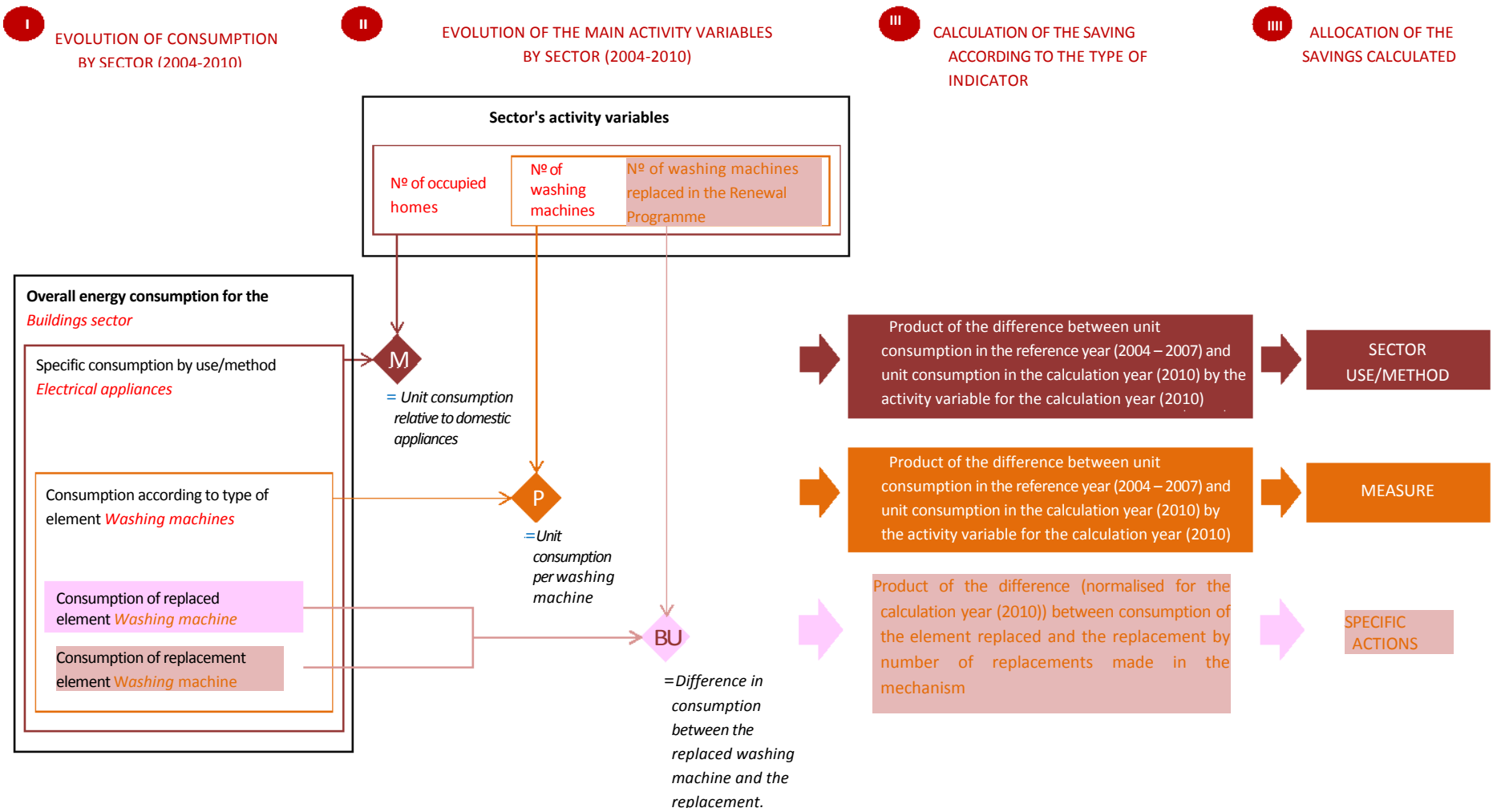
Methodology

The quantification of savings is carried out in line with the methodological recommendations set out by the European Commission and described in the document entitled "*Recommendations on measurement and verification methods within the framework of Directive 2006/32/EC on energy end-use efficiency and energy services*". Said methodology (see an illustrative example for the "Household Electrical Appliances Renewal Programme" case in Figure 1) is the result of the coherent combination of *top-down* or ascending and *bottom-up* or descending approaches:

- The descending approach uses *top-down* indicators (called *M* or *P* indicators by the European Commission) based on differences between the units consumed in the reference years (2004 and 2007) and the calculation year (2010). These indicators use aggregated information concerning the sector's consumption, means of transport or energy use and statistical data from the different activity variables.

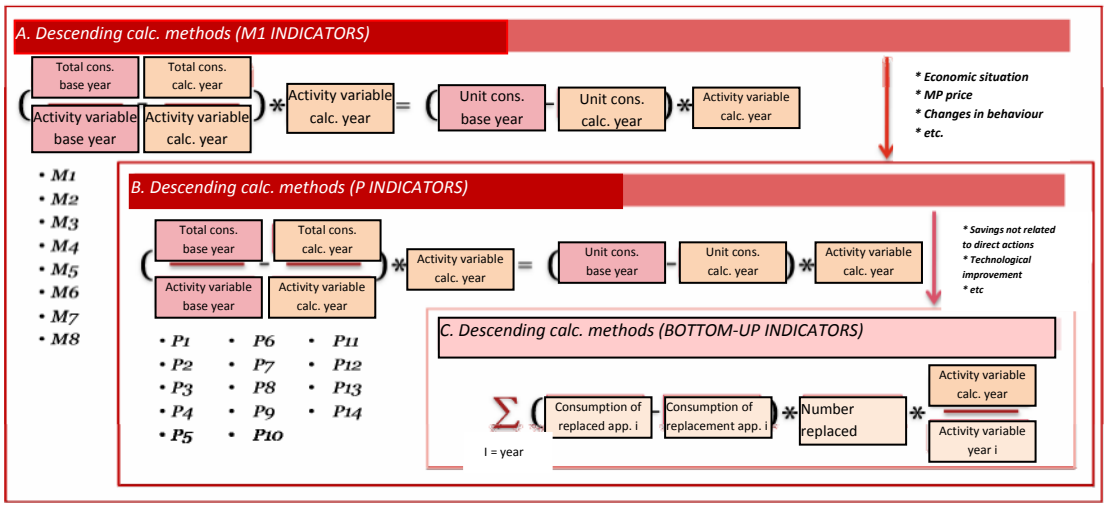
- The ascending or *bottom-up (BU)* indicators use specific and quality information on each of the actions performed during the analysis period. The result from the same will be the product of the difference between consumption before and after the implementation of the improvement by the number of actions.

Figure 1. *Outline of the calculation methodology and allocation of energy savings according to the type of indicator (M, P and BU) by sector, measure and action,* using the "Household Electrical Appliances Renewal Programme" as an example



The differences in the results obtained through this double approach (descending-ascending) enable the explanation of indirect and/or non-quantifiable effects associated with structural and current changes, as shown in Figure 2. This analysis is possible since the savings were calculated for 2010 with respect to the same temporal basis (2004 or 2007), and the activity variables for the indicators present distinct sensitivities to current or structural variations in each of the sectors.

Figure 2. *Outline of the energy saving calculation methodology, where top-down and bottom-up indicators are coherently combined*



The descending indicators used in this study are first and foremost *P* indicators (preferred by the European Commission[1]), although in some cases, *M* indicators were chosen when quality statistical information could not be found. The majority of *P* indicators enable the disaggregation of those macroeconomic effects that are not associated with energy saving or efficiency.

The positive or negative sign of the savings calculated depends on if the value of the indicator chosen decreases or increases between the reference year and 2010. On its part, the size of the savings will be determined by the product of the difference in the unit consumption of final energy in the base year and in the calculation year, by each sector's activity variable.

Table 1 shows the relationship between the descending indicators used for each sector, means of transport or energy use in residential and tertiary sectors (heating, cooling, SHW, lighting and appliances). Once the total savings are calculated, they will be assigned to each sector and measure defined in the plan, with special care being taken when grouping or adding them to calculate global savings so as to avoid double counting.

The calculation details for each of the sectors are described in the different chapters of this Annex.

[1] "*Recommendations on measurement and verification methods in the framework of Directive 2006/32/EC on energy end-use efficiency and energy services*". European Commission. Directorate-General for Energy.

Table 1. *Top-down (descending) indicators used to calculate savings*

SECTOR			ENERGY INDICATOR	UNIT
INDUSTRY	Division 1 Parametric Method (LAS-PDM1)		$L_{Technological}$ PDM1 indicator of technological effect by economic sector	ktep/10^6 €
			$L_{Structural}$ PDM2 indicator of structural effect by economic sector	ktep/10^6 €
TRANSPORT	Unit saving per vehicle replaced according to type of replacement + unit saving associated with efficient driving courses			gep/pkm
	ROAD		M53/PB Energy consumption of buses per fleet	tep/veq
		GOODS	M52/A2 Energy consumption of lorries and light vehicles per fleet of equivalent vehicles	tep/veq
	RAIL	PASSENGERS	P10 Energy consumption of passenger rail transport by number of passengers (passengers-km)	gep/pkm
		GOODS	P11 Energy consumption of freight rail transport by amount of goods (tons-km)	gep/tkm
	MARITIME (GOODS)		M7 Energy consumption of the maritime carriage of goods (coastal and river shipping) by amount of goods (tons-km)	gep/tkm
	AIR (DOMESTIC PASSENGERS)		Mav Energy consumption of air passenger transport by means of domestic flights by operations (n° of flights)	gep/pkm
	MODAL CHANGE	PASSENGERS from private to collective means	P12 Transfer of passenger traffic from the private vehicle to collective means (bus, train and metro)	%
		GOODS from road torail and maritime	P13 Transfer of freight traffic from road to rail and maritime	%
BUILDINGS	**RESIDENTIAL**	THERMAL ENVELOPE AND THERMAL EQUIPMENT	P1 Domestic energy consumption of heating by surface area of main homes (corrected by climatic conditions)	tep/m_2
			P2 Domestic energy consumption of cooling units by surface area of main homes (corrected by climatic conditions)	tep/m_2
			P3 Domestic energy consumption of SHW per inhabitant	tep/inhabitant
		LIGHTING	P5 Domestic energy consumption of lighting per main home	tep/household
	TERTIARY	THERMAL ENVELOPE AND EQUIPMENT	M311 Domestic non-electrical energy consumption for heating in the tertiary sector per employee (corrected by climatic conditions)	tep/employee
			M411 Electrical energy consumption for heating in the tertiary sector per employee (corrected by climatic conditions)	tep/employee
			M412 Electric energy consumption for cooling in the tertiary sector per employee (corrected by climatic conditions)	tep/employee
			M312 Non-electric energy consumption in the tertiary sector relative to SHW per employee	tep/employee
			M413 Electrical energy consumption in the tertiary sector relative to SHW per employee	tep/employee
		LIGHTING	M42 Energy consumption of lighting in the tertiary sector per employee	tep/employee
EQUIPMENT	**RESIDENTIAL**	ELECTRICAL APPLIANCES	P4 Domestic energy consumption of electrical appliances per appliance	tep/appliance
			P41 Domestic energy consumption of cookers per appliance	tep/cooker
	TERTIARY	ELECTRICAL APPLIANCES	M44 Electrical energy consumption of electrical appliances and office equipment in the tertiary sector per employee	tep/employee
		COOKERS	M43 Electrical energy consumption of cookers in the tertiary sector per employee	tep/employee
			M32 Non-electrical energy consumption of cookers in the tertiary sector per employee	tep/employee
PUBLIC SERVICES	PUBLIC LIGHTING		MAP Energy consumption of lighting per household	tep/household
	WATER DESALINATION		$MAG_{desalination}$ Energy consumption of desalination by volume of desalinated water	ktep/hm^3 year
	WATER PURIFICATION		$MAG_{purification}$ Energy consumption of water purification per inhabitant	tep/inhabitant
AGRICULTURE AND FISHERIES			M8' Energy consumption of agriculture and fisheries per unit of GVA	ktep/10^6 €

[2] Given the quality of the information available for evaluation of the savings associated with the carriage of passengers by road, *bottom-up* methodology has been used due to its accuracy, instead of using more aggregated statistical data like in the rest of the indicators.

2. Summary of energy saving results and avoided emissions

Table 2 shows the final and primary energy savings as well as the volume of emissions of CO_2 avoided in 2010, taking 2004 and 2007 as reference years. These savings should not be confused with the period's cumulative savings, but constitute the savings in 2010 due to the improvement in energy efficiency with respect to the situation in the reference year (2004 or 2007).

Table 2. *Results of final and primary energy savings as well as emissions of $C0_2$ avoided in all sectors -including energy transformation[3]- in 2010 with 2004 and 2007 as base years*

		Final energy saving 2010 [ktep]		**Primary energy saving 2010 [ktep]**		**Emissions of $C0_2$ emissions 2010 [ktCO_2]**	
	Indicators used	Base year 2004	Base year 2007	Base year 2004	Base year 2007	Base year 2004	Base year 2007
INDUSTRY	$L_{technological} + L_{structural}$	**-798,6**	**-2.865,6**	**-2.695,7**	**-5.717,4**	**-5.281,8**	**-12.416,8**
TRANSPORT		6.586,9	4.561,1	7.027,3	4.909,2	21.906,9	13.330,1
Road	$BU_{RP}+BU_{cet}+M53+M52$	6.920,0	4.916,1	7.722,6	5.494,4	23.436,9	14.788,7
Rail	*P10+P11*	-317,4	-206,7	-677,8	-419,2	-1.468,0	-953,9
Maritime	*M7*	52,3	-99,9	58,6	-111,9	166,8	-342,1
Air	*Mav*	-68,0	-48,3	-76,1	-54,1	-228,8	-162,5
BUILDINGS AND EQUIPMENT		**2.232,5**	**2.529,1**	**3.165,0**	**4.189,1**	**6.982,8**	**9.269,0**
Residential		354,9	751,9	724,4	1.160,3	1.504,0	2.587,7
Thermal envelope and equipment	*P1+P2+P3*	273,9	698,6	521,8	1.034,5	1.094,3	2.318,6
Lighting	*P5*	81,0	53,3	202,6	125,7	409,6	269,2
Tertiary		2.076,7	1.569,9	3.149,9	2.631,0	6.861,9	5.814,1
Thermal envelope and thermal equipment	*M311+M411+M412+M312+M413*	1.363,7	1.322,0	1.365,5	2.046,9	3.254,4	4.563,4
Lighting	*M42*	713,0	247,9	1.784,4	584,1	3.607,4	1.250,7
Equipment	*P4+P41+M44+M43+M32*	-199,1	207,3	-709,2	397,8	-1.383,0	867,1
PUBLIC SERVICES		**31,8**	**28,6**	**79,6**	**67,4**	**161,0**	**144,3**
Public lighting	*MAP*	4,6	11,3	11,5	26,5	23,2	56,8
Water	$MAG_{desalination} + MAG_{purification}$	27,2	17,3	68,2	40,9	137,8	87,5
AGRICULTURE AND FISHERIES	*M8'*	425,5	466,7	535,5	580,4	1.526,3	1.673,2
TOTAL OF END-USE SECTOR SAVINGS		**8.478,2**	**4.719,9**	**8.111,7**	**4.028,7**	**25.295,1**	**11.999,8**
ENERGY TRANSFORMATION		N/A	N/A	9.767	7.019	51.797	53.254
Electricity generation	$AEP_{generation}$	N/A	N/A	9.482	6.909	51.466	52.947
Oil Refining	$AEP_{refinery}$	N/A	N/A	72	39	38	186
Cogeneration	$AEP_{cogeneration}$	N/A	N/A	213	71	293	121
TOTAL OF END-USE SECTORS AND TRANSFORMATION		**8.478,2**	**4.719,9**	**17.878,7**	**11.047,7**	**77.092,1**	**65.253,8**

We should remember that these results do not show all final energy savings achieved in the period, but only those due to improved efficiency, as is the case for technological development or the result of actions by the Administration. Therefore, the quantification of effects derived from the current economic climate is minimised.

The total saving achieved in 2010 with respect to 2004 was 8.478,2 ktep and 4.719,9 ktep with respect to 2007. These results show energy savings of 8.3% and 4.8% respectively, on final energy consumption for the calculation year (93.423 ktep).

[3] The procedure for calculating savings in the energy transformation sector is described in section VII of this Annex.

The main savings in terms of final energy are as follows:

- In relation to the industry sector, in 2010, its contribution had a negative result with respect to both base years. Taking 2004 as a reference year, negative savings of -798,6 ktep were achieved on final consumption, whilst a comparison to 2007 achieved -2.865,6 ktep. Unit consumption in the sector has increased in recent years largely due to decreased use of production capacities and the maintenance of fixed energy consumption.

- The main savings relative to final consumption were made in the transport sector; 6.586,9 ktep for base year 2004 and 4.561,1 ktep for base year 2007. A large part of the savings are concentrated on road transport (6.920 ktep), which makes up for the negative savings made relative to rail transport. These consumption increases occurred as a result of the fall in the carriage of goods —a consequence of the current economic crisis— and the subsequent reduction in loading factors (increased consumption per ton-kilometre transported).

- The buildings sector —which includes energy uses relative to the thermal envelope and thermal installations, interior lighting and equipment— achieved a total saving of 2.232,5 ktep in 2010 as against 2007. These results are largely due to the improvement in the energy efficiency of the thermal envelope and thermal equipment and are mainly localised in the tertiary sector (approximately 61% of the total savings in 2010 correspond to uses relative to heating, cooling and sanitary hot water in the tertiary sector).

- The public services sector —which includes uses relative to external lighting and the water cycle— contributed with 31.8 ktep with respect to 2004 and 28.6 ktep with respect to 2007. In the case of public lighting, the increase in electricity consumption per household due to new urban developments and the installation of new light points, has depreciated the savings due to improved energy efficiency and technological renewal.

- The agriculture and fisheries sector increased its contribution from 425.5 ktep in the 2004-2010 period to 466.7 ktep in the 2007-2010 period. This improvement is due to the increase in weight relative to the less energy-intensive subsector, the agricultural and livestock sector, compared with the fisheries sector, representing the first 95% of the added value and 85% of the energy consumption for the whole Agriculture and Fisheries Sector.

Table 3 shows the savings achieved through the calculation of ascending indicators for the evaluation of direct savings as a result of the different action mechanisms; each one is described below[4].

[4] Chapter 3 of the 2011-2020 Energy Efficiency Action Plan describes each of the mechanisms mentioned in detail.

Table 3. *Results of final and primary energy saving as well as emissions of $C0_2$ avoided in 2010 as a result of the different action mechanisms*

	Final Energy Savings in 2010 [ktep]	**Primary Energy Savings in 2010 [ktep]**	**Emissions of CO_2 avoided [$ktCO_2$]**
IDAE-AUTONOMOUS COMMUNITIES PROGRAMME (1)	2.304,5	3.221,2	7.843,9
STRATEGIC PROJECTS PROGRAMME	199,9	337,0	722,5
PROGRAMMES EXECUTED DIRECTLY BY IDAE	140,5	302,2	653,8
Efficient driving of passenger vehicles	1,1	1,2	3,7
Efficient driving of lorries and buses	30,7	34,4	105,0
MOVELE project	2,1	1,2	6,0
Programme for the distribution of low-consumption bulbs	84,9	212,5	429,5
Programme for the 2-for-1 distribution of low-consumption bulbs	13,0	32,5	65,8
Programme for replacing traffic lights	8,7	20,4	43,7
OTHER PROGRAMMES (Prever Plan, VIVE, 2000 E)	867,8	966,5	2.767,4
TOTAL	**3.512,7**	**4.826,9**	**11.987,6**

(1) The savings achieved due to this mechanism are broken down in Table 4. *Source: IDAE*

IDAE-Autonomous Communities Programme

The Autonomous Communities, within the context of their competencies, have been carrying the measures contained in the 2005-2007 and 2008-2012 Action Plans out since 2005. As a result of the signing of collaboration agreements with IDAE, the way in which said measures should be carried out has been set out: basically, the conditions for receiving the public support set out in said Plans and the maximum support intensities. The agreements signed for the execution of the measures contained in the 2008-2012 Action Plan have taken on a multi-year character, therefore the agreements signed will continue to be in force until 2012.

As a result of the foregoing, the Autonomous Communities manage approximately 75% of the total budget for the 2005-2007 and 2008-2012 Action Plans, with the Ministry of Industry, Trade and Tourism, through IDAE, assuming direct management of the remaining 25%. Through this support, a direct saving of 2,304.5 ktep was achieved in 2010 distributed between the different sectors.

Table 4. *Summary of the savings achieved in 2010 (base year 2004) through joint action programmes between IDAE and the Autonomous Communities(2005-2010)*

	Final E. savings [ktep]	Primary E. savings [ktep]	Emissions of CO_2 avoided [ktCO_2]
INDUSTRY	**1.068,6**	**1.585,8**	**3.468,6**
Energy Audits	N/C	N/C	N/C
public aid programme	1.068,6	1.585,8	3.468,6
TRANSPORT	**947,8**	**944,1**	**2.978,1**
Urban mobility plans and Transport plans for companies	860,0	846,4	2.683,8
Greater participation of road transport in collective means	N/C	N/C	N/C
Road transport fleet management	1,3	1,5	5,0
Efficient driving of private vehicles	52,4	58,1	173,1
Efficient driving of lorries and buses	30,0	33,5	102,5
Renovation of the private vehicle fleet	2,7	3,0	8,6
Renovation of the road transport fleet	1,5	1,6	5,0
BUILDINGS AND EQUIPMENT	**195,5**	**438,5**	**898,8**
Energy renewal of the thermal envelope inexisting buildings	22,3	42,5	89,1
Improvement in the energy efficiency of thermal installationsin existing buildings	61,1	116,4	244,2
Improvement in the energy efficiency of interior lighting installationsin existing buildings	29,7	74,4	150,4
Construction of new buildings and renovation of existing buildings withhigh energy ratings	0,9	1,5	3,3
Improvement of the energy efficiency of electrical appliances	81,4	203,7	411,8
PUBLIC SERVICES	**84,7**	**211,9**	**428,4**
Renovation of existing exterior public lighting installations	77,7	194,3	392,9
Studies, feasibility analysis and audits of existing externallighting installations	N/C	N/C	N/C
Training of municipal energy managers	N/C	N/C	N/C
Improvement of current drinking water, supply,waste water purification and desalination plants	7,0	17,6	35,5
AGRICULTURE AND FISHERIES	**8,0**	**11,6**	**30,4**
Promotion and training of technicians for the efficient use of energy in the agriculture and fisheries sector.	N/C	N/C	N/C
Incentives for migration from spraying or gravityirrigation systems to localised irrigation systems.	2,1	4,5	9,8
Improvement in saving and energy efficiency in the fisheries sector.	4,1	4,6	14,1
Energy audits and action plans to improve farms.	1,6	2,2	6,0
Support for conservation agriculture	0,2	0,2	0,6
TOTAL OF END-USE SECTORS	**2.304,5**	**3.191,9**	**7.804,3**
ENERGY TRANSFORMATION	**N/C**	**29,3**	**39,6**
Feasibility studies for cogenerations	N/C	N/C	N/C
Energy audits for cogenerations	N/C	N/C	N/C
Promotion of cogeneration plants in non-industrial activities	N/C	9,5	12,1
Promotion of small-capacity cogeneration plants	N/C	0,8	1,4
Promotion of cogeneration plants in industrial activities	N/C	19,0	26,1
TOTAL END-USE SECTORS + ENERGY TRANSFORMATION	**2.304,5**	**3.221,2**	**7.843,9**

(N/C) The savings achieved due to said actions could not be quantified. Source: IDAE

- **Programmes executed directly by IDAE**

  The public resources managed by IDAE directly within the context of the 2005-2007 and 2008-2012 action plans were applied to national programmes and are directed at final energy users not covered by public aid programmes or training and information undertaken by Autonomous Administrations.

  In particular, these mechanisms constitute Strategic Projects, the objective of which is to encourage sectorial, singular and innovative actions which in turn encourage saving and improved energy efficiency. The savings achieved through this mechanism are estimated at 199,9 ktep of final energy in 2010.

  The remaining programmes managed directly by IDAE focused on the transport sector, through efficient driving training courses and the MOVELE project; the residential sector, through programmes to distribute low consumption bulbs; and, in the public services sector, through the programme to replace traffic lights with Optics using LED technology. All these supports translated into a total saving of 140.5ktep of final energy in 2010.

- Other programmes, such as vehicle substitution plans (PREVER plan 1997-2007, Plan VIVE 2008-2010 and Plan 2000E 2010), achieved a final energy saving of 867,8 ktep in 2010.

3. Conclusions drawn in the sectors under the study

In particular, the following considerations should be highlighted in each of the study's sectors as well as the economic strength realised from the Administration:

Industry

The industry sector did not achieve final energy savings in any of the two analysis periods 2004-2010 (-798,6 ktep) and 2007-2010 (-2.865,6 ktep) due, basically, to the fall in production ratios in some fields.

The economic crisis makes the analysis of the results derived from energy efficiency measures in this sector difficult. On the one hand, unit consumption has increased in recent years as a result of the low use of production capacities, derived from production reductions and the maintenance of fixed consumption, which produces negatives savings. On the other hand, the loss in the relative weight of the sectors associated with manufacturing produced positive results in terms of savings through structural change.

It should be noted that efforts were made to lessen said results through actions designed to improve the energy efficiency of industrial equipment. The Administration developed and financed the measures proposed in the 2005-2007 and 2008-2012 Action Plans, formulated around collaboration agreements between IDAE and Autonomous Communities (1.068,6 ktep in 2010 with respect to 2004), and the IDAE Grants for Strategic Projects Programme.

Table 5. *Public support managed directly by IDAE, or by IDEA in collaboration with the Autonomous Communities, applied through measures related to the Industry Sector in the period 2006-2010*[5]

	2006	2007	2008	2009	2010
IDAE-Autonomous Communities programme [k€]	28.327	28.839	29.614	29.351	28.456
Energy audits and other studies [k€]	1.888	1.610	2.556	2.385	1.981
Public aid programme [k€]	24.633	27.119	26.059	26.853	25.149
Strategic projects [k€]			15.100	65.700	68.800

Source: IDAE

Transport

The savings achieved in this sector (6.586,9 ktep in 2010 with respect to 2004 and 4.561,1 ktep with respect to 2007) show varied performances depending on the different means of transport: road, rail, maritime and air. Generally, for all the means, we can see a decreasing trend in terms of consumption and total traffic in the final years of the period analysed due to the economic climate. This effect reports, particularly in the carriage of goods, a significant decrease in industrial activity causing fall in consumption and lorry and light vehicle traffic, whilst the fleet remains constant.

A large part of the savings achieved are concentrated on road transport (6.920 ktep and 4.916,1 ktep), mainly, in the carriage of goods.

Rail transport achieved negative savings in both analysis periods (-317,4 ktep and -206,7 ktep), as a result of decreased goods traffic due to the current economic crisis and the reduction in loading factors. Energy consumption is the same with lower occupancy levels.

Negative savings made in the air traffic sector (-68,0 ktep and -48,3 ktep) are due to the increase, in relative terms, in energy consumption per flight in the period analysed.

The measures in the 2005-2007 Action Plans for the sector and set out in collaboration agreements between IDAE and the Autonomous Communities (947,8 ktep in 2010 with respect to 2004) have boosted, among other things, the renewal of vehicles and modal change to more efficient means of transport. Support for Sustainable Urban Mobility Plans and the communication and dissemination programmes has contributed, also, to boosting energy efficiency in transport.
In addition to these measures established through the Autonomous Communities, other actions managed through IDAE have been implemented as supports for strategic projects; the MOVELE project and efficient driving programmes, and other programmes outside of vehicle replacement plans (PREVER, VIVE and 2000E). These actions have been made possible by other policy-level efforts such as fiscal discrimination in the tax for the registration of vehicles and Regulation 443/2009/EC setting out limits in terms of CO_2 emissions from new private vehicles. These mechanisms have notably contributed to improving energy efficiency of the private vehicle fleet.

[5] The total supports for the IDEA-Autonomous Communities Programme do not correspond to the sum of measures identified in the table, since, in addition to these, it also includes supports for training and dissemination actions in the industrial sector and to actions to improve efficiency and the promotion of energy research.

Table 6. *Public support managed directly by IDAE, or by IDAE in collaboration with the Autonomous Communities, applied through measures for the Transport Sector in the period 2006-2010*[6]

	2006	2007	2008	2009	2010
IDAE-Autonomous Communities programme [k€]	17.137	19.039	32.289	28.646	24.365
Urban mobility plans and Transport plans for companies [k€]	8.182	9.621	17.048	11.589	8.962
Greater participation of road in collective means [k€]	4.321	1.539	1.972	1.148	367
Management of road transport fleets [k€]	200	597	1.580	1.847	2.355
Efficient driving of private vehicles [k€]	1.025	2.172	3.368	4.117	3.324
Efficient driving of lorries and buses [k€]	1.206	2.215	2.594	3.465	2.919
Renewal of the private vehicle fleet [k€]	259	1.133	4.120	4.614	4.809
Renewal of road transport fleets [k€]	1.924	1.695	1.575	1.582	1.605
Strategic projects [k€]			4.222	10.917	10.527

Source: IDAE

Buildings and equipment

With regard to the energy savings achieved in both analysis periods in buildings and equipment (2.232,5 ktep in 2010 with respect to 2004 and 2.529,1 ktep with respect to 2007), approximately two thirds comes from the thermal envelope and thermal installations in buildings, localised, mainly, in the tertiary sector (approximately 61% of the total savings in 2010 correspond to savings for heating, cooling and sanitary hot water in the tertiary sector).

The remainder of the savings achieved come from the installation of more efficient interior lighting, since no savings were made in the context of equipment due to the increase in equipment and the high-performance requirements for new equipment.

The sector has achieved significant results through the measures proposed in the 2005-2007 and 2008-2012 Action Plans, supported by policy-based actions which stimulated energy efficiency in construction.

The four measures associated with the sector and set out in collaboration agreements between IDAE and the Autonomous Communities (195.5 ktep in 2010 with respect to 2004) have boosted the renewal of the thermal envelope, improvements to thermal installations, improvements to lighting plants and the replacement of electrical appliances. The 2-for-1 Programme for the free distribution of high efficiency bulbs, as well as the IDEA Grants for Strategic Projects Programme and communication and dissemination programmes have also contributed to boosting energy efficiency in the construction sector.

[6] The total supports for the IDAE-Autonomous Communities Programme do not correspond to the sum of measures identified in the table, since, in addition to these, it includes supports aimed at training actions and dissemination in the transport sector, greater participation of the maritime sector in the carriage of goods and greater participation of rail in intercity transport.

These measures were made possible by policy-level efforts and, in particular, through publication of the Technical Building Code (RD 314/2006), this assumes improved

Efficiency in the field of the thermal envelope and thermal equipment. Likewise, we should point out the new Regulation on Thermal Building Installations (RD 1027/2007), which calls for periodic revision of the energy efficiency of these installations, and the requirement for energy certification of buildings put forward by RD 47/2007.

Table 7. *Public support managed directly by IDAE, or by IDEA in collaboration with the Autonomous Communities, applied through measures related to the Buildings and Equipment Sector in the period 2006-2010*[7]

	2006	2007	2008	2009	2010
IDAE-Autonomous Communities programme [k€]	**87.785**	**78.735**	**139.210**	**143.157**	**148.268**
Energy renewal of the thermal envelope in existing buildings [k€]	15.330	8.245	23.968	27.381	36.577
Improved energy efficiency of thermal installations in existing buildings	13.523	12.869	41.512	38.820	38.803
Improved energy efficiency of interior lighting installations in existing buildings [k€]	1.782	1.860	4.058	7.421	7.400
Construction of new buildings and renovation of existing buildings with high energy ratings			2.008	2.172	2.028
Improved energy efficiency of electrical appliances [k€]	55.231	51.280	61.100	59.395	55.333
Strategic projects [k€]			**25.158**	**32.553**	**38.835**
IDAE directly executed programmes [k€]			**3.130**	**27.848**	**13.693**
Distribution of low consumption lamps [k€]				27.848	13.693
2-for-1 offer on low consumption lamps[k€]			3.130		

Source: IDAE

Public services

The public services sector achieved positive savings in the 2004-2010 period (31.8 ktep) due, mainly, to improved efficiency in the use of the water table, and, more specifically, in the desalination process. However, of the savings made in the second analysis period 2007-2010 (28.6 ktep), the weight related to the public lighting increased substantially.

The use of public lighting has seen its intensity increase significantly due to the increasing urban strength in recent years. The approval of the energy efficiency Regulation in exterior lighting plants through RD 1890/2008, has meant a certain boost in efficiency in this sector.
The 2005-2007 and 2008-2012 Action Plans stimulated energy efficiency in the public services sector through different measures. The initiatives implemented were set out, mainly, in collaboration agreements between IDAE and the Autonomous Communities (84,7 ktep in 2010 with respect to 2004) which has boosted the energy efficiency of exterior lighting plants, as well as current drinking water, supply, waste water purification and desalination plants. The savings achieved in this sector were determined, basically, through the measure relating to the renewal of exterior lighting plants, to which those resulting from other IDAE programmes should be added: the traffic light replacement programme for example.

[7] The total supports destined for the IDAE-Autonomous Communities Programme do not correspond to the sum of measures indicated in the table, since, in addition to these, it also includes support designed for actions, among others, associated with audits, training. disclosure, boiler replacement, inspections and improved efficiency of lifts.

Table 8. *Public support managed directly by IDAE, or by IDAE in collaboration with the Autonomous Communities, applied through measures related to the Public Services Sector in the period 2006-2010*

	2006	2007	2008	2009	2010
IDAE-Autonomous Communities programme [k€]	**21.409**	**22.596**	**30.090**	**33.723**	**29.173**
Renovation of existing public lighting installations [k€]	17.185	17.893	26.321	28.901	25.623
Studies, feasibility analysis and audits of existing external lighting installations	1.393	2.544	1.672	2.052	1.714
Training of municipal energy managers	112	0	177	345	265
Improvement in the energy efficiency of drinking water, supply, purification of waste water and desalination plants [k€]	2.719	2.159	1.920	2.426	1.572
Strategic projects [k€]					**356**
IDAE direct execution programmes [k€]				**31.794**	
Traffic light replacement programme [k€]				31.794	

Source: IDAE

Agriculture and Fisheries

According to the indicators studied, in the agriculture and fisheries sector, final energy savings were achieved in both evaluation periods (425,5 ktep in 2010 with respect to 2004 and 466,7 ktep with respect to 2007), due, basically, to a fall in production and technological improvement.

In the agriculture subsector, positive savings were achieved through energy improvements to agricultural machinery and the change in irrigation systems. However, the increase in the degree of conditioning through air-conditioning equipment in livestock farms and greenhouses, has meant that its energy intensity has increased, generating negative savings in said use.

The savings made in the fisheries and agriculture subsector correspond to direct actions developed by the Administration designed to reduce the energy consumption of different types of ships, the fall in economic activity and the natural technological evolution of the fishing fleet.

Table 9. *Public support managed directly by IDAE, or by IDEA in collaboration with the Autonomous Communities, applied through measures related to the Agriculture Sector in the period 2006-2010*[8]

	2006	2007	2008	2009	2010
IDAE-Autonomous Communities programme [k€]	**1.378**	**4.540**	**3.980**	**3.657**	**4.581**
Promotion and training of technicians for the efficient use of energy in the agriculture and fisheries sector [k€]	935	1.355	956	899	808
Incentives for migration from spraying or gravity irrigation systems to localised irrigation systems [k€]		2.800	946	1.391	1.749
Improved saving and energy efficiency in the fisheries sector [k€]			1.003	459	611
Energy audits and action plans to improve farms [k€]	362	308	982	839	1.179
Support for conservation agriculture [k€]			93	69	235

[8] The total supports destined for the IDAE-Autonomous Communities Programme do not correspond to the sum of measures indicated in the table, since, in addition to these, it also includes the "Plan for tractor renewal and improved energy efficiency through ICT".

Source: IDAE

Energy transformation

The results in the primary energy transformation sector have been analysed, that is to say, electricity generation, oil refining processes and cogeneration.

In 2010, from a total primary energy consumption of 131.927 ktep in Spain, 62.358 ktep (47%) was from oil, mostly processed in Spanish refineries and 49.249 ktep (37%) was consumed by national electricity production. These amounts demonstrate the strategic importance of energy efficiency in the energy transformation sector.

In the period studied, the practical total of savings corresponds to the improved global output from electricity generation (9.482 ktep of primary energy in 2010 with respect to 2004 and 6.909 ktep with respect to 2007), including improved self-consumption. This is mainly due to the high penetration of renewable energies and natural gas combined cycles, which have been used in our mix of electricity generation.

Cogeneration also plays an important role in the achievement of primary energy savings (213 ktep in 2010 with respect to 2004 and 71 ktep with respect to 2007) through high efficiency in simultaneous heat and electricity production with respect to the separate production of these energy flows.

On its part, the refining sector made savings (72 ktep in 2010 with respect to 2004 and 39 ktep with respect to 2007) due, in large part, to the decrease in losses in the production process.

Table 10. *Public support managed directly by IDAE, or by IDEA in collaboration with the Autonomous Communities, applied through measures related to the Energy Transformation Sector in the period 2006-2010*

	2004	2007	2008	2009	2010
IDAE-Autonomous Communities programme [k€]	**2.467**	**4.427**	**3.484**	**1.424**	**1.516**
Feasibility studies for cogenerations [k€]	444	348	416	281	316
Energy audits for cogenerations [k€]	177	274	186	90	156
Promotion of cogeneration plants in non-industrial activities [k€]	426	629	496	952	866
Promotion of low-capacity cogeneration plants [k€]		132	130	102	178
Promotion of cogeneration plants in industrial activities [k€]	1.420	3.044	2.257		
Strategic projects [k€]				**80**	

Source: IDAE

II. INDUSTRY SECTOR

1. Summary of savings in the industry sector

INDUSTRY

The industry sector did not achieve final energy savings in any of the two analysis periods 2004-2010 and 2007-2010 due, basically, to the fall in production ratios in some fields. Final energy consumption in this sector was 28.209,4 ktep in 2010, 28% nationally.

Savings diagram

The savings in the industry sector are structured according to their technological or structural origin:

<table>
<tr><td colspan="3">Industry [L] = -798.6 ktep$_{2010}$ (Base year 2004)</td></tr>
<tr><td>Improved consumption structure [LE] = 1.655.1 ktep$_{2010}$ (Base year 2004)</td><td colspan="2">Improved technology [LT] = -2.454.1 ktep$_{2010}$ (Base 2004)</td></tr>
<tr><td></td><td>Collaboration agreements [BUin$_1$]= 1.068.6 ltep$_{2010}$ (Base year 2004)</td><td>Strategic projects [BUin$_2$] = 131.5 ktep$_{2010}$ (Base year 2004)</td></tr>
</table>

Sector consumption

	Final energy 2010 [ktep]
TOTAL CONSUMPTION FOR THE INDUSTRY SECTOR	**28.209,4**
Wood, cork and furniture	705,0
Food, drink and tobacco	2.352,2
Textiles, leather and footwear	597,3
Cardboard, paper and printing	2.534,5
Chemical	4.943,7
Non-metallic minerals	6.093,1
Metallurgy and metal products	5.944,2
Machinery and mechanical equipment	320,9
Transport equipment	851,7
Electrical, electronic and optical equipment	345,1
Rest of the manufacturing industry	3.521,7

Result of savings achieved

	Final energy saving 2010		Primary energy saving 2010 [ktep]		Emissions of $C0_2$ avoided 2010 [$ktCO_2$]	
	Base year 2004	Base year 2007	Base year 2004	Base year 2007	Base year 2004	Base year 2007
TOTAL SECTOR SAVINGS	**-798,6**	**-2.865,6**	**-2.695,7**	**-5.717,4**	**-5.281,8**	**-12.416,8**
Wood, cork and furniture	86,8	-120,9	105,7	-145,4	240,5	-334,9
Food, drink and tobacco	436,7	-194,0	748,9	-319,9	1.597,0	-708,2
Textiles, leather and footwear	319,8	40,8	527,4	64,8	1.132,1	144,1
Cardboard, paper and chemical	-407,1	-428,5	-559,0	-575,1	-1.240,9	-1.305,0
printing	-1.071,1	-41,7	-2.076,6	-77,1	-4.343,8	-168,7
Non-metallic minerals	-212,6	325,2	-242,1	368,1	-559,5	855,4
Metallurgy and metal Products	1.283,1	-281,4	1.747,6	-374,9	3.886,0	-851,6
Machinery and mechanical Equipment	12,8	-21,3	28,3	-44,5	58,1	-96,3
Transport equipment	69,1	-196,3	109,5	-301,0	236,7	-671,9
Electrical, electronic and optical equipment	-5,4	-40,9	-12,6	-90,5	-25,6	-194,7
Rest of the manufacturing industry	-1.310,8	-1.906,5	-3.072,9	-4.221,8	-6.262,4	-9.085,1

Conclusions

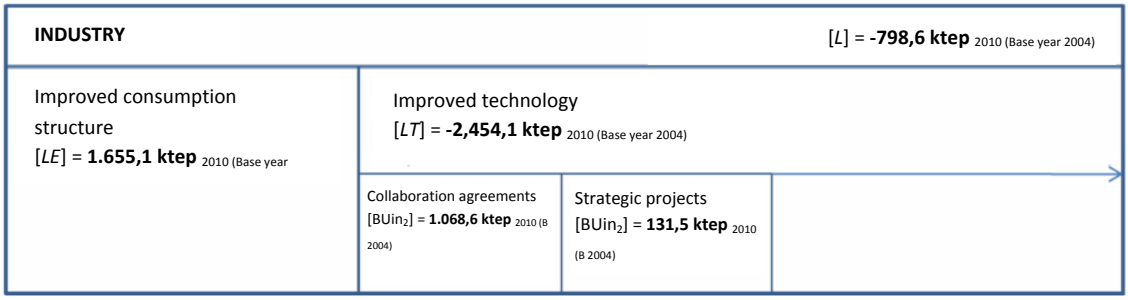
The industry sector made negative global final energy savings of -798,6 ktep in the 2004-2010 period. Said negative savings were reduced, mainly, thanks to the evolution of the structure of the sector itself, with 1.655,1 ktep being attributed to this cause. On the other hand, we can see negative saving values of -2.454,1 ktep, due to the fall in production ratios in some fields negatively affecting the energy efficiency of some industrial processes. In relation to the sector's structure, we should point out that whilst some industries with lower energy intensity ratios (Wood, Cork and Furniture, Textiles, Leather and Footwear, Electric, Electronic and Optical Equipment and Transport Equipment), as well as Metallurgy and Manufacturing of Metal Products and Non-Metallic Minerals, reduced the sector's total weight, other more intensive industries increased their added value (Pulp, Paper and Cardboard, Printing and Chemical), as well as the rest of Industry and Food, Drinks and Tobacco. As the main activity variable, we took Gross Value Added (GVA) as a reference both for the sector and for each of the economic sectors, the generalised fall of which in 2009 was parallel to the current economic situation. Part of these global savings were achieved thanks to the improved energy efficiency of equipment (1.194,8 ktep) as a result of the measures proposed in the 2005-2007 and 2008-2012 Action Plans, formulated through the collaboration agreements between IDAE and the Autonomous Communities (1.068,6 ktep), and the IDAE Grants for Strategic Projects Programme (131,5 ktep).

2. Outer boundaries

In percentage terms, the industry sector has reduced its weight in final energy consumption from 36% in 2004 to 28% in 2010, achieving savings in energy consumption thanks to a change in the consumption structure which encouraged economic sectors to be less energy intensive.

The outline of energy savings in industry can be seen in Figure 3, which shows the values achieved in 2010 using 2004 as a base year and where it is possible to see the main boundaries. The sector's global negative savings are -798,6 ktep, of which 1.655,6 ktep is attributable to the sector's structural change and negative savings of -2.454,1 ktep are attributable to a loss in efficiency caused by a fall in production in some industrial sectors.

Figure 3. *Diagram of the energy savings in the industry sector in 2010 with base year 2004*



The different economic sectors used in this analysis are as follows:

1. Wood, cork and furniture
2. Food, drinks and tobacco
3. Textiles, leather and footwear
4. Cardboard, paper and printing
5. Chemical
6. Non-metallic minerals
7. Metallurgy and metal products
8. Machinery and mechanical equipment
9. Transport equipment
10. Electrical, electronic and optical equipment
11. The rest of the manufacturing industry, including: Transformation of Rubber and Plastics, Non-Energetic Extractions, Construction, Recycling and Other manufacturing industries.

In terms of the sector's activity ratios, the *Industrial Production Index (IPI)* presents an increase in the period in some of the areas (2 and 5) compared with the rest which show falls in levels of activity, as shown in the following sections. It has direct implications on the level of energy consumption.

Methodology

To determine the total savings relative to final consumption in the Industry Sector as well as its various economic sectors, we used indicators based on the Division 1 Parametric Formula Method. This is calculated as a sum of the partials obtained through two sub-indicators measuring technological and structural evolution both in the sector itself and in the different economic sectors.

Technological effect by economic sector

$$LT_{R2010} = [C_{R2004} + R.(C_{R2010} - C_{R2004})].L_n\left[\frac{\frac{C_{R2010}}{GVA_{2010}}}{\frac{C_{R2004}}{GVA_{R2004}}}\right]$$

where:
- C_{Ri}: Final energy consumption in the sector in year i
- R: Remainder
- GVA_i: Gross Value added in the sector in year i

Structural effect by economic sector

$$LT_{R2010} = [C_{R2004} + R.(C_{R2010} - C_{R2004})].L_n\left[\frac{\frac{C_{R2010}}{GVA_{2010}}}{\frac{C_{I2004}}{GVA_{I2004}}}\right]$$

where:
- C_{Ri}: Final energy consumption in the sector in year i
- R: Remainder
- GVA_{Ri}: Gross Value Added in the sector in year i
- GVA_{Ii}: Gross Value Added in the industry sector in year i

Use the following expression to calculate factor R:

$$R = \frac{1}{L_n\left(\frac{C_{R2010}}{C_{R2004}}\right)} - \left(\frac{C_{R2004}}{C_{R2010} - C_{R2004}}\right)$$

where:
- C_{Ri}: Final energy consumption in the sector in year i

Therefore, the specific savings achieved by each economic sector in the 2004-2010 period is the sum of the specific technological and structural effects in 2010.

Savings by economic sector

$$L_R = LT_R + LE_R$$

where:
- LT_R : Result of the PDM1 technological indicator for economic sector R in the 2004-2010 period
- LE_R: Result of the PDM1 structural indicator for economic sector R in the 2004-2010 period

To calculate the total savings achieved in 2010 in the industry sector as a whole, we can add the partial savings made in each economic sector thanks to the property of adding the Division 1 Parametric Method formula:

Savings in the industry sector

$$L_I = \sum L_R = \sum (LT_R + LE_R)$$

where:

- L_R : Result of the PDM1technological indicator for economic sector R in the 2004-2010 period

Key variables in the industry sector

Table 11 shows all the variables which directly affect the calculation of the savings achieved in the Industry Sector and in the respective economic sectors.

Table 11. *Evolution of the final energy consumption used in the calculation of savings in the industry sector and its economic sectors in the 2004-2010 period*

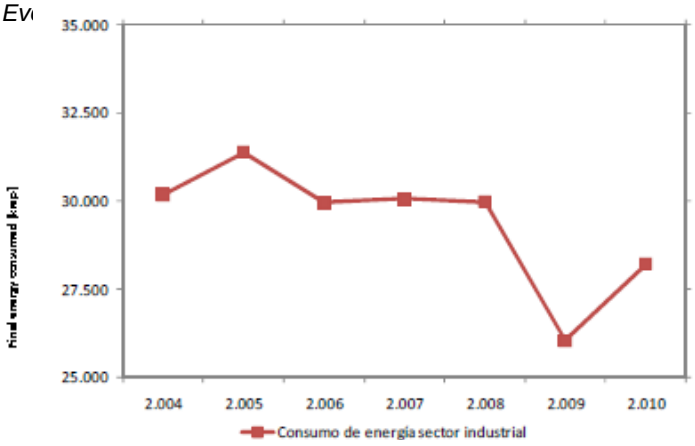
	2004	2007	2008	2009	2010
Energy consumption [ktep]	**30.174,8**	**30.055,5**	**29.971,1**	**26.040,2**	**28.209,4**
Wood, cork and furniture	866,2	697,9	751,1	706,5	705,0
Food, drinks and tobacco	3.044,0	2.556,5	2.428,1	2.184,6	2.352,2
Textiles, leather and footwear	991,0	746,7	593,6	524,9	597,3
Cardboard, paper and printing	2.360,0	2.516,0	2.500,5	2.290,4	2.534,5
Chemical	4.312,0	5.770,1	5.201,2	4.381,3	4.943,7
Non-metallic minerals	6.477,9	7.519,3	6.959,6	5.900,5	6.093,1
Metallurgy and metal products	7.880,2	6.687,0	6.437,0	5.615,3	5.944,2
Machinery and mechanical equipment	366,3	354,3	362,9	318,3	320,9
Transport equipment	1.009,0	788,4	860,1	751,0	851,7
Electrical, electronic and optical equipment	373,9	361,7	370,4	325,0	345,1
Rest of the manufacturing industry	2.494,2	2.057,6	3.506,6	3.042,4	3.521,7

Source: IDAE

Energy consumption in the industry sector presents -as we can see in Figure 4- a downward trend between 2004 and 2010 (-6,5%) due, basically, to the current economic situation.

The economic sectors that have been most affected by the situation are Textiles, Leather and Footwear, which saw a fall in consumption in the period by - 39,7%; Metallurgy and Metal Products with falls of -24,6%; and Food, Drinks and Tobacco, with falls of -22,7%.

Figure 4. *Ev* *.0 period*



Energy consumption in the industry sector

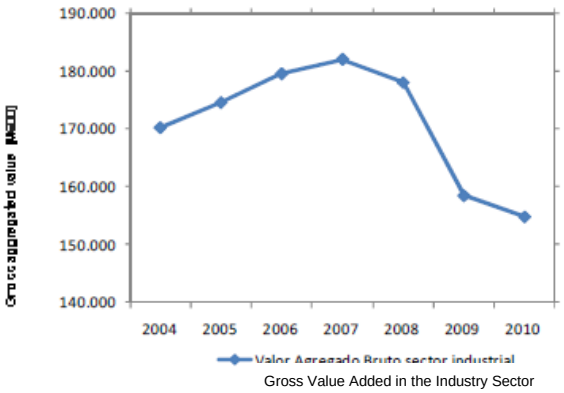
The *Industry* Sector's *Gross Value Added* increased by 7% between 2004 and 2007 and a fall of -15% from this point to 2010 (Table 12). For the 2004-2010 period as a whole, the fall was -9.1%. The economic sectors which were most affected by the economic situation in terms of GVA were wood, cork and furniture (-36,6 %), textiles, leather and footwear (-34,2%), non-metallic minerals (-33,4 %) and transport equipment (-22,4%).

Table 12. *Evolution of the Gross Value Added (GVA) used to calculate the savings in the industry sector and its economic sectors in the 2004-2010 period*

	2004	2007	2008	2009	2010
***Gross Value Added* [ME00]**	**170.192,6**	**182.037,9**	**177.994,7**	**158.428,7**	**154.756,1**
Wood, cork and furniture	5.962,4	5.881,2	5.461,2	4.118,7	3.782,5
Food, drink and tobacco	14.249,2	15.247,3	15.084,2	15.000,7	15.315,4
Textiles, leather and footwear	6.401,0	5.603,1	5.481,8	4.439,7	4.213,5
Cardboard, paper and printing	10.116,4	10.618,7	10.121,0	9.393,9	9.211,1
Chemical	10.362,1	10.752,6	10.640,8	10.646,9	11.554,7
Non-metallic minerals	8.948,3	9.355,7	8.836,4	6.689,2	5.959,6
Metallurgy and metal products	17.786,3	19.024,6	18.252,7	14.574,2	14.841,1
Machinery and mechanical equipment	8.268,5	8.554,8	8.673,9	7.408,0	7.735,5
Transport equipment	12.302,7	13.160,0	12.255,7	9.620,3	9.552,8
Electrical, electronic and optical equipment	6.897,8	7.353,3	7.265,4	5.854,0	6.041,1
Rest of the manufacturing industry	68.897,8	76.486,4	75.921,5	70.683,0	66.548,9

Source: IDAE

Figure 5. *Evolution of Gross Value Added (GVA) in the industry sector in the 2004-2010 period*



Gross Value Added in the Industry Sector

Total savings in the industry sector

In order to calculate energy savings achieved in the period, we applied the aforementioned indicators using the sector's variables and the macroeconomics in Tables 11 and 12. The final consumption energy savings are shown in Table 13.

Table 13. *Results of savings according to PDM1 in the industry sector in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	**Industry sector total**	***LT+LE***	**2.131,1**	**-798,6**
	Technological effect in the industry	*LT*	285,2	-2.454,1
	Structural effect in the industry sector	*LE*	1.845,9	1.655,5
Base year 2007 [ktep]	**Industry sector total**	***LT+LE***	**136,7**	**-2.865,6**
	Technological effect in the industry	*LT*	-1.205,5	-3.987,7
	Structural effect in the industry sector	*LE*	1.342,2	1.122,1

If we take the indicators proposed into account, we can see negative savings of -798,6 ktep in the industry sector in the period studied. These were less due to the evolution that occurred in the weight relative to each economic sector within the sector's consumption structure. With respect to the technological effect, we can see significant negative savings which indicate that the fall in production ratios in certain economic sectors has had a negative effect on the energy efficiency of some industrial processes.

Table 14 gives more details about the energy behaviour of each of the economic sectors relative to technological results and Table 15 shows the same relative to structural results. As we can see in Figure 6, the non-metallic mineral sector, with a relative weight of the sector's final energy consumption of 22% in 2010, presents the major penalties with respect to the PDM1 technological indicator, due to a negative variation in 2009 and 2010 in the ratio between the subsector's energy consumption and *Gross Value Added (GVA).*

Figure 6. *Evolution of final energy consumption and Gross Value Added (GVA) in the "Non-Metallic Minerals" area in the 2004-2010 period*

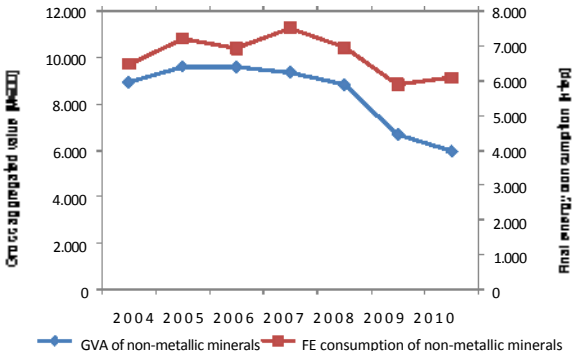


Table 14. *Results of technological savings according to PDM1 for each activity area in 2009 and 2010 with base years 2004 and 2007*

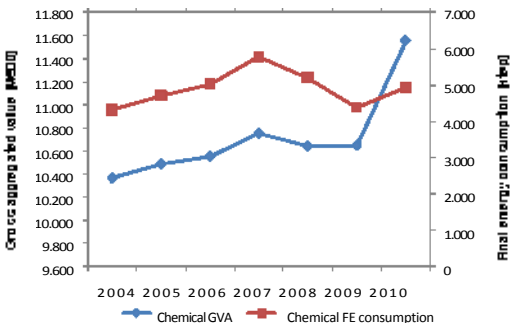
		Associated indicator	2009	2010
Base year 2004 [ktep]	**Industry sector total**	***∑LTi***	**285,2**	**-2.454,1**
	Wood, cork and furniture	*LT*	-130,2	-195,0
	Food, drink and tobacco		992,5	885,4
	Textiles, leather and footwear		197,7	68,6
	Cardboard, paper and printing		-102,7	-403,9
	Chemical		48,6	-128,4
	Non-metallic minerals		-1.222,0	-2.169,1
	Metallurgy and metal products		933,6	692,9
	Machinery and mechanical equipment		10,4	22,6
	Transport equipment		43,1	-77,5
	Electrical, electronic and optical equipment		-8,3	-18,9
	Rest of the manufacturing industry		-477,6	-1.130,9
Base year 2007 [ktep]	**Industry sector total**	***∑LTi***	**-1.205,5**	**-3.987,7**
	Wood, cork and furniture	*LT*	-258,7	-316,7
	Food, drink and tobacco		333,2	215,2
	Textiles, leather and footwear		75,3	-41,3
	Cardboard, paper and printing		-68,7	-377,6
	Chemical		1.339,0	1.211,0
	Non-metallic minerals		-621,3	-1.632,0
	Metallurgy and metal products		-563,3	-823,8
	Machinery and mechanical equi		-12,4	-0,5
	Transport equipment		-203,7	-325,8
	Electrical, electronic and optical equipment		-41,5	-52,9
	Rest of the manufacturing industry		-1.183,4	-1.843,3

Table 15. *Results of structural savings according to PDM1 for each economic sector in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	**Industry sector total**	***∑Li***	**1.845,9**	**1.655,5**
	Wood, cork and furniture	*LE*	233,8	281,8
	Food, drink and tobacco		-318,7	-448,7
	Textiles, leather and footwear		215,8	251,2
	Cardboard, paper and printing		5,8	-3,2
	Chemical		-429,2	-942,7
	Non-metallic minerals		1.356,5	1.956,5
	Metallurgy and metal products		852,5	590,2
	Machinery and mechanical equipment		13,1	-9,8
	Transport equipment		152,3	146,6
	Electrical, electronic and optical equipment		32,3	13,5
	Rest of the manufacturing industry		-268,2	-179,9
Base year 2007 [ktep]	**Industry sector total**	***∑LEi***	**1.342,2**	**1.122,1**
	Wood, cork and furniture	*LE*	152,6	195,7
	Food, drink and tobacco		-290,0	-409,2
	Textiles, leather and footwear		59,0	82,1
	Cardboard, paper and printing		-39,3	-50,9
	Chemical		-650,8	-1.252,7
	Non-metallic minerals		1.312,6	1.957,1
	Metallurgy and metal products		782,7	542,3
	Machinery and mechanical equipment		1,7	-20,8
	Transport equipment		134,2	129,5
	Electrical, electronic and optical equipment		30,6	12,1
	Rest of the manufacturing industry		-151,1	-63,2

For its part, the chemical sector, with a relative weight of the sector's final energy consumption of 18% in 2010, presents the best penalties with respect to the PDM1 structural indicator, due to gradual removal from 2008 in the ratio between the subsector's energy consumption and Gross Value Added (GVA) as shown in Figure 7.

Figure 7. *Evolution of final energy consumption and Gross Value Added (GVA) in the "Chemical" sector in the 2004-2010 period*



Additionally, it was considered of interest to check the calculation presented through the PDM1 formula, which would result in use of the descending indicator proposed by the European Commission, *M8*, with the aim of checking the accuracy of the conclusions drawn. The *M8* indicator is defined as the ratio between the industrial sector's final energy consumption and the GVA.

$$M8 = \left(\frac{E^I}{VA^I}\right)$$

where:
- E^I: Energy consumption in the industry sector
- VA^I: Gross Value Added (GVA) in the industry sector

The savings relative to the outer boundary in the sector using the *M8* indicator are a result of multiplying the difference between the values of this in the reference years (2004 and 2007) and the calculation year (2010) by the sector's Gross Value Added (GVA) and by boundary K which determines the industry sector's percentage of final energy consumption not affected by the entry into force of Directive 2006/32/EC.

$$\text{Savings achieved by } M8 = \left[\left(\frac{E^I_{04_T}}{VA^I_{04}}\right) - \left(\frac{E^I_{10}}{VA^I_{10}}\right)\right] . VA_{2010} . K_{2004}$$

where
- E_I: Energy consumption in the industry sector
- *K:* Percentage of final energy consumption not affected by Directive 2006/32/EC
- VA^I: Gross Value Added (GVA) in the industry sector

The total savings achieved in the industry sector through indicator *M8* are recorded as both direct and indirect savings.

Table 16. *Results of savings in the industry sector in 2009 and 2010 with base years 2004 and 2007 according to indicator M8*

		Associated indicator	2009	2010
Base year 2004	Industry sector	*M8*	2.048,8	-771,5
Base year 2007	Industry sector	*M8*	117,3	-2.658,2

As we can see, the results obtained through the PDM1 methodology and through *M8* indicators are coherent, showing differences in the order of 7%.

3. Improved energy efficiency of industrial equipment

The technological evolution of the equipment facilitates the achievement of improved consumption ratios by unit produced in the industrial processes. Despite representing lower operating costs for companies, in many cases this equipment undertakes substantial investments, and therefore the decision to deal with projects to improve energy efficiency is not immediate.

Subsequently, in the 2005-2007 and 2008-2012 Action Plans, measures were set out to promote the incorporation of more efficient equipment, articulated through various initiatives developed from IDAE:

- Collaboration agreements between IDAE and the Autonomous Communities in the 2005-2010 period through those which adopted public support for the acquisition of equipment to improve energy efficiency.
- IDAE's Grants for Strategic Projects Programmes in the 2008-2010 period — public aid programmes for investment in saving and energy efficiency projects.

3.1. Collaboration agreements between IDAE and the Autonomous Communities

The collaboration agreements between Administrations set out a wide spectrum of actions both from public support and training courses. In the case of investments in equipment, the amount of the support assigned covers up to 22% of the equipment cost.

To calculate the saving from support programmes approved within the context of these collaboration agreements, annual reports established by the Autonomous Communities were used for the savings achieved, basically, through public aid programmes and energy audits.

It is believed that the lifespan of this type of improvement is greater than the savings' analysis period, therefore the savings made in 2010 are a result of the sum of the specific savings defined as the quotient between the savings made in year t and the GVA of the same year recorded since 2008.

$$BU = \sum_{t=2008}^{2010} \frac{Ah_t}{GVA_t} \cdot VAR$$

where:

- Ah_t: Annual reports from the Autonomous Communities concerning:
  - public aid programme
  - Energy audits and other studies
  - Training and disclosure activities
  - Programme for improving efficiency and promoting research
- GVA_t: Gross Value Added for the industry in year t.

3.2. IDAE Grants for Strategic Projects Programme

This initiative aims to complement and reinforce the efforts made on the part of the different Administrations to encourage companies to carry out multiyear investment projects in saving and energy efficiency technologies.

This relates to covering certain types of projects which do not have enough support with the current existing mechanisms, with a continuous and open support vision (direct and indirect benefits in all sectors).

To calculate the effect produced by these strategic projects, annual reports established by IDAE on the savings made thanks to investments in energy efficiency related to this initiative were used.

It is believed that the lifespan of this type of improvement is greater than the analysis period so the savings made in 2010 are the sum of the specific savings reported since 2008 normalised to the 2010 activity index.

$$BU = \sum_{t=2008}^{2010} Ah_t$$

where:

- Ah_t : Annual savings in relation to strategic projects developed by IDAE

3.3. Summary of the industry sector's direct savings

These are considered as direct savings produced as a result of the implementation of specific measures which promoted the improvement of industrial equipment and which enabled the reduction of consumption through the mechanisms developed from the Public Administrations.

Table 17. *Savings made due to the "Improved equipment in the industry sector" measure during the 2004-2010 period*

		Associated indicator	2009	2010
Base year 2004 [ktep]	**Improved equipment in the industrial**	$BU_{indC} + BU_{indC}$	**952,2**	**1.200,1**
	IDAE-Autonomous Communities collaboration	BU_{indC}	854,8	1.068,6
	Strategic projects	BU_{indC}	97,3	131,5
Base year 2007 [ktep]	**Improved equipment in the industrial**	$BU_{indC} + BU_{indC}$	**550,4**	**803,9**
	IDAE-Autonomous Communities collaboration	BU_{indC}	453,0	672,5
	Strategic projects	BU_{indC}	97,3	131,5

4. Savings achieved in the industry sector up to 2010

The industry sector made negative global final energy savings of -798,6 ktep in the 2004-2010 period. Said negative savings were reduced, mainly, thanks to the evolution of the structure of the sector itself, with 1,655.6 ktep being attributed to this cause. On the other hand, we can see negative savings values of -2.454,1 ktep due to the fall in production ratios in some fields negatively affecting the energy efficiency of some industrial processes.

Table 18. *Results of savings in the industrial sector according to PDM 1 (total, technology and structure) in 2009 and 2010 with base years 2004 and 2007 according to indicator M8*

		Associated indicator	2009	2010
Base year 2004 [ktep]	**Industry sector total**	***LT+LE***	**2.131,1**	**-798,6**
	Technological effect in the industry sector	*LT*	285,2	-2.454,1
	Structural effect in the industry sector	*LE*	1.845,9	1.655,5
Base year 2007 [ktep]	**Industry sector total**	***LT+LE***	**136,7**	**-2.865,6**
	Technological effect in the industry sector	*LT*	-1.205,5	-3.987,7
	Structural effect in the industry sector	*LE*	1.342,2	1.122,1

In the case of the industrial sector, indirect effects cannot be counted; this is the same for effects of double counting. This is the reason why the results from the PDM1 formulas have the property of being additives and the total is calculated as a sum of the partials.

III. TRANSPORT SECTOR

1. Summary of savings in the transport sector

THE TRANSPORT SECTOR

During the analysis period, the transport sector remains, with 39.3% of the total final energy consumption in 2010, the primary consumer sector ahead of industry and the other sectors. The sector's energy consumption is directly related to its activity. Periods with large falls in consumption such as the current situation give rise to fuel savings, due to the decrease in journeys and vehicle movements, particularly in the case of the carriage of goods.

Sector consumption

	Final energy 2010 [ktep]
TOTAL CONSUMPTION TRANSPORT SECTOR	**36.744**
ROAD TRANSPORT	29.375
RAIL TRANSPORT	1.156
MARITIME TRANSPORT	1.100
AIR TRANSPORT	5.112

Result of savings achieved

	Final energy saving 2010 [ktep]		Primary energy saving 2010 [ktep]		CO_2 [ktCO2] emissions avoided 2010	
	Base year 2004	Base year 2007	Base year 2004	Base year 2007	Base year 2004	Base year 2007
TOTAL SAVINGS TRANSPORT SECTOR	**6.451,1**	**4.561,1**	**6.874,1**	**4.909,2**	**21.471,2**	**13.330,1**
ROAD TRANSPORT	6.701,4	4.910,4	7.499,0	5.489,7	22.759,6	14.773,0
RAIL TRANSPORT	-317,4	-206,7	-677,8	-419,2	-1.468,0	-953,9
MARITIME TRANSPORT	52,3	-99,9	58,6	-111,9	166,8	-342,1
AIR TRANSPORT	-68,0	-48,3	-76,1	-54,1	-228,8	-162,5
INTERMODAL	82,7	5,6	70,4	4,7	241,7	15,6

Conclusions

The savings show varied performances depending on the different means of transport. The majority of the saving achieved by the transport sector focuses on road transport (6.701,4 ktep), particularly the carriage of goods, which makes up for the negative savings achieved for rail and air transport.

Rail transport achieved negative savings of -317,4 ktep however, it behaves differently according to the boundaries defined for the carriage of passengers and the carriage of goods. Within passenger transport, there are limited savings through the improvement of technical efficiency (24.3 ktep) however, these savings cannot compensate for the negative performance in terms of the carriage of goods due to low occupation and the increase in consumption per ton-kilometre transported.

The maritime sector shows relatively high positive savings given its size (52,3 ktep), due to a relative increase in traffic greater than that of fuel consumption.

The air sector shows negative savings of -68,0 ktep, due to an increase in consumption greater, in relative terms, than flights during the period analysed.

Generally, for all the means of transport, there is a decreasing trend in terms of consumption and total traffic in the latter years of the period analysed due to the economic climate. This effect is particularly pronounced in the carriage of goods, where the significant decrease in industrial activity causes a fall in consumption and lorry and light vehicle traffic whilst the fleet remains constant.

Finally, the indicators that measure change of mode show that savings were achieved (82.7 ktep) both in the carriage of goods and passengers. The carriage of passengers by rail and road has seen increases however, rail and maritime goods traffic declined in the period analysed, due, in large part, to the economic slowdown.

With respect to the renovation of the private vehicle fleet, fiscal discrimination on registration tax and the application of European regulation 443/2009 persuaded people buying new vehicles to look at those which are more efficient, the savings achieved by this being 425,3 ktep/year. In addition, direct actions from IDAE or those in collaboration with the Autonomous Communities, in addition to the specific vehicle renovation plans, reported savings equivalent to 309,6 ktep/year. The total savings associated with improving energy efficiency through renovation of the private vehicle fleet are 734,9 ktep/year.

Measurement-mechanism matrix

Measures \ Mechanisms		IDEA-Autonomous Communities Cooperation Programme	IDEA's Grants for Strategic Projects Programme	Strategy to promote the electric vehicle in Spain 2010-2015	Plan Prever	Fiscal discrimination for vehicle registration tax	Regulation 443/2009	Initial qualification and continuing training of road transport drivers (RD 1032/2007)	Plan VIVE	Plan 2000E	Total
2010 Base year 04 [ktep]	PMUS and PTT (1)	860,0									860,0
	Road transport fleet management	1,3									1,3
	Efficient driving of road transport	30						30,6			60,6
	Efficient driving of private vehicles	53,5									53,5
	Renovation of road transport fleets	1,5									1,5
	Renovation of private vehicles	6,9		2,1	275,3	425,3			10,0	15,4	734,9
	Total	953,2		2,1	275,3	425,3		30,6	10,0	15,4	1.711,8
2010 Base year 07 [ktep]	PMUS and PTT (1)	563,4									563,4
	Road transport fleet management	1,2									1,2
	Efficient driving of road transport	21,7						30,3			52,0
	Efficient driving of private vehicles	40,9									40,9
	Renovation of road transport fleets	1,0									1,0
	Renovation of private vehicles	4,9		2,1	-	188,5			10,0	15,4	220,9
	Total	633,1		2,1		188,5		30,3	10,0	15,4	879,4

(1) Sustainable urban mobility plans and Workers' transport plans

ROAD TRANSPORT

The energy savings achieved for road transport (6.701,4 ktep in the 2004-2010 period) were determined to have been for the carriage of goods, in large part through the decline in activity, and in private vehicles through the improvement of the fleet's efficiency. These means of transport account for almost 80% of the transport sector's final energy consumption in Spain in 2010.

The following analysis shows the energy savings achieved during the 2004-2010 period for road transport. To calculate the outer boundary of the global savings, *P* indicators proposed by the European Commission and ascending indicators developed by ourselves were used; whilst to evaluate the savings achieved through specific measures only ascending indicators were used.

Results achieved

		Final energy saving 2010 [ktep]	
		Base year 2004	Base year 2007
A2	Lorries	5.880,4	3.864,8
P8	Private vehicles	116,4	1.005,7
BU_{gf}	Road transport fleet management	1,3	1,2
BU_{cec}	Efficient driving of road transport fleets	60,6	52,0
BUcet	Efficient driving of private vehicles	53,5	40,9
BU_{rf}	Renovation of road transport fleets	1,0	1,0
BU_{rp}	Renovation of private vehicles	870,8	276,0
PB	Buses	32,6	39,9
ROAD TRANSPORT TOTAL*		6.837,3	4.910,4

*Indicators affecting totals correspond to shaded cells.

Savings diagram

The saving relative to road transport is organised into three main areas, taking into account the type of vehicle that the measure is focused on: private, freight or collective.

ROAD TRANSPORT TOTAL: BU_{rp} + BU_{cet} + A2 + PB = 6.701,4 ktep 2010 (base year 2004)

PRIVATE VEHICLES: BU_{rp} BU_{cet} = 788,4 ktep 2010 (base year 2004)

	Renovation of private vehicles (BU_{rp}) 734.9 ktep 2010 (base year 2004)	Efficient driving of private vehicles (BU_{cet}) 53.5ktep 2010 (base year 2004)	

GOODS: A2=5.880,4 ktep 2010 (base year 2004)

	Renovation of road transport fleets (BU_{rf}) 1.0ktep 2010 (base year 2004)	Road transport fleet management (BU_{gf}) 1.3 ktep 2010 (base year 2004)	Efficient driving of Lorries (BU_{cec}) 60,6 ktep 2010 (base year 2004)	

COLLECTIVE: PB: 32,6 ktep 2010 (base year 2004)

Conclusions

According to the descending and ascending indicators, global savings of 6.701,4 ktep have been achieved since 2004, the carriage of goods being where the most savings were achieved (5.880,4 according to indicator *A2*). Savings induced by measures accounted for savings of 734,9 ktep in vehicle renovations (private vehicles and lorries) and 53,5 ktep in measures relating to the efficient driving of private vehicles. Collective transport in the period analysed achieved 32,6 ktep.

OTHER MEANS OF TRANSPORT

The energy savings achieved for other means of transport and modal change (-250,3 ktep in the 2004-2010 period) were in part determined by improvements in the efficiency of maritime transport (52,3 ktep) and the transfer of passengers to more efficient means (82,7 ktep). Other means of transport accounted for around 20% of all final energy consumption in the transport sector in Spain in 2010.

To calculate the outer boundary, the corrected *M* and *P* indicators proposed by the European Commission have been used, whilst to evaluate the savings achieved through change of mode measures, *P* indicators (contribution) have been used, corrected or not according to the measure.

Results achieved

		Final energy saving 2010 [ktep]	
		Base year 2004	Base year 2007
P10	Passengers	24,3	29,8
P11	Goods	-341,7	-236,5
TOTAL RAIL TRANSPORT		-317,4	-206,7
M7	Maritime transport	52,3	-99,9
Mav	Air transport	-68,0	-48,3
TOTAL OTHER MEANS OF TRANSPORT		-15,6	-148,2
P12	Intermodal passengers	84,7	6,7
P13	Intermodal passengers	-2,0	-1,1
BU_{pm}	Sustainable urban mobility plans (PMUS) and Workers transport plans (PTT)	860,0	563,4
BU_{cc}	Greater participation of collective means of road transport	44,7	-12,3
BU_{fimer}	Passenger contribution	85,4	64,1
BU_{fipas}	Goods contribution	-	-
TOTAL INTERMODALITY			

*Indicators affecting totals correspond to shaded cells.

Conclusions

The savings corresponding to rail, maritime and air means of transport collectively achieved negative energy saving values in the period studied, due particularly to the poor performance of the carriage of goods by rail. The global result of rail transport was calculated using the sum of indicators *P10* and *P11* proposed by the European Commission, which gives a value of -317,4 ktep.

The maritime sector shows a relatively positive performance given its size, due to a relative increase in traffic greater than fuel consumption; a value of 52,3 ktep in 2010 with respect to 2004, calculated using the *M7* indicator proposed by the European Commission.

Finally, according to a descending *Mav* indicator proposed by ourselves from the indicators proposed by the European Commission, no savings were achieved in the air transport sector in the study period. The sector shows negative savings for an increase in consumption greater, in relative terms, than operations between 2004 and 2010 and particularly between 2007 and 2010.

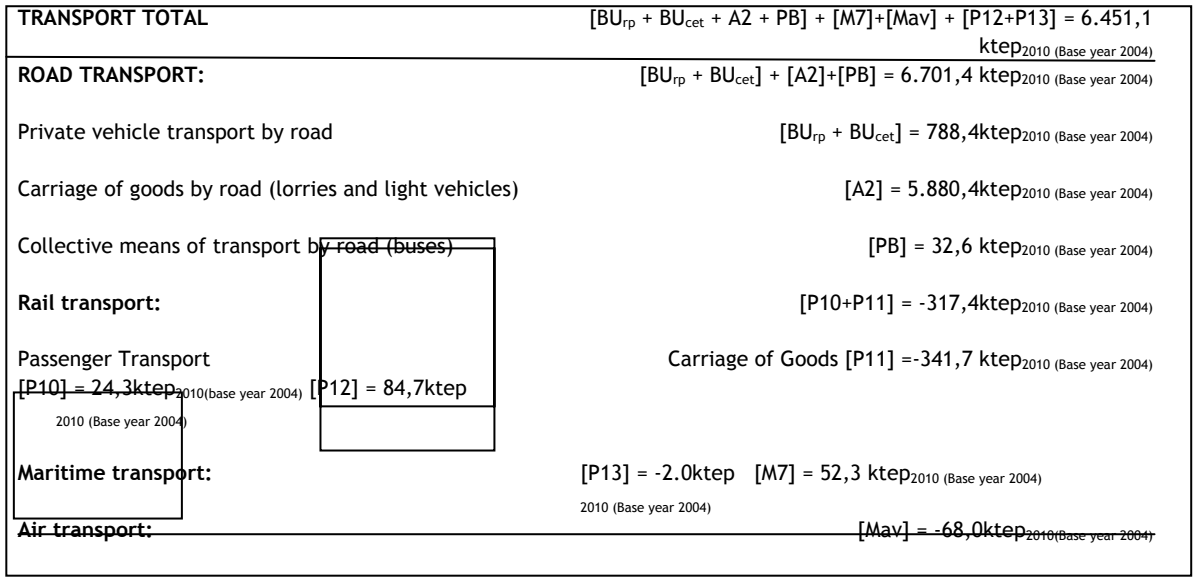
The descending *P* indicators for change of mode show improved energy efficiency (82.7 ktep) both in the carriage of goods and passengers. To calculate the savings induced by direct actions, corrected *P* indicators for change or mode were used. The measures analysed show reduced savings due to the fact that, generally speaking, the contribution of collective transport did not make significant progress. The economic crisis, in terms of increasing the unemployment rate, has caused a decrease in urban and intercity journeys for all means of transport.

2. Outer boundaries

To calculate the energy savings in the *Transport* Sector, a series of analysis boundaries have been defined based on the indicators selected. Firstly, the sector is structured into means of transport: road, railway, maritime (sea and river) and air. Subsequently a second level of boundaries has been defined for some modes in the calculation of saving indicators. For the analysis of road transport, this is structured into private vehicles, freight (lorries and light vehicles) and collective means (buses), whilst rail transport comprises passengers and freight.

The diagram of energy savings in the sector can be seen in Figure 8, which shows the values achieved in 2010 using 2004 as a base year and differentiates the savings by means of transport.

Figure 8. *Diagram of energy saving in the Transport sector in 2010 with base year 2004*



Below, the calculation methodology is shown as well as the key energy saving variables relating to the means of transport: road, rail, maritime and air.

2.1. Road transport

Road transport accounted for almost 80% of all final energy consumption nationally in 2010. To go into depth with the calculation of specific savings associated with different vehicle types, measures and means mechanisms, a series of overlapping analysis boundaries have been defined. The broadest distinguish between different types of vehicles: private vehicles, freight (lorries and light vehicles) and collective (buses).

Methodology

The diagram of energy savings in the road transport sector is presented in Figure 9, which shows the values achieved in 2010 using 2004 as a base year and differentiates the savings by activity.

Figure 9. *Diagram of the energy savings in road transport in 2010 with base year 2004*

<table>
<tr><td colspan="5">ROAD TRANSPORT: BU_{rp} + BU_{cet} + A2 + PB = 6.701,4 ktep 2010 (base year 2004)</td></tr>
<tr><td colspan="5">PRIVATE VEHICLES: BU_{rp} BU_{cet} = 788,4 ktep 2010 (base year 2004)</td></tr>
<tr><td></td><td>Renovation of private vehicles (BU_{rp})
734.9 ktep 2010 (base year 2004)</td><td>Efficient driving of private vehicles (BU_{cet})
53.5ktep 2010 (base year 2004)</td><td colspan="2"></td></tr>
<tr><td></td><td colspan="4">GOODS: A2=5.880,4 ktep 2010 (base year 2004)</td></tr>
<tr><td></td><td>Renovation of road transport fleets (BU_{rf})
1.0ktep 2010 (base year 2004)</td><td>Road transport fleet management (BU_{gf}) 1.3 ktep 2010 (base year 2004)</td><td>Efficient driving of Lorries (BU_{cec}) 60,6 ktep 2010 (base year 2004)</td><td></td></tr>
<tr><td colspan="5">COLLECTIVE: PB: 32,6 ktep 2010 (base year 2004)</td></tr>
</table>

To calculate the energy savings in road transport, both descending indicators proposed by the European Commission and descending and ascending indicators developed by ourselves have been used. Ascending indicators have also been calculated to calculate the impact of the different measures and mechanisms promoted by the Administration.

Private vehicles

Base year 2004

The saving corresponding to the initial boundary in 2010 with base year 2004 was calculated from the sum of the ascending BU_{rp} and BU_{cet} indicators.

The BU_{rp} indicator, developed by ourselves, is based on the unit saving associated with each renovated vehicle according to different types of replacement:

- Natural renovation with associated replacement
- Natural renovation without associated replacement
- Vehicle replacement plans
- Replacement by a hybrid vehicle
- Replacement by an electric vehicle

The saving from applying the indicator is as follows:

$$\text{Savings achieved by } BU_{rp} = \sum_{t=base\ year}^{t=i} (UE_t^x \cdot O_t^x) \cdot D_i$$

where:

- $UE\ xt$ = Unit saving per private vehicle depending on the type of replacement
- Di = Average distance travelled by private vehicles in a year
- Oxt = Number of annual operations (replacement plan and number of hybrid vehicles registered etc).

The BU_{cet} indicator is an indicator developed by ourselves based on the unit saving associated with efficient driving courses for drivers and trainers. The calculation of the savings associated with this measure has been performed using an ascending indicator based on the reduction in unit consumption derived from the driving courses.

The saving from applying the indicator is as follows:

$$\text{Savings achieved by } BU_{cet} = \left(UE^{CA} - UE^{CAFormado}\right) \cdot D_i^{av.km CA} \cdot S_{alumnos}$$

where:

- UE^{CA} = Average unit consumption of private vehicles
- $UE^{CAFormados}$ = Average unit consumption of private vehicles driven by trained drivers
- $D_i^{av.km CA}$ = Average distance travelled by private vehicle
- $S_{alumnos}$ = Number of equivalent students trained

Base year 2007

To calculate the savings in base year 2007, Indicator *P8* "Energy consumption of private vehicles per passenger-km" has been chosen (proposed by the European Union), allowing the savings corresponding to improved techniques and driving efficiency to be isolated. The savings are calculated as the variation of the ratio of consumption and traffic measured in passengers-km.

$$P8 = \left(\frac{E^{CA}}{T^{CA}}\right)$$

where:

- E^{CA} = Total consumption of private vehicles
- T^{CA}= Total private vehicle traffic

The savings relating to the outer boundary in road transport measured by *P* and *M* indicators are the result of the multiplication of the difference between the values of these indicators for the reference year (2007) and the calculation year (2010) and the value of the activity variable relative to the indicator.

For example, for indicator *P8* in 2010 with base year 2007:

$$\text{Savings achieved by } P8 = \left(\frac{E^{CA}_{2007}}{T^{CA}_{2007}} - \frac{E^{CA}_{2010}}{T^{CA}_{2010}}\right) * T^{CA}_{2010}$$

Goods

The saving corresponding to the initial boundary in 2010 with base year 2004 was calculated using descending indicator A2.

In the second analysis boundary, the indicator proposed by the European Commission "Energy consumption of lorries and light vehicles per vehicle" is used. Said indicator is calculated as the ratio of total consumption for the carriage of goods and the total fleet of lorries and light vehicles.

$$A2 = \left(\frac{E^{TLV}}{S^{TLV}}\right)$$

where:

- E^{TLV} = Consumption in the carriage of goods by road
- S^{TLV} = Total fleet of lorries and light vehicles

The following boundary is formed by the descending indicators that measure the measures and specific mechanisms concerning lorries and light vehicles in the period analysed.

Collective means

The saving corresponding to the initial boundary was calculated from the ascending *PB* indicator, it being understood that the indicator proposed by the European Commission *M5* "Energy consumption per equivalent vehicle", is only calculated for buses. Said indicator allows the total consumption of collective means of transport by road to be related to the fleet of buses. The variation of the indicator identifies the energy savings in the period analysed for collective means of transport.

$$PB = \left(\frac{E^{Col}}{\quad}\right)$$

where:

- E^{Col} = Consumption of collective road transport
- S^{Bus}= Total fleet of buses on the road

For base year 2004, the sum of the specific savings associated with the BU_{rp}, BU_{cet}, *A2* and *PB* indicators shows the global savings achieved for road transport in 2010. For base year 2007, the global savings achieved for road transport in 2010 are the result of the sum of the specific savings associated with the *P8*, *A2* and *PB* indicators, which present more consistent behaviour.

Key variables in road transport

This section discusses all the variables that directly affect the calculation of the savings achieved in this means of transport.

Table 19. *Evolution of final energy consumption in the Transport Sector in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Total transport consumption [ktep]	38.317	40.804	39.313	37.464	36.744

Source: IDAE

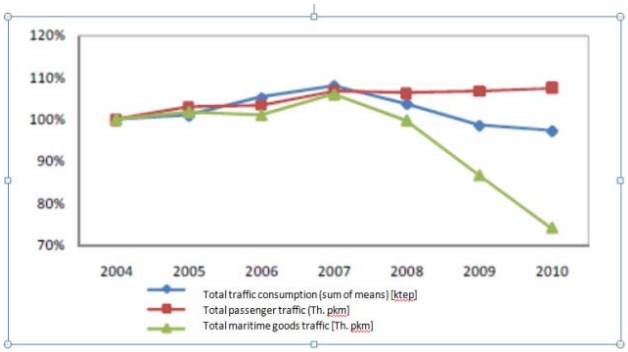
Table 20. *Evolution of the generic activity variables used in the calculation of savings in road transport in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Total road transport consumption [ktep]	30.082	32.460	31.158	29.749	29.375
Total private vehicle consumption [ktep]	11.775	13.112	12.778	12.336	12.400
Total consumption of lorries and light vehicles [ktep]	16.789	17.503	16.325	14.944	13.500
Total consumption of buses [ktep]	963	1.039	997	952	1.028
Intercity private vehicle traffic [Mill pkm]	330.192	343.293	342.611	350.536	350.980
Intercity bus traffic [Mill pkm]	53.458	59.163	60.864	57.233	59.691
Circulating private vehicles [Und.]	14.798.238	16.478.026	16.769.713	16.647.129	16.711.309
Bus fleet [Und.]	39.370	42.192	42.992	43.315	43.383

Source: IDAE

We can see, due to the current economic situation, a downward trend in total consumption in the last years of the period analysed. It is in the carriage of goods that the strength of decrease in industrial activity is most noted, causing the fall in consumption, whilst the fleet remains constant.

Figure 10. *Evolution relative to consumption and passenger and goods traffic in the transport sector in the 2004-2010 period*



The contribution of collective road transport with respect to private vehicle traffic maintained similar values to 2004, although significant variations occurred during the period analysed.

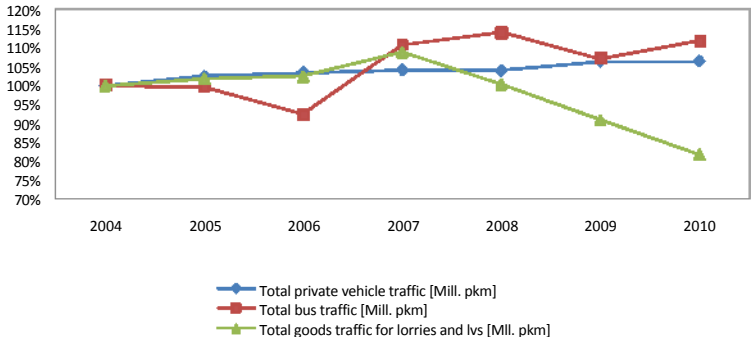


Figure 11. *Evolution relative to traffic by vehicle type on the road in the 2004-2010 period*

This behaviour is due to the transfer of passenger traffic, in terms of collective transport, to rail in urban environments and local rail in intercity environments. In addition, the increase in the unemployment rate has caused a fall in urban and intercity journeys made for all types of means of transport.

Table 21. *Evolution of distances travelled per vehicle in the 2004-2010 period*

	2004	2007	2008	2009	2010
Average distance travelled by private vehicles [km]	13.437	12.824	12.428	12.703	12.665
Average distance travelled by urban private vehicles [km]	9.033	9.039	8.544	8.573	8.540
Average distance travelled by intercity private vehicles [km]	4.404	3.784	3.885	4.130	4.125
Average distance travelled by lorries and lgvs (weighting) [km]	45.195	47.505	45.855	44.399	40.335

Source: IDAE

Total savings achieved for road transport

To calculate the energy saving achieved in the period, the BU_{rp}, BU_{cec}, *A2* and *PB* indicators were used, applying the sector's variables previously presented.

Table 22. *Results of energy savings achieved for road transport in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	**Total road transport**	**BU_{rp}+ BU_{cet}+A 2 +PB**	**5.368,8**	**6.701,4**
	Renovation of private vehicles	BU_{rp}	651,7	734,9
	Private vehicles	*P8*	164,4	116,4
	Lorries	*A2*	4.573,9	5.880,4
	Buses	*PB*	107,1	32,6
	Efficient driving of private vehicles	BU_{cet}	36,1	53,5
Base year 2007 [ktep]	**Total road transport**	***P8+A2+PB***	**3.710,9**	**4.910,4**
	Renovation of private vehicles	BU_{rp}	138,7	220,9
	Private vehicles	*P8*	1.052,6	1.005,7
	Lorries	*A2*	2.543,9	3.864,8
	Buses	*PB*	114,4	39,9
	Efficient driving of private vehicles	BU_{cet}	23,5	40,9

According to the sum of ascending and descending indicators in Table 22, savings of 6.837,3 ktep were achieved for road transport in the 2004-2010 study period, representing a percentage saving of 23.3% on final energy consumption associated with the mode. This result is determined, basically, by indicator *A2*, which quantifies the savings associated with the carriage of goods by road as seen in Figure 13.

Figure 12. *Evolution of indicator P8 relating to private vehicle traffic in the 2004-2010 period*

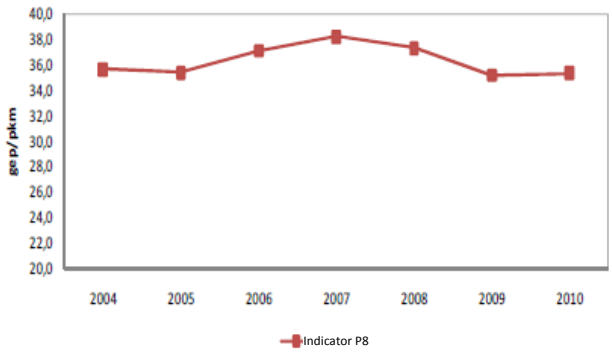
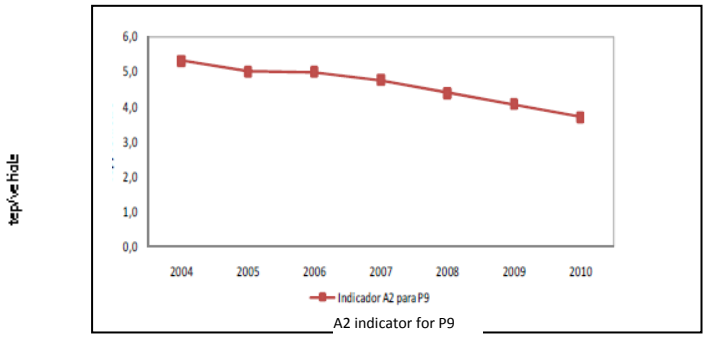


Figure 13. *Evolution of indicator A2 relative to the carriage of goods by road in the 2004-2010 period*



2.2. Rail transport

Rail transport accounted for almost 3.1% of the total national final energy consumption in 2010. To look at the calculation of specific savings associated with different vehicle types, measures and means mechanisms in more depth, two areas of analysis have been defined based on the two activities of rail transport: passengers and goods.

Methodology

The diagram of energy savings in the rail transport sector are presented in Figure 14 shows the values achieved in 2010 using 2004 as a base year and differentiates the savings by activity.

Figure 14. *Diagram of energy savings in rail transport in 2010 with base year 2004*

RAIL TRANSPORT TOTAL	P10+P11 = -317,4 ktep 2010(base year 2004)
PASSENGERS P10 = 24,3 ktep 2010(base year 2004)	GOODS P11 = -341,7 ktep 2010(base year 2004)

To calculate the savings achieved for rail transport, two indicators proposed by the European Commission have been used: indicator *P10* "Energy consumption for the carriage of passengers by rail by passenger-km" and indicator *P11* "Energy consumption for the carriage of goods by rail by ton-km".

Both indicators allow the measurement of energy savings based on a ratio of energy consumption and rail traffic for the carriage of passengers on the one hand *(P10)*, and for the carriage of goods on the other (*P11*).

Passengers

The calculation of the saving associated with the carriage of passengers by rail was performed using indicator *P10* proposed by the European Commission, calculated as a ratio of energy consumption and passenger traffic. The variation of the indicator shows the savings derived from improved energy efficiency and improved loading factors.

$$P10 = \left(\frac{E^{RF}}{T^{RF}}\right)$$

where:

- E^{RF} = Total consumption for rail transport
- T^{RF} Total passenger traffic for rail transport

Goods

The calculation of the saving associated with the carriage of goods by rail was performed using indicator *P11* proposed by the European Commission, calculated as a ratio of energy consumption and goods traffic. Similar to the previous indicator, the variation of the indicator shows the savings derived from improved energy efficiency and improved loading factors.

$$P11 = \left(\frac{E^{RFm}}{T^{RFm}}\right)$$

where:

- E^{RFm} = Total consumption for the carriage of goods by rail
- T^{RFm} = Total goods traffic for rail transport

Key variables in rail transport

Table 23 shows all the variables that directly affect the calculation of the savings achieved for this means of transport.

Table 23. *Evolution of the generic activity variables for rail transport in the 2004-2010 period*

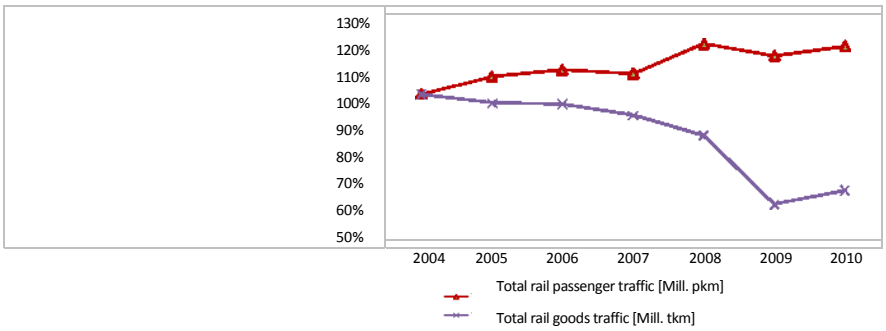
	2004	2007	2008	2009	2010
Total rail transport consumption [ktep]	1.090	1.193	1.169	1.124	1.156
Rail transport consumption for passengers [ktep]	224	246	241	232	238
Rail transport consumption for goods[ktep]	866	948	929	893	918
Total passenger traffic for the railway [Mill. pkm]	20.386	21.857	23.969	23.137	23.824
Total goods traffic for the railway [Mill. pkm]	12.018	11.124	10.287	7.391	8.000

Source: IDAE

Goods traffic by rail showed declining behaviour in the period analysed, due, in large part, to the slowdown in economic activity and improved flexibility of competitive means of transport.

However, the carriage of passengers by rail experienced completely different behaviour with increased traffic in the period analysed. This growth is due, in large part, to the introduction of new high-speed lines, particularly the one linking Madrid and Barcelona.

Figure 15. *Evolution relative to passenger and goods traffic in the 2004-2010 period*



Total savings achieved for rail transport

To calculate the energy saving achieved in the period, the indicators described were used applying the sector's variables presented for calculation of the indicators.

Table 24. *Results of energy saving for rail transport in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Rail	*P10 + P11*	-337,1	-317,4
	Rail passengers	*P10*	23,3	24,3
	Rail goods	*P11*	-360,4	-341,7
Base year 2007 [ktep]	Rail	*P10 + P11*	-234,6	-206,7
	Rail passengers	*P10*	28,6	29,8
	Rail goods	*P11*	-263,2	-236,5

According to the *P10* and *P11* descending indicators, no savings were achieved in the period studied due, mainly, to the poor performance of goods transport. In terms of the carriage of passengers, limited savings were achieved through improvements in technical efficiency. However, the carriage of goods by rail shows a negative performance in terms of energy saving.

Positive savings could not be achieved due, basically, to the economic situation, which caused a significant fall in traffic whilst only small savings were achieved in consumption due to a fall in the average occupation of trains.

Figure 16. *Evolution of indicator P10 relative to the carriage of passengers by rail in the 2004-2010 period*

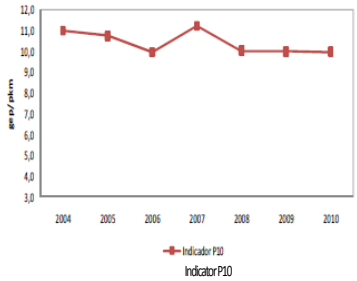
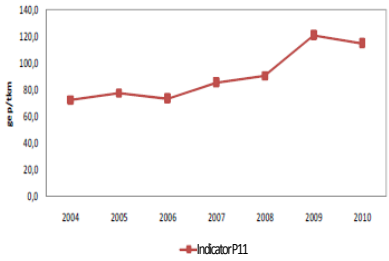


Figure 17. *Evolution of indicator P11 relative to the carriage of goods by rail in the 2004-2010 period*



2.3. Maritime transport

Maritime transport is understood, for the purposes of this analysis, as the sum of coastal and river transport and accounted for 3.0% of total final energy consumption of the transport sector in Spain in 2010. The scope of this analysis was limited to the carriage of goods, which accounts for 81.9% of this means of transport's total consumption.

Methodology

Calculation of the savings associated with maritime transport was performed using indicator *M7* proposed by the European Commission, understood as the ratio between total consumption and total maritime goods transport. The variation of the indicator shows the savings derived from improved energy efficiency and improved loading factors.

$$M7 = \left(\frac{E^W}{T^W}\right)$$

where:

- E^W = Consumption for maritime carriage of goods (sea and river)
- T^W = Total traffic for the maritime carriage of goods (sea and river)

Key variables in maritime transport

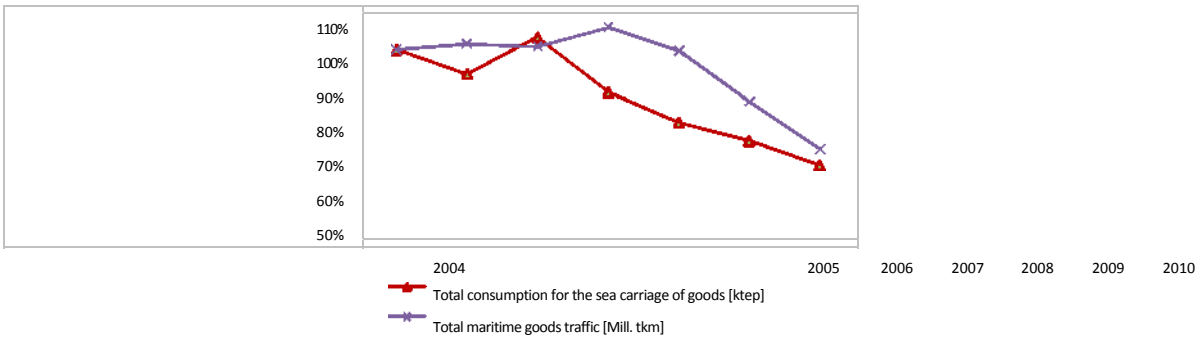
Table 25. *Evolution of maritime consumption and traffic in the 2004-2010 period*

	2004	2007	2008	2009	2010
Total consumption for the maritime carriage of goods [ktep]	1.285	1.144	1.042	981	900
Total maritime goods traffic [Mill.pkm]	43.120	45.675	43.005	37.345	31.973

Source: IDAE

The maritime carriage of goods was significantly affected by the economic crisis. However, the fall in consumption was greater, in relative terms, than the fall in goods traffic between 2004 and 2010, as seen in Figure 18.

Figure 18. *Evolution relative to traffic and consumption for the maritime carriage of goods in the 2004-2010 period*



Total savings achieved by maritime transport

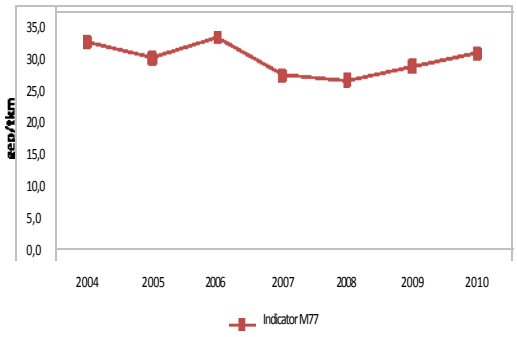
To calculate the energy saving achieved in the period, the indicators described were used applying the sector's variables presented for calculation of the indicators.

Table 26. *Results of energy saving for maritime transport in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Maritime Transport	*M7*	131,9	52,3
Base year 2007 [ktep]	Maritime Transport	*M7*	- 45,9	- 99,9

The maritime sector shows savings in 2010, with respect to the situation in 2004, of 52,3 ktep, representing a percentage savings of 5.5% on final energy consumption in the maritime goods transport sector.

Figure 19. *Evolution of indicator M7 relating to maritime transport in the 2004-2010 period*



2.4. Air transport

In 2010, air transport accounted for 13.9% of total final energy consumption of the transport sector in Spain.

Methodology

To calculate the savings achieved in air transport, indicators *M5*, *M6* and *M7* were taken as a reference by other means of transport. This new indicator, called *Mav*, is calculated as the ratio of total energy consumption and total traffic (number of flights during the year).

$$Mav = \left(\frac{E^{Aéreo}}{T^{Aéreo}} \right)$$

where:

- $E^{Aéreo}$ = Consumption of air transport
- $T^{Aéreo}$ = Total air traffic (number of flights)

Key variables in the air transport sector

Table 27 shows all the variables that directly affect the calculation of the savings achieved by this means of transport.

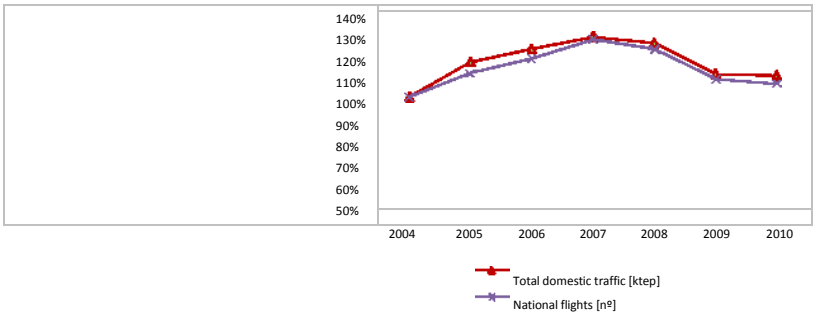
Table 27. *Evolution relative to air traffic and consumption in the 2004-2010 period*

	2004	2007	2008	2009	2010
Total domestic traffic [ktep]	1.902	2.413	2.357	2.097	2.083
National flights [Units]	820.409	1.030.450	994.158	885.427	869.222

Source: IDAE, INE

Figure 20 shows that air transport has experienced a sharp decline in flights since 2008 (-13%), although the consumption-flight ratio remained almost constant during this period. In this sector, a lot of effort will be required to improve the efficiency of consumption through the acquisition of more efficient aircraft, optimised traffic management and measures associated with improving pilots' flying skills. There is also great potential for improving the efficiency of mobile handling equipment at airports.

Figure 20. *Evolution relative to consumption and national flights in the air transport sector in the 2004-2010 period*



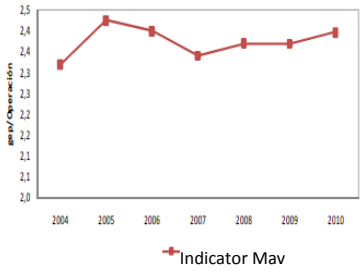
Total savings achieved by air transport

To calculate the energy saving achieved in the period, the *Mav* indicator was used applying the sector's variables presented in Table 28.

Table 28. *Results of energy saving in air transport in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004[ktep]	Air transport	*Mav*	- 44,5	- 68,0
Base year 2007[ktep]	Air transport	*Mav*	- 24,4	-48,3

Figure 21. *Evolution of the Mav indicator relating to air transport in the 2004-2010 period*



The fall in flights was due, in large part, to fewer journeys. Despite the results achieved during this period, the air transport sector has launched a large number of initiatives aimed at reducing its operational costs and its effect on the demand for air traffic.

2.5. Modal change

The majority of the energy efficiency measures established by the IDAE, basically, in collaboration with the Autonomous Communities, in the period analysed were focused on change of mode, that is to say, on the promotion of more energy efficient means of transport.

Methodology

The saving corresponding to the transfer of passenger and goods traffic to more efficient means of transport was calculated using the *P12* indicator "Public transport contribution to the land carriage of passengers" and *P13* "Rail and maritime carriage of goods defined by the European Commission.

Passengers

With respect to the carriage of passengers, the saving was calculated from the contribution of collective transport compared with road transport. For its calculation, the variations in contribution were multiplied by the differential between the unit consumption of collective transport and road transport standardised by traffic in 2010.

$$P12 = \left(\frac{T_{Public}^{Pa}}{T^{Pa}}\right)$$

where:

- T^{Pa} = Total passenger traffic
- T_{Public}^{Pa} = Total passenger traffic in air transport

For example, for indicator *P12*, in 2010 with base year 2004:

$$\text{Savings achieved by } P12 = \left(\frac{T_{Public2010}^{Pa}}{T_{2010}^{Pa}} - \frac{T_{Public2004}^{Pa}}{T_{2004}^{Pa}}\right) \cdot T_{2010}^{Pa} \cdot \left(UE_{2010}^{CA} - UE_{2010}^{PT}\right)$$

where:

- T^{Pa} = Total passenger traffic
- T_{Public}^{Pa} = Total passenger traffic in terms of collective transport
- UE^{CA} = Unit consumption of private vehicles
- UE^{PT} = Unit consumption for collective transport

Goods

For its part, the savings relative to the carriage of goods were calculated from variations in the transport contribution of rail and maritime transport compared with other means of transport. For its calculation, the contribution variations were multiplied by the differential between the unit consumption of rail and maritime transport and road transport standardised by traffic in 2010.

$$P13 = \left(\frac{T_{RW}^{Fr}}{T^{Fr}}\right)$$

where:

- T^{Fr} = Total goods traffic
- T_{Rw}^{Fr} = Total rail and maritime goods traffic

Total savings achieved by modal change

This section shows the results of the total savings achieved through changing to more efficient means of transport, both in terms of passengers and goods, including savings achieved due to indirect effects produced in the sector.

To calculate the energy saving achieved in the period, the indicators described were used in the first section, applying the sector's variables presented for calculation of the change of mode indicators.

Table 29. Results of energy saving by change of mode in the air transport sector in 2009 and 2010 with base years 2004 and 2007

		Associated indicator	2009	2010
Base year 2004 [ktep]	Total savings through modal change	P12+P13	14,8	82,7
	Passengers	P12	33,3	84,7
	Goods	P13	-18,5	-2,0
Base year 2007 [ktep]	Total savings through modal change	P12+P13	-54,4	5,6
	Passengers	P12	-45,1	6,7
	Goods	P13	-9,3	-1,1

According to the *P12* and *P13* "contribution" indicators, modal change achieved savings of 82,7 ktep with respect to 2004, which accounts for 0,2% of final energy consumption associated with the total for the *Transport* Sector (see Table 29).

Due to the economic crisis in Spain in 2008, we have seen a decreased growth in the hoped for amount of collective transport mode, which has resulted in a reduction of the modal transfer savings, given that saving indicator under consideration depends on total traffic.

Figure 22. *Evolution of the P12 indicators relative to modal change in the carriage of passengers in the 2004-2010 period*

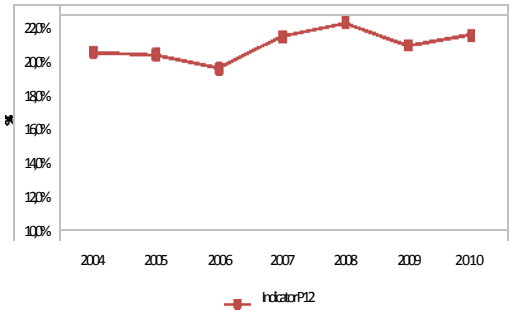
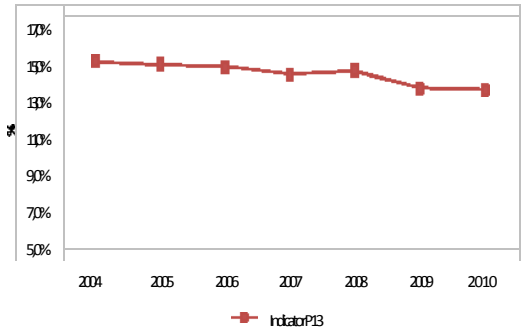


Figure 23. *Evolution of the P13 indicators relative to modal change in the carriage of goods in the 2004-2010 period*



3. Sustainable Urban Mobility Plans (PMUS) and Workers' Transport Plans (PTT)

Sustainable Urban Mobility Plans (PMUS hereinafter) promote the use of more sustainable means of displacement (walking, bicycle and public transport), compatible with economic growth, therefore achieving a better quality of life for citizens. The implementation of the PMUS in Spain is recent and falls within a well-defined strategic framework through action policies such as the PEIT (Strategic Infrastructure and Transport Plan 2005 - 2020) or the 2005 - 2007 and 2008 - 2012 Action Plans.

Methodology

To calculate the effect produced by the measure, the information used was provided by the Autonomous Communities for the savings made thanks to public supports aimed at this measure. This is the sum of savings recorded every year since 2004 or 2007 depending on the calculation base year chosen.

$$BU_{pmus} = \sum Ah_{pmus}$$ where:

- Ah_{pmus}: Annual savings reported by the Autonomous Communities concerning "PMUS"

Key variables

Table 30 shows all the variables that directly affect the calculation of savings achieved by this measure.

Table 30. *Evolution of the specific "PMUS and PTT" variables in the 2004-2010 period*

	2004	2007	2008	2009	2010
Saving for every 100 bicycles [tep]	9,32	9,32	9,32	9,32	9,32
Operating bicycles [number]	-	5.285	6.883	6.883	6.883
IDAE's investment in PMUS [k €]	-	9.602	17.048	11.551	8.962

Source: IDAE

Various concepts can be found under the "IDAE's investment in PMUS" epigraph. Said investments include the amounts dedicated to actions such as *"Sustainable Urban*

Mobility Plans (PMUS)" and *"Workers' Transport Plans (PTT)"*, since the latter are an integral part of the correct implementation of a PMUS in a community.

Within the actions implemented, there are various types of initiatives:

- Complete studies of sustainable mobility.
- Promotion of urban transport by bicycle: design and implementation of public-use bicycle systems in cities, preferably of average-size (see Table 32).
- Feasibility studies and pilot programme experiments related to PMUS and PTT.
- Studies to follow-up the results of the introduction of sustainable urban mobility measures.
- Training courses for mobility managers.

Direct savings achieved

To calculate the energy saving achieved through this measure in the period, indicator BU_{pm} was used, applying the sector variables presented in Table 31.

Table 31. *Results of energy saving through the "PMUS and PTT" measure in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004[ktep]	Sustainable Urban Mobility Plans (PMUS) and Workers Transport Plans (PTT)	BU_{pm}	725,6	860,0
Base year 2007[ktep]	Sustainable Urban Mobility Plans (PMUS) and Workers Transport Plans (PTT)	BU_{pm}	429,0	563,4

The "PMUS and PTT" measure achieved, as shown in Table 33, savings of 860,0 ktep in the 2004-2010 period, which accounts for 2.3% of total final energy consumption in the transport sector in 2010.

4. Greater participation of collective means in road transport

This measure aims to achieve greater participation of collective means in transport by road, compared against the participation of private vehicles, improving both public transport infrastructures and service quality.

Methodology

The saving associated with the use of collective transport by road was calculated using corrected indicator *P12* proposed by the European Commission, which relates the variations in the contribution of collective transport by road (bus) compared with private transport (private vehicles).

$$BU_{cc} = \left(\frac{T^{PaColCarr}}{T^{Pa}} \right)$$

where:

- T^{Pa} = Total passenger traffic by road
- $T^{PaColCarr}$ = Total passenger traffic by collective means by road (bus)

For example for indicator BU_{cc} in 2010 with base year 2004:

$$\text{Savings achieved by } BU_{cc} = \left(\frac{T^{PaColCarr}_{2010}}{T^{Pa}_{2010}} - \frac{T^{PaColCarr}_{2004}}{T^{Pa}_{2004}} \right) - T^{Pa}_{2010} - \left(UE^{CA}_{2010} - UE^{PT}_{2010} \right)$$

where:

- T^{Pa} = Total passenger traffic by road
- $T_{Public^{Pa}}$ = Total passenger traffic by collective means by road (bus)
- UE^{CA} = Unit consumption of private vehicles
- UE^{PT} = Unit consumption of collective transport by road (bus)

Key variables

Table 32 shows all the variables that directly affect the calculation of the savings achieved by this measure.

Table 32. *Evolution of the specific variables relative to the greater participation of collective means in road transport for the 2004-2010 period*

	2004	2007	2008	2009	2010
Intercity private vehicle traffic [Mill pkm]	330.192	343.293	342.611	350.536	350.980
Intercity bus traffic [Mill pkm]	53.458	59.163	60.864	57.233	59.691

Source: Ministry of Public Works, IDAE

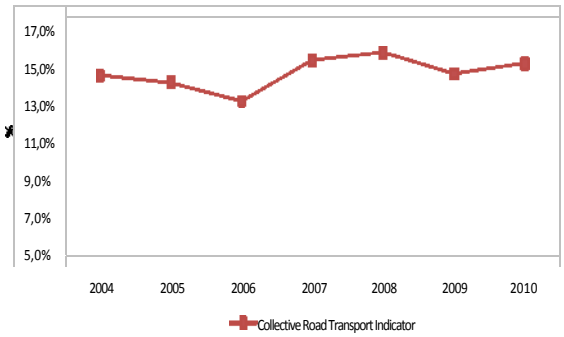
Direct savings achieved

To calculate the energy saving achieved through this measure in the period, indicator *BUcc* was used applying the sector variables presented in Table 33.

Table 33. *Results of energy saving through the "Greater participation of collective means in transport by road" measure in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Greater participation of collective transport by road	BU_{cc}	7,7	44,7
Base year 2007 [ktep]	Greater participation of collective transport by road	BU_{cc}	-50,3	-12,3

Figure 24. *Evolution of the "Greater participation of collective means in transport by road" indicator in the 2004-2010 period*



The "Greater participation of collective means in transport by road" measure achieved 44.7 ktep in the 2004-2010 period, which accounts for 0.1% of total final energy consumption in the *Transport* Sector in 2010.

Due to the economic crisis in Spain in 2008, growth was not as high as expected for the contribution ofcollective means of transport, which influenced modal transfer savings which were negative since the saving indicatorconsidered is independent of total traffic.

5. Greater participation of the railway in intercity transport

Improved participation of rail, both in terms of theintercity carriage of travellers and goods, has become a priority objective for the Spanish government in recent years.

Greater participation of rail in the carriage of goods facilitates the achievement of European objectives relative to emissions. However, this growth should not be mentioned in isolation, since it should be the core of a logistical operation model which optimally combines each means of transport. Since then, the Public Administration has made significant effortsso that rail plays a key role in the sector in 2020.

Methodology

To calculate the savings, ascending indicators *P12* and *P13* proposed by the European Commission were taken as reference, corrected so as to differentiate between urban and intercity transport.

With respect to the carriage of passengers, the savings from variations in the contribution of intercity transport by rail[9] were calculated compared with other means of transport, relating variations in contribution by the differential between the unit consumption of rail and that of competitive means of transport (road and air) normalised by traffic in 2010.

[9] Excluding "Cercanias" considering that its scope of competence is urban and/or metropolitan transport

$BU_{fipas} = \left(\frac{T^{RPa}}{T^{Pa}}\right)$ where:

- T^{Pa} = Total passenger traffic by intercity rail
- T^{RPa} – Total intercity passenger traffic

Likewise, in the carriage of goods, the savings from variations in the transport contribution of the carriage of goods by rail were calculated compared with other means of transport. Said variation has been multiplied by the differential of the unit consumption of rail transport and the average weighted unit consumption of competitive means of transport (road and river/sea) standardised for traffic in tons-km in 2010.

$BU_{fimer} = \left(\frac{T^{RFr}}{T^{Fr}}\right)$

where:

- T^{Fr}= Total goods traffic for intercity rail transport
- T^{RFr}= Total intercity goods traffic

The total saving from the measure is obtained by adding the savings achieved by the BU_{fipas} and BU_{fimer} indicators.

Key variables

Table 34. *Evolution of the variables from the "Greater participation of rail in intercity transport" measure in the 2004-2010 period*

	2004	2007	2008	2009	2010
Unit consumption of private vehicles [gep/pkm]	35,7	35,4	37,1	38,2	37,3
Unit consumption of BUSES [gep/pkm]	60,6	60,3	60,0	59,8	59,5
Unit consumption of AIRCRAFT [gep/pkm]	18,0	18,2	20,4	17,6	16,4
Unit consumption of TRAINS [gep/pkm]	11,01	11,24	10,05	10,01	9,99
BUS intercity passenger traffic [Mill. pkm]	47.286	52.953	54.795	51.343	53.555
PRIVATE VEHICLES intercity passenger traffic [Mill. pkm]	330.192	343.293	342.611	350.536	350.980
RAIL intercity passenger traffic [Mill. pkm]	10.767	11.698	13.917	13.659	14.561
AIRCRAFT intercity passenger traffic [Mill. km]	20.641	25.933	22.237	20.343	20.206
IDAE's total investment in the measure [k€]	-	48.424	-	38.400	-

Source: MINISTRY OF PUBLIC WORKS, INE, IDAE

It should be noted that the passenger traffic of intercity buses reached its peak in 2008 and that, since this year, a sharp fall in traffic began, particularly in 2006 (which has values inferior to 2007) with a slight recovery in 2010.

In the case of intercity rail passenger traffic, a qualitative jump was detected due to the entry into service of new High-Speed routes, particularly the Madrid-Barcelona line. However, traffic relative to normal-speed trains (regional and long-distance) experienced limited or negative growth.

Direct savings achieved

To calculate the energy saving achieved for this measure in the period, the sector variables have been applied to the indicators described as BU_{fipas} and BU_{fimer} (Table 35).

Table 35. Results of energy saving through the "Greater participation of rail in intercity transport" measure in 2009 and 2010 with base years 2004 and 2007

		Associated indicator	2009	2010
Base year 2004 [ktep]	Rail transport	BU_{fipas}+BU_{fimer}	63,2	85,4
	Carriage of goods by rail	BU_{fimer}	-	-
	Carriage of passengers by rail	BU_{fipas}	63,2	85,4
Base year 2007 [ktep]	Rail transport	BU_{fipas}+BU_{fimer}	42,3	64,1
	Carriage of goods by rail	BU_{fimer}	-	-
	Carriage of passengers by rail	BU_{fipas}	42,3	64,1

Figure 25. *Evolution of the indicator for the "Greater participation of rail in intercity transport" measure for passengers in the 2004-2010 period*

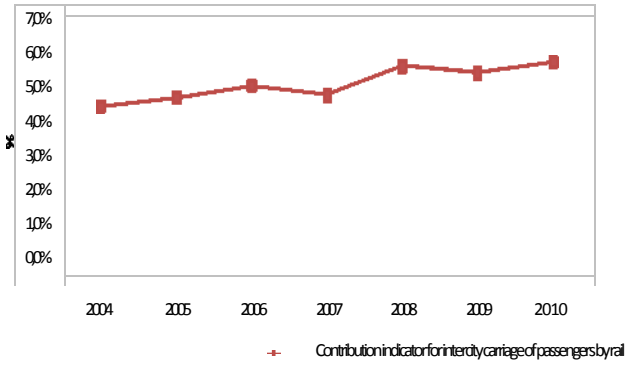


Table 35 shows that the "Greater participation of rail in intercity transport" measure achieved, as a whole, positive savings both for base years 2004 and 2007 in 2010. With respect to the carriage of passengers in 2010 with base year 2004, a direct saving of 85,4 ktep was achieved in 2010, which accounts for 6.9% of consumption for transport by rail. With base year 2007, these values are 64,1 ktep and 5,3% respectively.

With respect to the carriage of goods, the savings haven't been calculated, since the significant fall in goods traffic using rail transport for the economic period means that the unit energy consumption of rail was greater than

the average weighted unit consumption of competitive means of transport (road and river/sea).

6. Greater participation of maritime transport in the carriage of goods

The achievement of this measure's objectives includes the consolidation of the losses as intermodal nodes of reference, which will serve to support the gradual implementation of the intermodal freight network. Therefore, the port authorities should act as reference agents for the development of intermodal logistical installations not only in the port service area, but inside, actively participating in consolidating the rail link within the intermodal chain.

To calculate the savings, ascending indicator *P13* proposed by the European Commission was taken as reference, as the cooperation between rail and maritime transport is required to increase penetration. Indicator *P13* is described in the section corresponding to change of mode.

7. Road transport fleet management

This measure hopes to encourage the general use of new data communication applications and other fleet management tools by all road transport companies, whether for the carriage of goods or for the collective carriage of passengers.

The measure includes, mainly, promotion and training programmes, as well as support systems for businesses which have introduced fleet management using energy efficiency criteria.

Methodology

Despite the fact that the measure considers transport fleets for both the carriage of goods and passengers by road, for the simplification and availability of data, only Fleet Management Systems (FMS hereinafter) were taken into account, implemented within companies transporting goods by road within the "IDAE-Autonomous Communities Programme". When it came time to quantify the mechanism results, all the measures not providing direct countable savings were removed, like for example, supports for the realisation of audits or training associated with fleet management.

The savings derived from supports for the implementation of FMS have been counted as follows:

$$\text{Saving obtained by } BU_{gf} = F_{AV} \cdot ue^{TLV} \cdot S_{ims} \cdot S_{TLVe}$$

where

- UE^{TLV}= Unit consumption of lorries and light vehicles
- F_{av} = Saving percentage on unit consumption attributable to FMS
- $STLV_e$ = Average stock of lorries and light vehicles per company with FMS
- S_{ims} = Number of companies with FMS

Once the data for the value of energy savings due to the implementation of a FMS is obtained for each year (tep/km), it is multiplied by the average distance per vehicle (lorries and light vehicles) for each year. Therefore, the saving for a determined period will correspond to the cumulative saving in tep/year per installation of a FMS, normalised by the distance travelled in the final year of the measurement period.

Key variables

Table 36 shows all the variables that directly affect the calculation of the savings achieved by this measure.

Table 36. *Evolution of specific variables relative to the "Road transport fleet management" measure in the 2004-2010 period*

	2004	2007	2008	2009	2010
Number of FMS systems installed [%]	-	32	22	97	127
IDAE's total investment in the measure [k€]	-	597	1.580	1.847	2.355

Source: IDAE

Direct savings achieved

To calculate the energy saving achieved through this measure in the period, the sector variables presented in Table 36 were applied to the BU_{gf} indicator.

Table 37. E*nergy saving results relative to the "Road transport fleet management" measure in the 2009 and 2010 period*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Road transport fleet management	BU_{gf}	0,8	1,3
Base year 2007 [ktep]	Road transport fleet management	BU_{gf}	0,6	1,2

The savings achieved by the "Road transport fleet management" measure, as shown in Table 37, are, in absolute terms, 1,3 ktep in 2010 with respect to the situation in 2004, representing a percentage saving of 0.01% on final energy consumption associated with the carriage of goods by road.

8. Efficient driving of private vehicles

In recent years, vehicle technology has evolved significantly however driving has stayed practically the same. This measure looks to correct this situation, providing a new driving style suited to the new technology.

Efficient driving helps to reduce fuel consumption, environmental emissions and, also, to improve safety. This measure includes the objective to establish new driving techniques both for new drivers and expert drivers of private vehicles.

Methodology

The saving derived from this measure was associated with the direct saving derived from efficient driving courses by IDAE for drivers and trainers. Calculation of the savings associated with this measure was performed using an ascending indicator from the reduction in unit consumption.

To calculate said indicator, a series of considerations or hypotheses were taken into account:

- The number of students and trainers trained as of 1 January in the year of implementation of the training courses is counted.
- Students and trainers make up the total number of drivers who improved their driving behaviour after the courses.
- A 15% improvement factor in the unit consumption on the average technical consumption of vehicles is assumed.
- A 1:5 ratio has been assumed to calculate the savings by a trained driver compared with those by a normal driver.

The savings derived have been counted as follows:

Savings achieved by BU_{cet} = $(UE^{CA} - UE^{CAFormado}) \cdot D_t^{av.kmCA} \cdot S_{alumnos}$

where:

- UE^{CA} = Average unit consumption of private vehicles
- $UE^{CAformadois}$ = Average unit consumption of private vehicles driven by trained drivers
- $S_{alumnos}$ = Number of equivalent drivers trained
- $Di_t^{av.km.CA}$ = Average distance travelled by private vehicle

Key variables

Table 38 shows all the variables that directly affect the calculation of the savings achieved by this measure.

Table 38. *Evolution of specific variables relative to the "Efficient driving of private vehicles" measure in the 2004-2010 period*

	2004	2005	2006	2007	2008	2009	2010
Equivalent students trained [number]	-	7.500	13.274	34.735	31.458	73.878	79.515
IDAE's total investment in the measure [k€]	-	600	1.025	2.172	3.368	4.117	3.324

Source: IDAE

Direct savings achieved

To calculate the energy saving achieved through this measure in the period, the sector variables presented in Table 41 were applied to the BU_{cet} indicator.

Table 39. *Results of energy saving through the "Efficient driving of private vehicles" measure in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Efficient driving of private vehicles	BU_{cet}	36,1	53,5
Base year 2007 [ktep]	Efficient driving of private vehicles	BU_{cet}	23,5	40,9

Table 41 shows, with respect to the situation in 2004, savings of 53.5 ktep, representing a percentage saving of 0.43% on final energy consumption associated with private vehicles.

9. Efficient driving of industrial vehicles

Energy consumption in the professional transport sector by road (passengers and goods) has a notable impact on the national total. Increasing energy efficiency in the sector and reducing its energy requirements is a priority, with the aim of improving its competitiveness and sustainability. An efficient driving style represents a medium to low cost and great efficiency for companies in the sector to achieve a reduction in fuel consumption and its associated costs.

The importance of efficient driving encouraged the European Commission to include in its Directive 2003/59/EC of 15 July 2003, among others, the optimisation of fuel consumption in training programmes both for the initial and continuing training of professional drivers. Additionally, this measure includes the establishment of a recognised quality certification system for companies dedicated to the carriage of passengers and goods by road based on said training of their drivers.

Methodology

The savings derived from this measure was associated with the saving derived from efficient driving courses by IDAE for drivers and trainers. The calculation was performed using an ascending indicator from the reduction in unit consumption derived from the driving courses.

To calculate said indicator, a series of considerations/hypotheses were taken into account:

- The number of students and trainers trained as of 1 January in the year of implementation of the training courses is counted.
- Students and trainers make up the total number of drivers who improved their driving behaviour after the courses.
- A 15% improvement factor in the unit consumption on the average technical consumption of vehicles is assumed.
- A 1:5 was assumed to calculate the savings by a trained driver compared with those by a normal driver.

The savings derived have been counted as follows:

$$\text{Savings achieved by } BU_{cec} = \left(UE^{TLV} - UE^{TLVFORMADO}\right) \cdot Di_t^{av.km\,TLV} \cdot S_{alumnosTLV}$$

where:

- UE^{TLV} = Average unit consumption of lorries and light vehicles
- $UE^{TLVformads}$ = Average unit consumption of lorries and light vehicles by trained drivers
- $S_{alumnosTLV}$ = Number of equivalent students trained
- $Di_t^{av.kmTLV}$ = Average distance travelled by lorry or light vehicle

Key variables

Table 40 shows all the variables that directly affect the calculation of the savings achieved by this measure.

Table 40. *Evolution of specific variables relative to the "Efficient driving of Lorries" measure in the 2004-2010 period*

	2004	2005	2006	2007	2008	2009	2010
Equivalent students trained [number]	-	-	4.785	13.253	15.748	45.146	49.795
IDAE's total investment in the measure [k€]	-	-	1.206	2.215	2.594	3.465	2.919

Source: IDAE

Direct savings achieved

To calculate the energy saving achieved through this measure in the period, the sector variables presented in Table 41 were applied to the indicator BU_{cec}.

Table 41. *Results of energy saving through the "Efficient driving of lorries" measure in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004[ktep]	Efficient driving of road transport	BU_{cec}	41,2	60,6
Base year 2007 [ktep]	Efficient driving of road transport	BU_{cec}	31,6	52,0

Table 41 shows, with respect to the situation in 2004, the savings reach 60,6 ktep, representing a percentage saving of 0,4% on final energy consumption associated with lorries and light vehicles. In base year 2007, these values are 52,0 ktep and 0,4% respectively.

10. Renovation of private vehicles

Renovation of the automobile fleet allows exploitation of the advantages gained with the improved energy efficiency of new vehicles. When understanding the energy saving through renovation of the fleet, there are two types of mechanisms or actions, some are designed to promote technological improvements to reduce consumption and emissions, and some focus on encouraging the purchase of more efficient vehicles. The following are among the most important mechanisms for promoting the renovation of private vehicles:

- Relevant European Directives and Regulations: such as, for example, Regulation (EC) 443/2009 from the European Parliament and Council of 23 April 2009, which sets out behavioural standards in terms of emissions from new private vehicles as part of the European Union's integrated approach to reduce CO_2 emissions from light vehicles.

- National support mechanisms, such as fiscal discrimination relative to the registration taxes for vehicles depending on their CO_2 emissions.

- Plans to encourage the purchase of new vehicles:

  - Plan Prever (Forecast Plan (1997-2007)). The Plan Prever was born in 1997 with the aim of accelerating the renovation of the Spanish vehicle fleet, one of the most ageing in Europe, where 35% of cars are over ten years old.

- Plan VIVE (2008-2010) Innovative Vehicle - Ecological Vehicle. Two-year support plan for the acquisition of a new vehicle. The Plan was designed to replace cars older than 15 years old with a new vehicle with CO_2 emission levels not greater than 120g/km or140 g/km if it also includes an electronic stability control system and facial detectors in the front seats (B0E-A-2008-10970).

- Plan 2000E (2010). Support plan for the purchase of a vehicle facilitated by the Spanish government, together with the Autonomous Communities and manufacturers. This support meant a 2000€ subsidy for the purchase of a car if it complies with the requirements set out. (Royal Decree 898/2009, of 22 May).

- Pilot Project illustrative of the electric vehicle, MOVELE. The MOVELE project, managed and coordinated by the IDAE, has achieved the introduction, in a two-year period (2009 and 2010), in urban environments, of 1,110 electric vehicles in different categories, in a broad range of companies, institutions and individuals, as well as the installation of 149 charging points for these vehicles, plus 409 additional charging points installed outside the Project.

- Various support programmes, within the scope of the collaboration agreements signed between IDAE and the Autonomous Communities for the purchase of electric or hybrid vehicles.

Methodology

Ascending indicators were used to perform the calculations associated with the quantifying of this measure.

Key variables

This indicator, called BU_{pr1}, measures the savings derived from the introduction, within the fleet, of a new private vehicle (without encouraging said purchase through any plan), either to replace a vehicle in the fleet (causing a write-off) or to add to it.

The first addend refers to the saving achieved by vehicles acquired as a replacement. Whilst the second corresponds to the saving from new vehicles bought to increase the vehicle fleet.

$$\text{Savings achieved by } BU_{pr1} = N_{sus}.\ UE_{sus} + N_{in}.\ UE_{in}$$

where:

- N_{sus}= Number of new registrations that add to a write-off. This does not include registrations derived from a private vehicle replacement plan
- UE_{sus} = Unit saving per new private vehicle which forms part of a replacement
- N_{in}= Number of new registrations that expand the fleet (difference between inclusions and write-offs, if applicable). This does not include new registrations derived from a private vehicle replacement plan.
- UE_{in} = Unit saving per new private vehicle that expands the fleet (difference between inclusions and write-offs, if applicable)

Private vehicle replacement plans

The results obtained from these indicators (BU_{pr2}, BU_{pr3} and BU_{pr4}) measure the savings achieved through the replacement of private vehicles through any plan to promote the purchase of new private vehicles.

$$\text{Savings achieved by Plan x} = N_x \cdot UE_x$$

where:

- N_x= Number of operations performed in the private vehicle replacement plan "x"
- UE_x= Unit saving per new private vehicle that forms part of a replacement plan

The vehicle replacement plans considered in this study coincide with the 2004-2010 period:

Plan	Indicator	Start year	End year
Plan PREVER[10]	*BUpr2*	1997	2007
Plan VIVE	*BUpr3*	2008	2010
Plan 2000E	*BUpr4*	2010	2010

Electrification of the private vehicle fleet

This indicator BU_{pr5} measures the savings achieved through the introduction of both hybrid and electric vehicles within the private vehicle fleet, without considering replacements. Just as indicator BU_{pr1} describes, this has been structured into two addends, referring to the saving boundary produced by hybrid vehicles and secondly, the saving achieved by electric vehicles.

$$\text{Savings achieved by } BU_{pr5} = N_h = UE_h + N_e - UE_e$$

where:

- N_h= Number of new hybrid vehicles
- UE_h = Unit saving per new hybrid vehicle introduced into the fleet
- N_e= Number of new electric vehicles
- UE_e = Unit saving per new electric vehicle introduced into the fleet

To calculate these indicators, a number of considerations have been made, set out below. For vehicles which form part of a replacement, the saving corresponds to the difference between the unit consumption of the new vehicle and the average consumption of the new registrations in the minimum years required for the write-off of a vehicle in the plan. In the case of private vehicles that do not form part of any replacement, the unit saving is calculated as the difference between the consumption of the new vehicle and the average unit consumption of the fleet in the reference year. An average period of rotation is considered to be ten years per vehicle.

IDAE-Autonomous Communities cooperation programme and the IDAE's Grants for Strategic Projects Programme

To count the effect produced by the IDAE-Autonomous Communities Programme and the IDEA's Grants for Strategic Projects Programme, within the "Renovation of the private vehicle fleet" measure, reports provided by the Communities on

[10]The timeframe considered for this plan is the period between 2004 and 2007.

the savings achieved through public support designed for said use, as well as IDAE's own reports were used. The savings achieved in 2010 are a result of the sum of the savings reported every year since 2004 or 2007 depending on the calculation base chosen.

$$BU_{pr6} = \sum_{t}^{i} Ah_{renturismos}$$

where:

- $Ah_{renturismos}$: Annual savings reported by the Autonomous Communities or IDAE relative to the "Renovation of the private vehicle fleet" measure

To obtain the total saving in a determined year, those savings by distance travelled are added from the reference year, multiplying by the kilometres travelled in the reference year, as shown in the following formula:

$$\text{Saving achieved by } BU_{rp} = \sum_{t=\text{base year}}^{t=i} (UE_t^x \cdot o_t^x) \cdot D_i$$

where:

- Ue^x_t = Unit saving per private vehicle depending on the type of replacement
- D_i = Average distance travelled by private vehicles in a year
- O^x_t = Number of annual operations in the year (replacement plan operations and number of registrations of hybrid vehicles etc)

Key variables

The following tables show all the variables that directly affect the calculation of the savings achieved by this measure.

Table 42. *Evolution of specific variables relative to the "Renovation of the private vehicle fleet" measure in the 2004-2010 period*

	2004	2007	2008	2009	2010
New registrations [number]	1.653.798	1.633.774	1.185.407	971.094	990.000
Write-offs [number]	800.000	887.395	734.638	937.297	750.000
Substitution plan operations [number]	455.623	329.687	720	100.940	200.000
Sale of electric and hybrid vehicles [number]	600	2.000	2.000	5.848	8.272
Saving per replaced vehicle base year 2004/2007 [gep/km]	7,44	5,21	4,86	5,48	6,06
Saving per additional vehicle base year 2004 [gep/km]	3,57	4,28	4,37	6,51	8,03
Saving per additional vehicle base year 2007 [gep/km]	-	3,41	3,50	5,64	7,15

Source: DGT, IDAE

Table 43. *Evolution of specific variables relative to the "Renovation of the private vehicle fleet" measure in the 2004-2010 period - Private vehicle replacement plans*

	2004	2007	2008	2009	2010
Operations performed Plan Vive [number]	-	-	360	50.470	-
Operations performed Plan Prever [number]	455.623	329.687	360	50.470	-
Operations performed Plan 2000E [number]	-	-	-	-	200.000

Source: MITYC

Table 44. *Evolution of specific variables relative to the "Renovation of the private vehicle fleet" measure in the 2004-2010 period - Electrification of the vehicle fleet*

	2004	2007	2008	2009	2010
Sale of electric vehicles [number]	-	-	-	448	1.082
Sale of hybrids [number]	600	2.000	2.000	5.400	7.190

Source: IDAE

Direct savings achieved

Calculation of the energy saving achieved in the period analysed for "Renovation of the private vehicle fleet" was performed using the ascending indicators cited in the previous sections.

Table 45. *Results of energy saving through the "Renovation of the private vehicle fleet" measure in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Renovation of the private vehicle fleet	$\sum BU_{rpi}$	651,7	734,9
	Natural renovation of the private vehicle fleet	BU_{rp1}	360,4	425,3
	Plan PREVER	BU_{rp2}	276,1	275,3
	Plan VIVE	BU_{rp3}	10,0	10,0
	Plan 2000E	BU_{rp4}	-	15,4
	Strategy to Promote the electric vehicle in Spain 2010-2015	BU_{rp5}	0,6	2,1
	IDAE-Autonomous Communities Cooperation Programme +IDEA's Grants for Strategic Projects Programme	BU_{rp6}	4,5	6,9
Base year 2007 [ktep]	Renovation of the private vehicle fleet	$\sum BU_{rpi}$	138,7	220,9
	Natural renovation of the private vehicle fleet	BU_{rp1}	125,6	188,5
	Plan PREVER	BU_{rp2}	-	-
	Plan VIVE	BU_{rp3}	10,0	10,0
	Plan 2000E	BU_{rp4}	-	15,4
	Strategy to Promote the electric vehicle in Spain 2010-2015	BU_{rp5}	0,6	2,1
	IDAE-Autonomous Communities Cooperation Programme + IDEA's Grants for Strategic Projects Programme	BU_{rp6}	2,5	4,9

In absolute terms, the savings achieved in 2010 with respect to the situation in 2004 are 734,9 ktep, as shown in Table 45, representing a percentage saving of 7% on final energy consumption associated with private vehicles.

11. Renovation of the road transport fleet

This measure aims to achieve energy savings by introducing more efficient vehicles into collective transport fleets for the carriage of passengers and goods.

Methodology

To calculate the effect produced by this measure, the information provided by the Autonomous Communities on savings made through public supports intended for this measure was used.

The savings achieved in 2010 are a result of the sum of the savings reported every year since 2004 or 2007 depending on the calculation base chosen, normalised by the average distance travelled by lorries and light vehicles.

$$BU_{rf} = \sum Ah_{renflotas}$$

where:

- $Ah_{renflotas}$: Annual savings reported by the Autonomous Communities relative to the "Renovation of road transport fleets" measure

Key variables

Table 46 shows all the variables that directly affect the calculation of the savings achieved by this measure.

Table 46. *Specific variables relative to "Renovation of road transport fleets"*

	2004	2007	2008	2009	2010
N° of IDAE actions [number]	-	154	97	241	203
IDAE's total investment in the measure [k€]	-	2.215	2.594	3.465	2.919

Source: IDAE

Direct savings achieved

Table 47. *Results of energy saving through the "Renovation of road transport fleets" measure in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Renovation of road transport fleets	BU_{rf}	0,6	1,0
Base year 2007 [ktep]	Renovation of road transport fleets	BU_{rf}	0,6	1,0

Finally, according to the results obtained in Table 47, the savings achieved by the "Renovation of road transport fleets" measure in 2010 with respect to the situation in 2004, are 1,0 ktep in absolute terms.

12. Savings achieved in the transport sector in 2010

The transport sector achieved savings of 6.586,9 ktep in the 2004-2010 period. These savings are due in large part to road transport (6.837,3 ktep), particularly the carriage of goods which makes up for the negative values for rail and air transport. Maritime transport achieved positive savings of 52,3 ktep and savings corresponding to change of mode reached 82,7 ktep.

Table 48. *Results of total energy saving in the transport sector in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 04 [ktep]	Transport Sector	$\sum$	5.133,9	6.451,1
	Road transport	$BU_{rp}+BU_{cet}+A2+PB$	5.368,8	6.701,4
	Rail transport	*P10 + P11*	-337,1	-317,4
	Maritime transport	*M7*	131,9	52,3
	Air transport	*Mav*	-44,5	-68,0
	Change of mode	*P12 + P13*	14,8	82,7
Base year 07 [ktep]	Transport Sector	$\sum$	3.351,5	4.561,1
	Road transport	*P8 + A2 + PB*	3.710,9	4.910,4
	Rail transport	*P10 + P11*	-234,6	-206,7
	Maritime transport	*M7*	-45,9	-99,9
	Air transport	*Mav*	-24,4	-48,3
	Change of mode	*P12 + P13*	-54,4	5,6

Below, you will find the possible indirect effects and non-quantifiable savings produced in the *Transport* Sector and the double-counting risks that may occur in the savings.

12.1. Indirect effects

In regard to the possible indirect effects which may be observed, the following should be taken into account for each of the means of transport studied:

Road transport

In the "Management of road fleets" measure, the complexity of making information available on savings relative to internal decisions by particular companies derived from the saving relative to the measure is limited to the "IDAE-Autonomous Communities" mechanism. Therefore, it has not been possible to count all the Fleet Management Systems (FMS) installed in Spain in the 2004-2010 period.

With respect to the "Efficient driving of private vehicles" measure, the complexity of measuring savings associated with the behaviour of citizens meant that only the direct saving derived from efficient driving courses organised by IDAE, directly or in collaboration with the Autonomous Communities, were counted. As a result, there is a series of indirect effects associated with this measure which have not been counted, such as, for example:

- Improvements in efficient driving motivated by the communication and dissemination campaigns.
- The effects associated with the economic situation, such as the rise in the price of oil or the loss of purchasing power.
- Greater driving efficiency due to the gradual penetration of onboard computers, GPS and other types of systems in the automobile fleet that help the driver to measure the consumption of the private vehicle in real time, as well as the selection of the type of driving depending on the type of road.
- The improvement in driving derived from more relaxed speed limits on roads, as well as greater control for compliance.

Likewise, in the "Efficient driving of industrial vehicles" measure, only the direct saving derived from efficient driving courses organised by IDAE, directly or in collaboration with the Autonomous Communities was measured. As a result, there are a series of indirect and non-quantifiable effects:

- More efficient driving due to the installation of Fleet Management Systems by companies, although their effect is assessed in part through the "Management of road transport fleets" measure.
- The installation of variable remuneration systems for employees depending on their associated energy consumption.

The saving achieved by the "Renovation of the private vehicle fleet" measure is determined, basically, by the number of new private vehicles, and their unit consumption. As a result, indirect effects associated with the current economic recession have been identified: on the one hand, the fall in registrations of more efficient vehicles since 2008 and, on the other hand and conversely, the increase in sales of smaller or lighter vehicles, as a result of the increase in fuel prices.

Rail transport

With respect to rail transport, results achieved through mechanisms where direct effects could not be counted, such as the Strategic Infrastructure and Transport Plan 2005 - 2020 (PEIT) and the Spanish Sustainable Mobility Strategy, will be considered as non-countable effects.

Maritime transport

It has not been possible to calculate, for maritime transport, the savings produced by the measure related to the carriage of goods: "Renovation of the maritime fleet". This initiative expects to introduce more efficient boats into companies' fleets through the installation of more efficient propellers, devices to regulate fuel consumption and the use of a dual gas/fuel engine.

Air transport

Savings produced by the following measures and mechanisms will be considered to be non-countable:

- Improvements in the management of aircraft fleets; in recent years, companies have tried to reduce the number of flights to maintain occupation levels at an acceptable level. In addition, the frequencies of flights have been replanned on certain routes.
- Efficient piloting in the air transport sector, implementing aircraft piloting techniques which enable substantial energy savings through training, promotion of courses for drivers and the signing of agreements with companies for the introduction of these efficiency protocols.
- Renovation of the air transport fleet through the natural technological evolution of aircraft.

Modal change

Various indirect effects influence the contribution of collective transport (bus, metro and rail) related to the economic climate, such as variations in the price of fuel and the unemployment rate. There is also an induced effect when some people who normally travel on foot or by bicycle change to using collective transport with the implementation of public transport infrastructure in this area, therefore increasing their energy consumption.

The greater participation of high-speed within the carriage of passengers by rail may have the rebound effect of improving collective transport for the carriage of passengers by road. The implementation of a high-speed option is usually associated with a process of "cannibalisation" of the contribution between this and the normal-speed train. In the presence of this situation, the bus may become the best collective transport alternative for those with reduced purchasing power.

In terms of its scope and multimodal approach, we can define a high level of equivalence between the Strategic Transport and Infrastructure Plan 2005-2020 (PEIT) and the "Transport infrastructure management" measure. The PEIT is trying to improve public transport, increase rail transport's contribution concerning the carriage of passengers and goods, increase the weighting of maritime and river transport and improve intermodality of the whole system. For its part, "Transport infrastructure management" has not been counted due to its size, intangibility and to avoid double-counting with other measures also included in the 2005-2007 and 2008-2012 Action Plans, particularly those dedicated to change of mode.

12.2. Double counting

In the calculation of the savings associated with different measures and mechanisms, the possible risks of double counting have been identified and minimised. In the counting of the savings associated with change of mode measures, there is a risk of double counting with others:

- In "Greater participation of rail transport in intercity transport", the promotion of rail transport for the carriage of passengers (collective transport) is proposed, which is also mentioned in the "*Sustainable Urban Mobility Plans*" measure. However, the Plans have an urban and/or metropolitan scope with which the exclusion of outskirt trains avoids this double counting.
- The development of "*Workers' Transport Plans*" by companies in a community

isan integral part of correctly implementing a PMUS.

- There is a risk of double counting, if the savings from the "PMUS" measure are added to the savings from the "Greater participation of collective measures in road transport", regarding the increased use of collective urban transport by road (urban bus) to be common to both measures.

There may be the possibility of double counting between "Management of road transport fleets" and efficient driving measures ("Efficient driving of private and industrial vehicles"), since in many cases, improved driving is associated both with a change in behaviour and the use of tools and support systems. However, the counting of these savings is limited to the "IDAE-Autonomous Communities Programme", a measure with an ascending indicator, which avoids double counting.

The risk of double counting was also mitigated by adding the savings from indicator *P12* to the savings from the "Greater participation of rail in intercity transport" measure in relation to the carriage of passengers by rail, because it is common to the indicators that measure both measures.

IV. BUILDINGS SECTOR

1. Summary of savings in the buildings sector

THE BUILDINGS SECTOR

Energy savings achieved during the 2004-2010 period in the buildings sector are mainly due to improvements made in the thermal envelope of buildings, lighting and equipment. Final energy consumption in this sector was 24.391 ktep in 2010, 26,1% of the national total.

Sector consumption

	Final energy 2010 [ktep]
TOTAL CONSUMPTION IN THE BUILDINGS SECTOR	24.391,7
USE OF THE THERNMAL ENV. AND TH. INSTALLATIONS	17.333,6
LIGHTING USE	2.333,7
EQUIPMENT USE	4.724,5

Result of savings achieved

	Final energy saving 2010 [ktep]		Primary energy saving 2010 [ktep]		Emissions of C02 avoided 2010 [ktCO2]	
	Base year	Base year	Base year	Base year	Base year	Base year
TOTAL SAVINGS FROM MEASURES	2.232,5	2.529,1	3.165,0	4.189,1	6.982,8	9.269,0
Renovation of the th. envelope + Improved Thermal installations	1.637,7	2.020,6	1.887,3	3.081,4	4.348,8	6.882,0
Improved interior lighting installations	793,9	301,2	1.987,0	709,8	4.017,1	1.519,8
Renewal of electrical appliances	-199,1	207,3	-709,2	397,8	-1.383,0	867,1

Conclusions

The buildings sector achieved savings of 2.232,5 ktep in the 2004-2010 period. 67% of these savings (1.637,7 ktep) are derived from improvements to the thermal envelope in buildings and their thermal installations and 33% (793,9 ktep) is due to the installation of more efficient interior lighting, whilst no savings were achieved in the equipment sector.

These results were thanks to the measures proposed in the 2005-2007 and 2008-2012 Action Plans, supported by policy-level actions which have stimulated energy efficiency in construction.

The four measures associated in the Action Plans, set out in collaboration agreements between IDAE and the Autonomous Communities, boosted the renewal of the thermal envelope, improvements to thermal installations, improvements to lighting plants and the replacement of electrical appliances.

These measures have been enhanced by efforts at policy level and, in particular, by the publication of the Technical Building Code (RD 314/2006), which promotes energy efficiency in the scope of the envelope and thermal systems, from the new Regulation concerning Thermal Installations in Buildings, which requires the periodic revision of the energy efficiency of these installations, and the requirement for energy certification for buildings (RD 47/2007). The 2-for-1 Programme and the programme to distribute high efficiency bulbs, as well as the IDEA's Grants for Strategic Projects Programme and communication and dissemination programmes have also contributed to boosting energy efficiency in the buildings sector.

The savings directly attributable to the plans and policies are 585.0 ktep. The Technical Building Code is the policy responsible for the greatest savings (231,7 ktep) accounting for almost 40% of savings. The mechanisms relative to interior lighting use - IDAE-Autonomous Communities cooperation programme, programmes to distribute free bulbs and the 2-for-1 programme- achieved savings of 127.6ktep. Finally the electrical appliance RENOVE Plan saved 81,4 ktep.

In addition to the savings directly attributable to the different mechanisms, there are other non-countable effects obtained as a difference between these and the savings calculated for the measures using descending indicators. These effects may be negative, as is the case for the renewal of electrical appliances, where part of these effects includes increased penetration of equipment in the tertiary sector.

Measurement-mechanism matrix

Measures \ Mechanisms		Collaboration agreements	IDEA's Grants for Strategic Projects Programme	Saving and energy efficiency action plan. 2-for-1 programme	Energy savings and efficiency action plan. Free distribution programme	New RITE (RD 1027/2007)	TBC (RD 314/2006)	Energy certification of buildings (RD 47/2007)	Communication and dissemination programmes	Non-countable effects	TOTAL
Base year 2004 [ktep]	Thermal envelope renewal	22,3	60,9			231,7			1.261,7		1.637,7
	Improved thermal installations	61,1									
	Improved int. lighting installations	29,7		13,0	84,9	666,3					793,9
	Renewal of electrical appliances	81,4				-280,5					-199,1
	TOTAL	**194,5**	**60,9**	**13,0**	**84,9**	**1.880,2**					**2.232,5**
Base year 2007 [ktep]	Thermal envelope renewal	17,6	60,9			167,0			1.725,1		2.020,6
	Improved thermal installations	50,0									
	Improved int. lighting installations	24,9		13,0	83,7	179,6					301,2
	Renewal of electrical appliances	56,5				150,8					207,3
	TOTAL	**149,0**	**60,9**	**13,0**	**83,7**	**2.222,5**					**2.529,1**

*Direct savings achieved by the mechanisms

** Indirect savings achieved by the mechanisms

USE OF THE THERMAL ENVELOPE AND THERMAL INSTALLATIONS

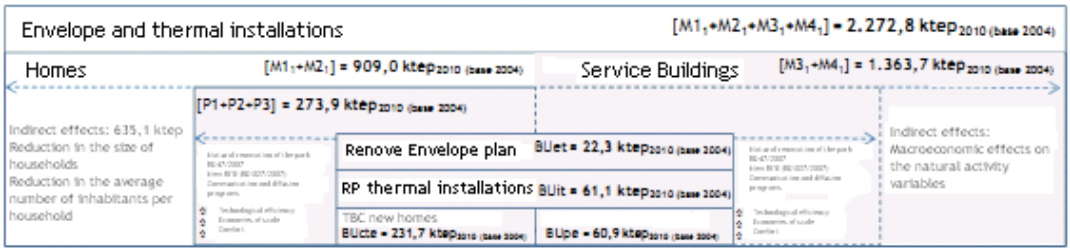
The energy savings achieved in the use of the thermal envelope and thermal installations have been determined by improvements in heating, cooling and sanitary hot water systems in the residential scope and tertiary sector. Final energy consumption for these uses was 17,333.6 ktep in 2010, 71% of that for buildings. To calculate the outer boundary of global savings, the *M* indicators proposed by the European Commission were used, whilst *P* indicators were used to assess the savings achieved through the energy renewal of the thermal envelope and thermal installations. It was only possible to assess the latter in residential terms, since there was no consistent statistical information available on savings in the tertiary sector which would enable calculation of the equivalent *P* indicators. Finally, it has been calculated by means of ascending indicators, the effect of the revolution induced by the Public Administration through the "RENOVE Plans" and that owing to the TBC entering into force.

Results achieved

		Final energy saving 2010 [ktep]	
		Base year 2004	Base year 2007
$M1_{11}$	Saving in thermal consumption per home intended for heating	290,7	316,0
$M1_{12}$	Saving in electricity consumption per home intended for SHW	356,5	338,5
$M2_{11}$	Saving in electricity consumption per home intended for heating	182,0	105,4
$M2_{12}$	Saving in electricity consumption per home intended for cooling	-72,5	19,5
$M2_{13}$	Saving in electricity consumption per home intended for SHW	152,4	132,3
$M3_{11}$	Saving in thermal consumption per employee intended for heating	1.278,0	736,0
$M3_{12}$	Saving in thermal consumption per employee intended for SHW	151,1	94,7
$M4_{11}$	Saving in electricity consumption per employee intended for heating	-306,9	-59,4
$M4_{12}$	Saving in electricity consumption per employee intended for cooling	251,7	544,9
$M4_{13}$	Saving in electricity consumption per employee intended for SHW	-10,1	5,9
P1	Saving in electrical and thermal consumption per m^2 intended for heating	153,7	316,3
P2	Saving in electricity consumption per m^2 intended for cooling	-76,6	16,9
P3	Saving in electrical and thermal consumption per inhabitant intended for SHW	196,9	365,4
BU_{et}	Thermal envelope RENOVE Plan	22,3	17,6
BU_{it}	Thermal installations RENOVE Plan	61,1	50,0
BU_{cte}	Technical building code	231,7	167,0
BU_{pe}	IDEA's Grants for Strategic Projects Programme	60,9	60,9
TOTAL FOR THE THERMAL ENVELOPE AND THERMAL INSTALLATIONS SUBSECTOR ($A13_{,,}+A13_{,2}+A1^{4}_{,,}+A1^{4}_{,2}+A1^{4}_{,3}+P$		1.637,7	2.020,6

Savings diagram

The saving relative to the thermal envelope and thermal installations has been organised into two main areas, taking into account that at which the measure is aimed; the domestic or tertiary sector.



Conclusions

The descending *M* indicators confirm that global savings of 2.272,8 ktep were achieved since 2004, the use of heating being where the most savings were achieved (64% of the total) since the penetration of cooling systems - and therefore associated consumption- has increased in homes. The descending *P* indicators show savings of 273,9 ktep in the domestic area. In the tertiary sector, due to the unavailability of indicators of the same type, the fixed results are maintained for the *M* indicators.

The initiatives known as "RENOVE Plans" achieved savings of 22,3 ktep relative to envelope renewal (facades, roofs and windows) and 61,1 ktep relative to the renewal of thermal installations (heating, cooling and sanitary hot water). In addition, ascending indicators meant we have been able to calculate the savings associated with the Technical Building Code (231,7 ktep) as well as the IDEA's Grants for Strategic Projects Programme (60,9 ktep).

Finally, through the differences between the external and interior saving boundaries, it is possible to distinguish determined indirect effects which, particularly, in the domestic sector are 651,1ktep, due to a reduction in the average size of homes and the average number of inhabitants occupying them.

USE OF INTERIOR LIGHTING

The energy savings achieved in the use of interior lighting in the domestic and tertiary sectors were determined, basically, through the distribution of low-consumption bulbs. Final energy consumption for this use was 2,333.7 ktep in 2010, 10% of that for buildings.

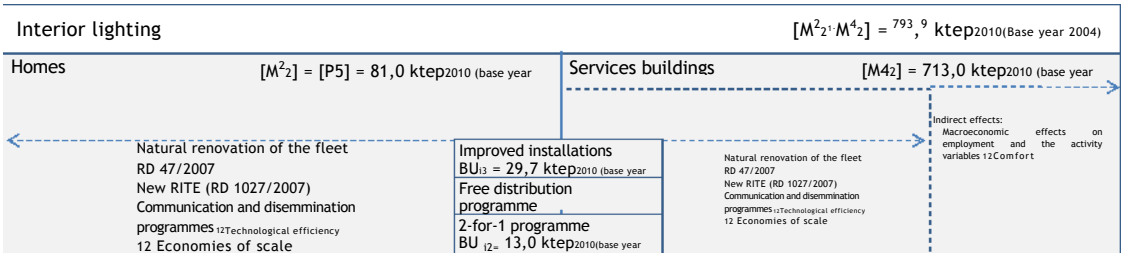
To calculate the exterior boundary of global savings, the *M* indicators proposed by the European Commission were used. In the residential sector, the *P* indicator proposed is equivalent to the previous ones. Through ascending indicators, the effect of the renewal induced by the Public Administration through support programmes for the renewal of lighting systems and special programmes promoting the use of efficient lamps was calculated.

Results achieved

		Final energy savings 2010 [ktep]	
		Base year 2004	Base year 2007
$M2_2$	Saving in electricity consumption per home intended for lighting	81,0	53,3
$M4_2$	Saving in electricity consumption per employee intended for lighting	713,0	247,9
P5	Saving in electricity consumption per home intended for lighting	81,0	53,3
BU_{i1}	Programme for the distribution of low-consumption lamps	84,9	83,7
BU_{i2}	Programme for the 2-for-1 distribution of low-consumption lamps	13,0	13,0
BU_{i3}	Improved energy efficiency of interior lighting installations	29,7	24,9
TOTAL FOR THE INTERIOR LIGHTING SUBSECTOR [ktep] ($M4_2$+P5)		793,9	301,2

Savings diagram

The saving relative to interior lighting has been organised into two main areas, taking into account the sector at which the measure is aimed; the domestic or tertiary sector.



Conclusions

The global saving of the interior lighting sector calculated using the *M* and *P* indicators proposed by the European Commission is 793,9 ktep, basically in the services sector (90% of the total).

The *bottom-up* savings were obtained from the periodic information submitted to IDAE by the Autonomous Communities on projects which are publically supported. On the other hand, two additional indicators were counted using ascending indicators: the programme for the 2-for-1 distribution of efficient lamps" (13,0 ktep) and the "Programme for the free distribution of efficient lamps" (84,9 ktep).

EQUIPMENT USE

The energy savings achieved in equipment use have been determined, basically, by improvements in the energy efficiency of electrical appliances, cookers and office equipment, both in the residential and tertiary sector. Final energy consumption for this use was 4,724.5 ktep in 2010, 19% of the buildings consumption.

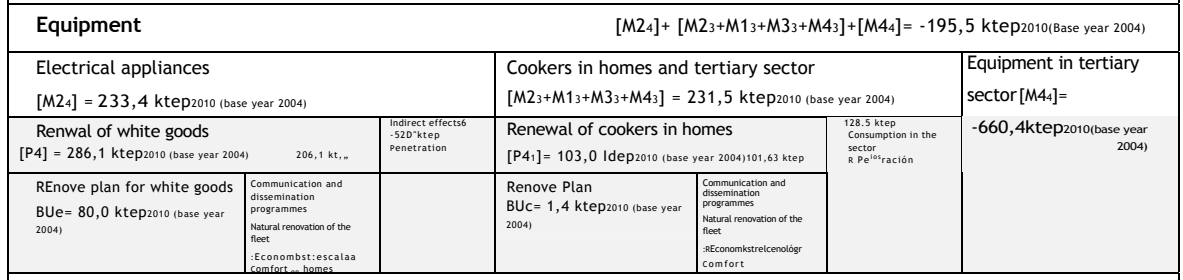
To calculate the external boundary, *M* indicators proposed by the European Commission have been used, whilst to evaluate the savings achieved through measures relating to the renewal of electric appliances and cookers, corrected *P* indicators were used. Finally, using ascending indicators, the effect renewal of the equipment induced by the Public Administration through the "RENOVE Plans" was calculated.

Results achieved

		Final energy saving 2010 [ktep]	
		Base year 2004	Base year 2007
$M1_3$	Saving in thermal consumption per home intended for cooking	183,0	132,9
$M2_4$	Saving in electricity consumption per home intended for electrical appliances	277,6	156,5
$M2_3$	Saving in electricity consumption per home intended for cooking	-23,7	-0,4
$M3_3$	Saving in thermal consumption per employee intended for cookers	83,0	27,8
$M4_3$	Saving in electricity consumption per employee intended for cooking	-10,7	-7,9
$M4_4$	Saving in electricity consumption per employee intended for office equipment	-660,4	-54,8
P4	Saving in unit consumption of electricity per electrical appliance	286,1	164,6
$P4_1$	Saving in unit consumption of thermal and electricity consumption per cooker[11]	103,0	77,8
BU_e	Renove Plan for white goods.	80,0	55,1
BU_c	Renove Plan for cookers	1,4	1,4
TOTAL FOR THE EQUIPMENT SUBSECTOR [ktep] ($M3_3$+$M4_3$+$M4_4$+P4+$P4_1$)		-199,1	207,3

Savings diagram

The saving relative to equipment has been organised into three main areas, taking into account the type of electrical appliances in question and the sector - domestic or services - which it fits into.



Conclusions

The descending *M* indicators suggest that no savings were achieved in the study period (-195,5 ktep) due, mainly, to better penetration of equipment both in the residential sector and particularly in the tertiary sector. In particular, we should take into account the fact that the variable used to standardise the consumption in this last sector is the number of full-time employees; this is a very sensitive variable given the current economic climate.

However, the descending *P* indicators, calculated for the domestic sector, show that savings were achieved (389,1 ktep) in the renewal of equipment since they are calculated according to the number of electrical appliances and cookers, variable units that have a direct link to consumption.

Ascending indicators were used to calculate the savings induced by direct actions. Through the unit saving obtained for each renewal, the number of replacements performed as part of the "Renove Plan" achieved a saving of 81,4 ktep.

Finally, through the differences between the external and internal saving boundaries, it is possible to give a value of -199,1 ktep to determined indirect effects associated with the measure. Basically, an increase in the energy intensity in homes and, basically in the tertiary sector due to an increase in penetration of equipment.

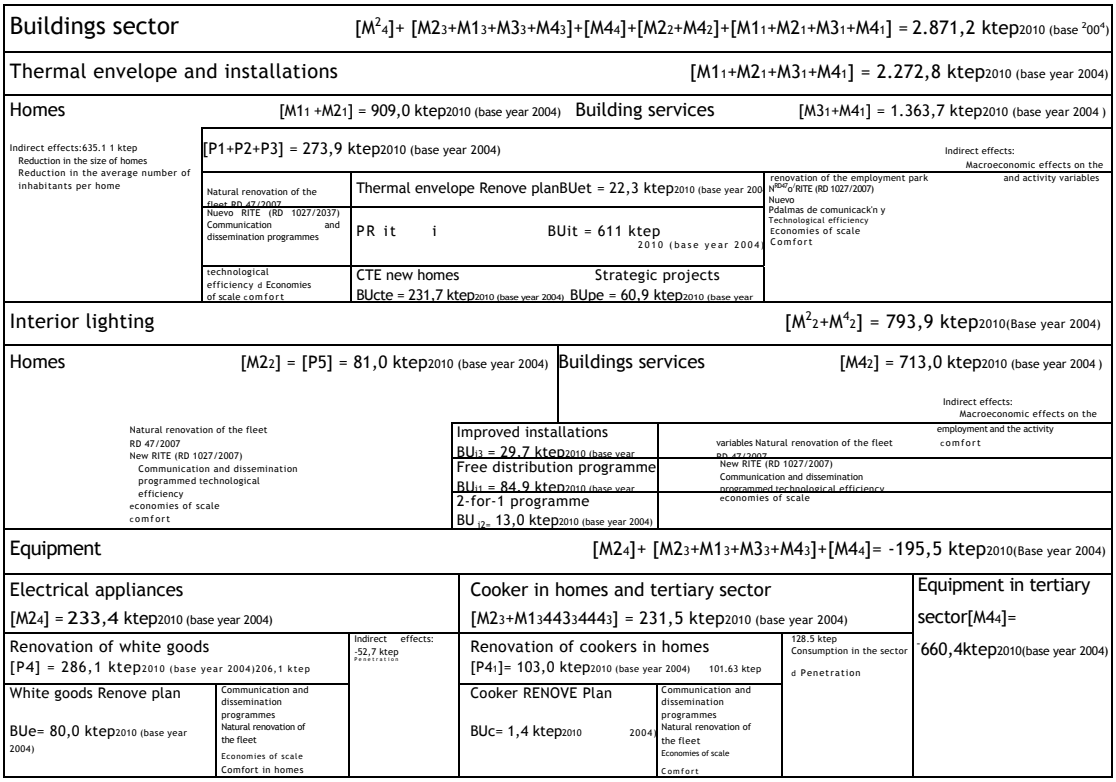
[11] The $P4_1$ indicator calculates the unit saving of electric cookers, gas and dual, as well as the saving on the consumption of independent ovens.

2. Outer boundaries

The buildings sector achieved energy consumption savings thanks to the improvement - both in the residential sector and the tertiary sector - of the thermal envelope and thermal installations, lighting and equipment.

The diagram of energy savings in buildings is presented in Figure 26, which shows the values achieved in 2010 using 2004 as a base year and differentiated the savings by use and subsector.

Figure 26. *Outline of the energy savings in the buildings sector in 2010 with base year 2004*



The methodology used for each savings calculation is described in the following sections, according to the energy uses in buildings: thermal envelopes and installations, interior lighting and equipment.

2.1. Thermal envelope and installations

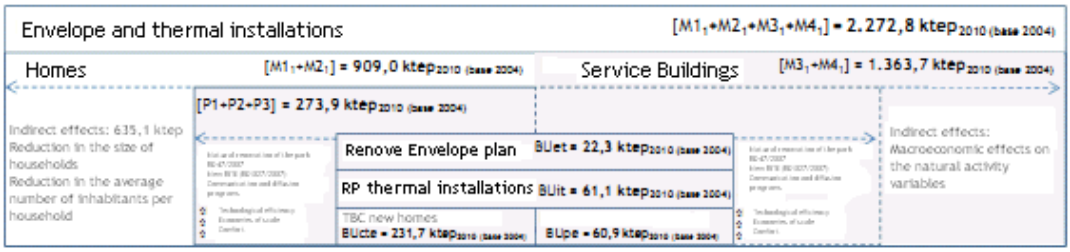
The measures associated with the thermal envelope promote the improvement of roofs, facades and windows, both in homes and buildings in the tertiary sector. Insofar as the reference to thermal installations, boilers, air-conditioning systems and systems for producing sanitary hot water will be included.

Methodology

Firstly, a distinction is made between homes (single-family and housing projects) and tertiary sector buildings (Figure 27). Due to the unavailability of specific

indicators proposed by the European Commission for the calculation of savings in this subsector, some descending *M* indicators were modified.
Then, the savings relative to the "Energetic renovation of the thermal envelope and improved energy efficiency of thermal installations in existing buildings" measure were calculated. The European Commission suggests that three descending *P* indicators are used for the residential sector. Finally, using ascending indicators (BU_{et} and BU_{it}), the savings achieved by different mechanisms promoted by the Administration through collaboration agreements between IDAE and the Autonomous Communities (Renove Plans) and the IDAE's Grants for Strategic Projects Programme were calculated. Likewise, the savings that the policy (Technical Building Code, mainly) has achieved since its entry into force in 2006 were calculated using an ascending indicator (BU_{cte}).

Figure 27. Outline of energy saving in the use of the envelope and thermal installations for 21010 with base year 2004



To be able to estimate the savings achieved in the uses of the envelope and thermal installations, we need to know the electrical and thermal energy consumption intended for each of the uses.

In addition, we need to find a suitable variable so as to normalise said consumption and thus determine the improvement in energy consumption as a difference of said unit consumption. In the domestic sector, consumption is intermittently related to the number of homes, therefore it was considered appropriate to analyse the evolution of unit consumption using said variable as a base. In the tertiary sector, energy consumption is related to the number of full-time employees.

Therefore, to calculate the subsector's global savings, the *M* indicators proposed by the European Commission were used, linking thermal or electrical energy consumption with the aforementioned variables associated with the domestic or tertiary sector, multiplied by the electrical or thermal consumption percentage of heating, cooling and sanitary hot water. The following indicators are used:

- In the domestic sector, indicator M1 "Thermal consumption per home" has been corrected differentiating between its intended use for heating and sanitary hot water. The M2 "Electricity consumption per home" has been corrected differentiating between its intended use for heating, cooling and sanitary hot water.

where:

- $E^{Hnon\text{-}el}$: Thermal consumption in homes
- *D*: Number of occupied households
- *FC*: % of the thermal domestic consumption intended for heating and SHW

$$M2_1 = \left(\frac{E^{Hel}}{D}\right) . FC$$

where:

E^{Hel}: Electricity consumption in homes
D: Number of occupied homes
FC: % of domestic electricity consumption intended for cooling, heating and SHW

- In the tertiary sector, indicator *M3* "Thermal consumption per full-time employee has been corrected depending on whether its intended use is heating or sanitary hot water. The *M4* "Electricity consumption per full-time employee" has been corrected by whether its intended use is heating, cooling or sanitary hot water.

$$M3_1 = \left(\frac{E^{Snon-el}}{\quad}\right) . FC$$

where:

- $E^{Snon\text{-}el}$: Thermal consumption in the tertiary sector
- em: Number of full-time employees in the tertiary sector
- SHW

$$M4_1 = \left(\frac{E^{Sel}}{em}\right) . FC$$

where:

- E_{Sel}: Electricity consumption in the tertiary sector
- *em*: Number of full-time employees in the tertiary sector

FC: % of the electricity consumption in the tertiary sector intended for cooling, heating and SHW

In the case of the indicators related to heating and cooling, a second correction was performed for climate, through the quotient between the average of the heating degree-days in the last 25 years with the heating degree-days from the savings calculation year.

The savings relating to the external boundary in the thermal envelope subsector are the result of multiplying the values from these indicators by the reference year (2004 or 2007) and the calculation year (2010) and the value of the activity variable relative to the indicator. As an example, for indicator M1, it will be:

$$Savings\ achieved\ by\ M1 = [$$

$$((E_{2004}{}^{1}(Hnon-el))/D_{2004}) . [FC]_{2004} - ((E_{2010}{}^{\circ}(Hnon-el))/D_{2010}) . [FC]_{2010}] . D_{2010}$$

where:

- $E^{Hnon\text{-}el}$: Thermal consumption in homes
- *D:* Number of occupied households
- *FC*: % of the thermal domestic consumption intended for heating and SHW

From the sum of the specific savings associated with each of these four corrected indicators (*M1+M2+M3+M4*) global savings were achieved due to the improvement in the thermal envelope and installations in buildings.

Key variables

$$M1 = \left(\frac{E^{Hnon-el}}{D}\right) FC$$

In this section, you will find all the variables which directly affectthe calculation of the savings achieved in this subsector.

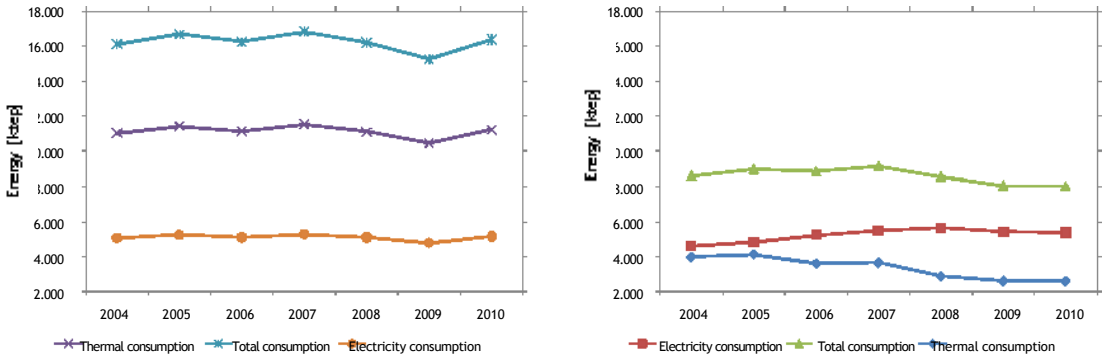
Table 49. *Activity variables used in the calculation of savings from M indicators in the use of the thermal envelope and installations in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Thermal consumption in homes[ktep]	11.045	11.534	11.103	10.448	11.223
Electricity consumption in homes[ktep]	5.072	5.296	5.098	4.798	5.154
Thermal consumption in tertiary buildings[ktep]	3.982	3.658	2.903	2.635	2.627
Electricity consumption in tertiary buildings[ktep]	4.619	5.476	5.646	5.414	5.388
Occupied homes[thousands of homes]	14.904	16.280	16.741	17.068	17.304
Full-time employees[thousands of employees]	11.518	13.471	13.786	13.439	13.408
Heating Degrees-Days	2546	2378	2431	2242	2305
Reference heating DD (25 years)	2126	2136	2144	2151	2139
Cooling degree days	568	426	568	563	564
Reference cooling DD (25 years)	560	560	560	560	560

Source: IDAE

Electricity consumption, both in homes and the tertiary sector, experienced growth between 2004 and 2010 (2% and 16% respectively) due in large part to the increase in equipment in homes and offices. However, thermal consumption saw a decrease in the tertiary sector during the period (34%).

Figure 28. *Evolution of thermal, electrical and total consumption in the domestic and tertiary sector between 2004 and 2010*



In addition, lower growth in occupied homes and a decrease in full-time employees were observed since 2008 as a result of the current economic crisis.

Figure 29. *Evolution of the number of homes occupied and the number of full-time employees from 2004 to 2010*

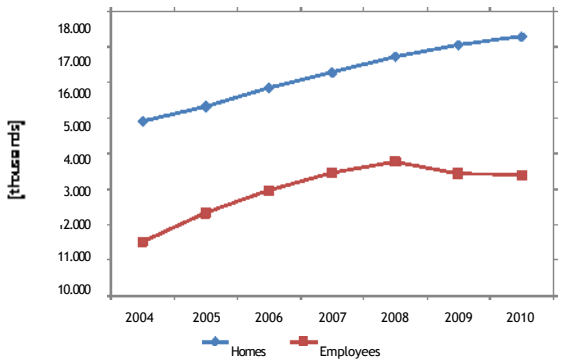
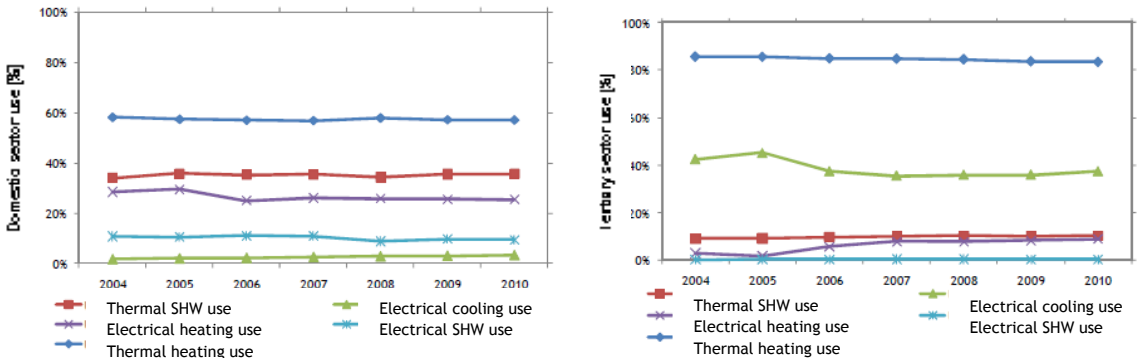


Table 50. *Distribution of thermal and electrical uses of the thermal envelope and thermal installations*

	2004	2007	2008	2009	2010
Domestic thermal use intended for heating [%]	58,2	56,8	57,9	57,1	57,0
Domestic thermal use intended for SHW [%]	34,0	35,4	34,3	35,5	35,7
Domestic electrical use intended for cooling [%]	1,7	2,6	2,8	3,1	3,3
Domestic electrical use intended for heating [%]	28,4	26,1	25,9	25,6	25,4
Domestic electrical use intended for SHW [%]	10,8	11,0	8,8	9,8	9,4
Thermal use in the tertiary sector intended for heating [%]	85,5	84,6	84,4	83,6	83,4
Thermal use in the tertiary sector intended for ACS [%]	9,1	10,0	10,3	10,1	10,3
Electrical use in the tertiary sector intended for cooling [%]	42,5	35,5	35,9	35,9	37,4
Electrical use in the tertiary sector intended for heating [%]	3,0	7,8	7,8	8,3	8,8
Electrical use in the tertiary sector intended for ACS [%]	0,2	0,5	0,5	0,4	0,4

Source: IDAE

Figure 30. *Evolution of percentage consumption in heating and thermal and electrical sanitary hot water and cooling in the domestic and tertiary sectors from 2004 to 2010*



In terms of heating, the domestic sector has reduced its percentage of use in terms of both electrical and thermal energy in recent years. However, in the tertiary sector, this fall in use only occurred in thermal energy, the percentage of use of electricity consumption relative to heating having increased by almost 6%.

In the period analysed, cooling in homes increased its use by almost double, a consequence of its greater penetration. However, in the tertiary sector, the use of cooling experienced a 5% fall in its percentage of use; this may be a result of better technology, the need to optimise costs and energy efficiency measures implemented.

Finally, the percentage of use of sanitary hot water in the domestic sector has increased in the case of thermal production (1.7%), it has also experienced slight growth when it is produced electrically. (1,4%). For its part, electrical use doubled in the tertiary sector and thermal use saw an increase of 1.2%.

Total savings achieved

The total savings achieved in the use of the thermal envelope and installations consider both direct and indirect savings.

To calculate the energy saving achieved in the period, the aforementioned indicators described were used applying the sector's variables and the macroeconomics required to calculate the indicators. The results can be found in Table 51 and the evolution of the indicators is shown in Table 52 and Figure 31.

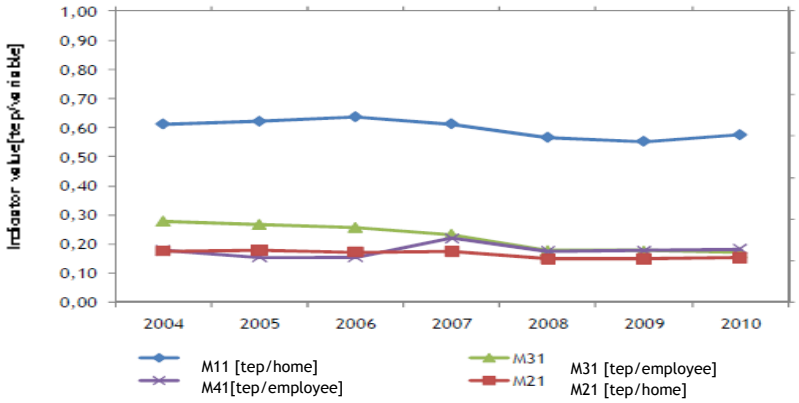
Table 51. *Results of saving in the use of the thermal envelope and installations in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Thermal env and ins. subsector	$M1_1+M2_1+M3_1+M4_1$	2.699,2	2.272,8
	Domestic sector	$M1_1+M2_1$	1.321,7	909,0
	Tertiary sector	$M3_1+M4_1$	1.377,5	1.363,7
Base year 2007 [ktep]	Thermal env and ins. subsector	$M1_1+M2_1+M3_1+M4_1$	2.660,1	2.233,7
	Domestic sector	$M1_1+M2_1$	1.324,3	911,7
	Tertiary sector	$M3_1+M4_1$	1.335,7	1.322,0

Table 52. *Evolution of M indicators related to use of the thermal envelope and installations between 2004 and 2010*

	Description	2004	2007	2008	2009	2010
$M1_1$	Indicator of unitary thermal consumption in the thermal envelope and installations per home [tep/home]	0,612	0,612	0,566	0,552	0,574
$M2_1$	Indicator of unitary electricity consumption in the thermal envelope and installations per home [tep/home]	0,123	0,123	0,105	0,105	0,108
$M3_1$	Indicator of unitary thermal consumption in the thermal envelope and installations per employee [tep/employee]	0,278	0,234	0,179	0,177	0,172
$M4_1$	Indicator of unitary electricity consumption in the thermal envelope and installations per employee [tep/employee]	0,179	0,220	0,175	0,177	0,184

Figure 31. *Evolution of the M indicators for the use of the thermal envelope and installations between 2004 and 2010*



The savings in the 2004-2010 study period were 2.272,8 ktep, 40% of which were achieved in thedomestic sector and 60% in the tertiary sector.

2.2. Interior lighting

The use of interior lighting can be articulated in the section corresponding to the domestic sector and in the section related to the tertiary sector.

From the group of indicators in the catalogue proposed by the European Commission for the calculation of savings, none mention lighting explicitly, with the exception of indicator P5 which was used to calculate interior boundaries. For this reason, we have corrected some of the descending M indicators to adapt them to measuring the savings achieved in thissubsector. In this case, the M2 "Electricity consumption per home" and M4 indicators "Electricity consumption per full-time employee" were corrected by the percentage of electricity consumption relative to interior lighting, both in homes and in the tertiary sector.

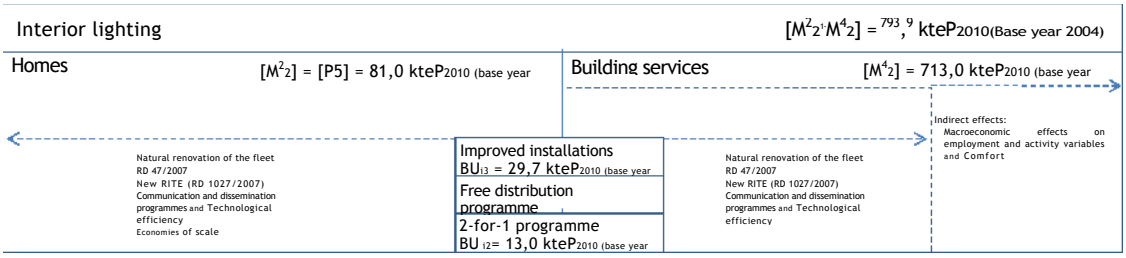


Figure 32. *Diagram of energy saving in the interior lighting subsector for 2010 with base* year 2004

In terms of the domestic sector, the P5 indicator proposed by the European Commission was used. However, for the tertiary sector, it was not possible to calculate the associated savings.

The result of the saving using indicator P5 shows the global renovation produced in the homes through both the natural evolution of the lighting systems and those induced by special measures promoted by IDAE.

For this latter case, the associated savings have been quantified using ascending indicators *(BU$_{i1}$*, *BU$_{i2}$* and *BU$_{i3}$*) using annual reports provided by the Autonomous Communities and other projects.

Methodology

To be able to obtain the saving achieved in this use, we need to know the evolution of electricity consumption in interior lighting both in the domestic and tertiary sectors. In the same way as for the thermal use, to be able to standardise the savings, it has been considered that homes - in the case of the domestic sector - and employee - in the tertiary sector - shall be the activity variables since they are closely related to consumption.

As a result, to calculate the global savings in the lighting subsector, the M2 "Electricity consumption per home" and M4 indicators "Electricity consumption per full-time employee" have been corrected by the electricity consumption percentage of interior lighting, both in homes and in the tertiary sector.

$$M2_2 = \left(\frac{E^{Hel}}{D}\right) * FC$$

where:
- E^{Hel} : Electric consumption in homes
- *D*: Number of occupied households
- *FC*: % of the domestic electric consumption intended for interior lighting

$$M4_2 = \left(\frac{E^{Sel}}{em}\right) * FC$$

where:
- E^{Sel}: Electricity consumption in the tertiary sector
- *em*: Number of full-time employees in the tertiary sector
- *FC*: % of the electricity consumption in the tertiary sector intended for interior lighting

The savings relating to the external boundary are the result of multiplying the difference of these values for the reference year (2004 and 2007) and the calculation year (2010) and the value of the activity variable relative to the indicator. For example, for indicator M2 it would be:

$$M2_2 = \left[\left(\frac{EHel2004}{D2004}\right) * FC2004 - \left(\frac{EHel2010}{D2010}\right) * FC2010\right] * D_{2010}$$

where:
- E^{Hel}: Electric consumption in homes
- *D*: Number of occupied households
- *FC*: % of the domestic electric consumption intended for interior lighting

Key variables

In this section, you will find all the variables which directly affect the calculation of the savings achieved in lighting.

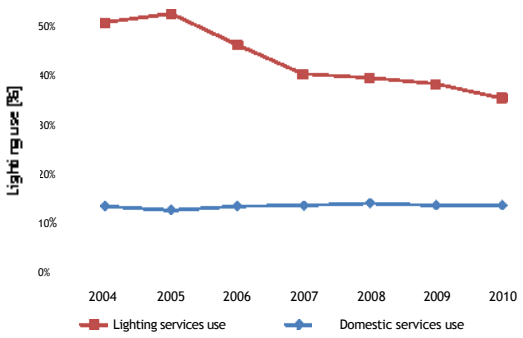
Table 53. *Activity variables used in the calculation of savings from M indicators in the interior lighting subsector in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Electricity consumption in homes[ktep]	5.072	5.296	5.098	4.798	5.154
Electricity consumption in tertiary buildings[ktep]	4.619	5.476	5.646	5.414	5.388
Occupied homes[thousands of homes]	14.904	16.280	16.741	17.068	17.304
Full-time employees[thousands of employees]	11.518	13.471	13.786	13.439	13.408
Domestic electrical use intended for lighting[%]	12,3%	12,3%	12,8%	12,4%	12,4%
Electrical use in the tertiary sector intended for lighting [%]	44,7%	35,6%	34,9%	33,9%	31,4%

Source: INE, IDAE

Table 53 and Figure 33 show how the percentage of interior lighting use in homes is practically constant, but it is the tertiary sector that considerably reduced its use (-13,3%), indirectly contributing to the generation of savings in the interior lighting subsector.

Figure 33. *Evolution of the lighting use percentage with respect to the total consumption in the domestic and tertiary sectors between 2004 and 2010*



Total savings achieved

To calculate the energy saving achieved in the period, the previously described indicators were used, applying the sector's variables and the macroeconomics required to calculate the indicators. The results can be found in Table 54 and the evolution of the indicators is shown in Table 55.

Table 54. *Results of energy savings in the interior lighting subsector in 2009 and 2010 with base years 2004 and 2007*

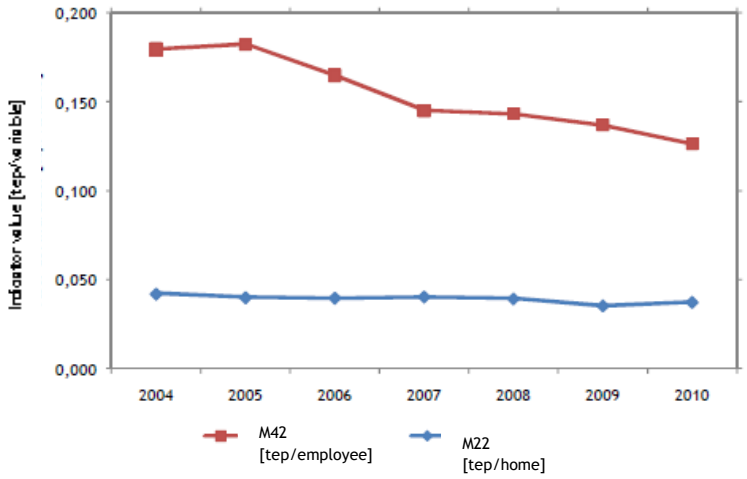
		Associated indicator	2009	2010
Base year 2004 [ktep]	Interior lighting subsector	$M2_2$+ $M4_2$	691,8	793,9
	Domestic sector	$M2_2$	116,4	81,0
	Tertiary sector	$M4_2$	575,4	713,0
Base year 2007 [ktep]	Interior lighting subsector	$M2_2$+ $M4_2$	$^{19}8,^{4}$	301,2
	Domestic sector	$M2_2$	89,1	53,3
	Tertiary sector	$M4_2$	109,2	247,9

If the corrected descending M indicators proposed by the European commission are taken into account, interior lighting use achieved savings of 793,9 ktep in the period studied (28% of the total savings achieved in the buildings sector). The majority of these savings (90%) were achieved in the tertiary sector.

Table 55. *Evolution of the M indicators for the interior lighting subsector between 2004 and 2010*

	Description	2004	2007	2008	2009	2010
$M2_2$	Indicator of unitary electricity consumption in lighting per home [tep/home]	0,0417	0,0401	0,0390	0,0349	0,0370
$M4_2$	Indicator of unitary electricity consumption in lighting per employee [tep/employee]	0,1794	0,1447	0,1430	0,1366	0,1263

Figure 34. *Evolution of M indicators for lighting use between 2004 and 2010*

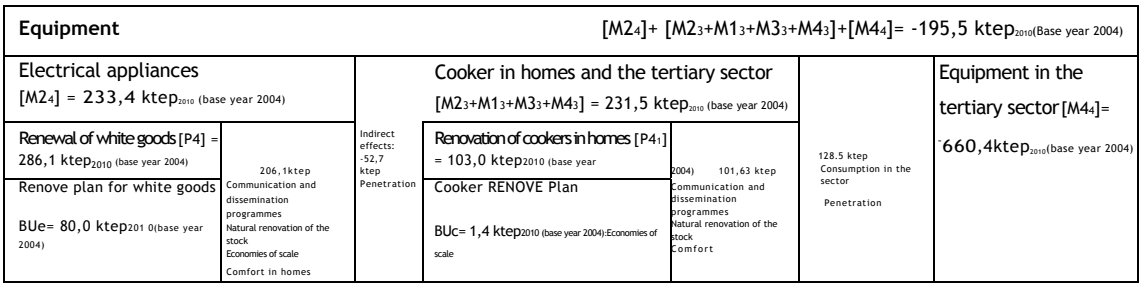


2.3. Equipment

The equipment subsector has been organised into three main areas taking into account thetype of electrical appliance analysed and the domestic or tertiary sector in which it fits: electrical appliances in homes, cookers in homes and services and equipment in the tertiary sector (Figure 35).

The boundaries related to said areas were established using M indicators proposed by the European Commission. Then the specificities of each indicator will be analysed according to the activity variables used for its calculation.

Figure 35. *Diagram of energy saving in the use of equipment for 2010 with base year 2004*



This analysis enabled the counting of measures relative to the renewal of white goods and cookers.
The indicator *P4* proposed by the European Commission was used for the first whilst, in the case of cookers, we needed to create a new indicator, $P4_1$, which can be seen in Figure 35.

The result of the saving using both indicators shows both the natural renovation of the stock of electrical appliances and cookers and that obtained through improvements induced by specific measures promoted by IDAE. For this latter case, it was possible to count it using ascending indicators (BUe and BUc) using the information available in the statistics relative to the RENOVE Plans.

Methodology

Electrical appliances in homes

The variation in the consumption relative to electrical appliances and other appliances per occupied household in Spain between the reference year (2004 and 2007) and the calculation year (2010) allows for the calculation of what has been the best in terms of the unit energy intensity per home. Therefore, to calculate the total savings achieved in this subsector, the M2 indicator "Electricity consumption per home" proposed by the European Commission was used corrected by the percentage of domestic electricity consumptionintended for both electrical appliances and other equipment.

$M2_4 =$ (E^{Hel})

where:
- E^{Hel}: Electric consumption in homes
- D: Number of occupied households

FC: % of the domestic electric consumption intended for electrical appliances and other equipment

Cookers in homes and the tertiary sector

The variation in consumption intended for cookers in relation to the number of homes occupied in the domestic sector or per full-time employee in the tertiary sector allows for the estimation of what has been the best in terms of units of energy intensity both per home and per worker.

We should mention that, whilst the occupied homes variable presents a stable performance, the full-time employees vary may be subject to significant variations in periods of economic recession, therefore said situation should be analysed when assessing the results in the tertiary sector.

For the calculation of the total savings in cookers, a combination of more complex M indicators than in the case of electrical appliances was used, since cookers and ovens may use both electrical and thermal energy in the domestic and tertiary sectors.

The indicators selected have been corrected according to the percentage of electrical and thermal consumption for cookers and ovens:

- In the domestic sector: M1 "Thermal consumption per home" and M2 "Electricity consumption per home" corrected for use intended for cookers.

$$M1_3 = \left(\frac{E^{Hnon-el}}{D}\right) * FC$$

where:
- $E^{Hnon-el}$: Thermal consumption in homes
- D: Number of occupied households
- FC: % of the thermal domestic consumption

$$M2_3 = \left(\frac{E^{Hel}}{D}\right) * FC$$

where:
- E^{Hel}: Electric consumption in homes
- D: Number of occupied households
- FC: % of the electrical domestic consumption intended for cookers and ovens

- In the tertiary sector: M3 "Electricity consumption per full-time employee and M4 "Electricity consumption per full-time employee" corrected for the use intended for cookers.

$$M3_3 = \left(\frac{E^{Snon-el}}{em}\right) * FC$$

where:
- $E^{Snon-el}$: Thermal consumption in the tertiary sector
- *em*: Number of full-time employees in the tertiary sector
- *FC*: % of the thermal consumption in the tertiary sector intended for cookers and ovens

$$M4_3 = \left(\frac{E^{Sel}}{em}\right) * FC$$

where:
- E^{Sel}: Electricity consumption in the tertiary sector
- *em:* Number of full-time employees in the tertiary sector
- *FC*: % of the electricity consumption in the tertiary sector intended for cookers and ovens

Equipment in the tertiary sector

Finally, the variation in consumption intended for office equipment and other equipment with respect to full-time employees in the tertiary sector, allows for the calculation of what has been the best in terms of unitary energy intensity per worker in the tertiary sector. Remember that the number of full-time employees will be affected in periods of economic recession.

The M4 "Electricity consumption per full-time employee" indicator proposed by the Commission corrected by the consumption percentage of said equipment in the tertiary sector.

$$M4_4 = \left(\frac{E^{Sel}}{em}\right) * FC$$

where:
- E^{Sel}: Electricity consumption in the tertiary sector
- *em*: Number of full-time employees in the tertiary sector
- *FC*: % of the electricity consumption in the tertiary sector intended for office automation and equipment

The savings relating to the external boundary are the result of multiplying the difference of these values for the reference year (2004 and 2007) and the calculation year (2010) and the value of the activity variable relative to the indicator.

As an example, for the M4 indicator:

$$\text{Savings achieved by M44} = \left[\left(\frac{E^{Sel}_{2004}}{em_{2004}}\right) * FC_{2004} - \left(\frac{E^{Sel}_{2010}}{em_{2010}}\right) * FC2010\right] - em_{2010}$$

where:
- E^{Sel}: Electricity consumption in the tertiary sector
- em: Number of full-time employees in the tertiary sector
- *FC*: % electricity consumption in the tertiary sector intended for office automation and equipment

Key variables

In this section, you will find all the variables which directly affect the calculation of the savings achieved in this subsector.

Table 56. *Activity variables used in the calculation of savings from M indicators in the equipment subsector in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Thermal consumption in homes [ktep]	11.045	11.534	11.103	10.448	11.223
Electricity consumption in homes [ktep]	5.072	5.296	5.098	4.798	5.154
Thermal consumption in tertiary buildings [ktep]	3.982	3.658	2.903	2.635	2.627
Electricity consumption in tertiary buildings [ktep]	4.619	5.476	5.646	5.414	5.388
Occupied homes [thousands of homes]	14.904	16.280	16.741	17.068	17.304
Full-time employees [thousands of employees]	11.518	13.471	13.786	13.439	13.408

Source: IDAE

Table 57. *Distribution by use in the equipment subsector in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Electrical domestic use intended for electrical appliances and others [%]	40,5%	41,0%	42,6%	41,7%	41,8%
Domestic thermal use intended for cookers and ovens [%]	7,8%	7,8%	7,8%	7,4%	7,3%
Domestic electrical use intended for cookers and ovens [%]	6,3%	7,0%	7,2%	7,5%	7,7%
Thermal use in the tertiary sector intended for cookers and ovens [%]	5,4%	5,3%	5,2%	6,3%	6,4%
Electrical use in the tertiary sector intended for cookers and ovens [%]	0,4%	0,5%	0,5%	0,6%	0,6%
Electrical use in the tertiary sector intended for office and other equipment [%]	9,2%	20,2%	20,5%	21,0%	21,4%

Source: IDAE

Figure 36. *Evolution of the consumption percentage of cookers, equipment and electrical appliances in the domestic and tertiary sectors in the 2004-2010 period.*

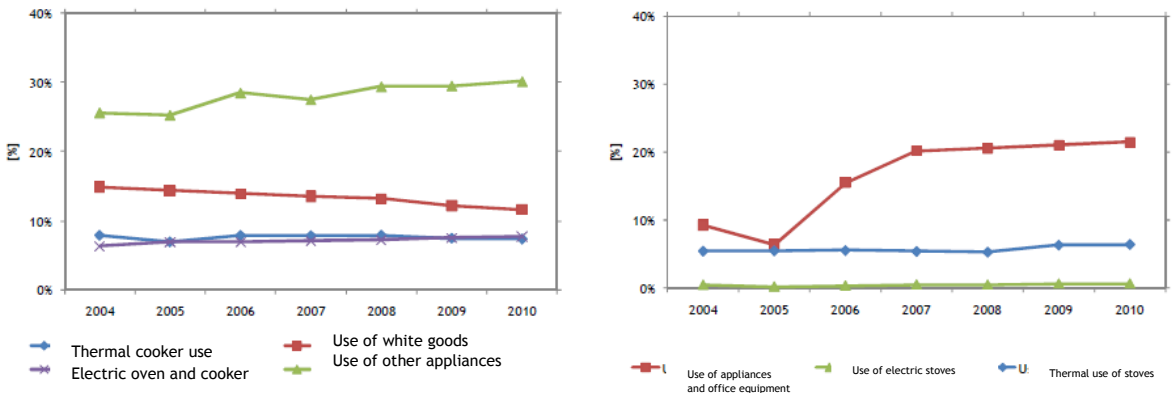


Figure 36 shows how the tertiary sector has increased its equipment significantly in the period studied, going from representing 9.2% of consumption in the sector in2004, to 21,4% in 2010.

This phenomenon can also be seen in the domestic sector, which has seen growth in brown goods (televisions, DVDs, stereos and computers etc).

On the other hand, white goods (refrigerators, washing machines, tumble-dryers and dishwashers etc) saw a decrease in their use percentage, penetration only increased in some cases, which generated energy savings.

Total savings achieved

To calculate the energy saving achieved in the period, the indicators described were used applying the sector's key variables and the macroeconomics required to calculate the indicators.

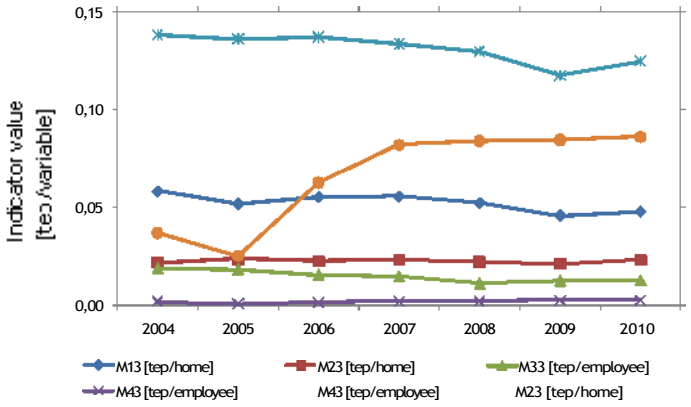
Table 58. *Results of saving in the use of equipment in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Equipment subsector	$M2_4+M2_3+M1_3+M3_3+M4_3+M4_4$	11,4	-195,5
	Electrical appliances in homes	$M2_4$	353,4	233,4
	Cookers in homes and the tertiary sector	$M2_3+M1_3+M3_3+M4_3$	298,1	231,5
	Equipment in the tertiary sector	$M4_4$	-640,1	-660,4
Base year 2007 [ktep]	Equipment subsector	$M2_4+M2_3+M1_3+M3_3+M4_3+M4_4$	463,5	254,0
	Electrical appliances in homes	$M2_4$	277,5	156,5
	Cookers in homes and the tertiary sector	$M2_3+M1_3+M3_3+M4_3$	219,2	152,3
	Equipment in the tertiary sector	$M4_4$	-33,1	-54,8

Table 59. *Evolution of M indicators related to the use of equipment in the 2004-2010 period*

	Description	2004	2007	2008	2009	2010
$M1_3$	Indicator of unitary thermal consumption in cookers and ovens per home [tep/home]	0,0581	0,0552	0,0520	0,0455	0,0475
$M2_3$	Indicator of unitary electricity consumption in cookers and ovens per home [tep/home]	0,0215	0,0229	0,0219	0,0210	0,0229
$M3_3$	Indicator of unitary thermal consumption in cookers and ovens per employee [tep/employee]	0,0186	0,0145	0,0110	0,0123	0,0125
$M4_3$	Indicator of unitary electricity consumption in cookers and ovens per employee [tep/employee]	0,0017	0,0019	0,0019	0,0025	0,0025
$M2_4$	Indicator of unitary electricity consumption in electrical appliances per home [tep/home]	0,1379	0,1334	0,1296	0,1172	0,1244
$M4_4$	Indicator of unitary electricity consumption for equipment and office equipment per employee [tep/employee]	0,0368	0,0820	0,0839	0,0844	0,0860

Figure 37. *Evolution of M indicators related to the use of equipment in the 2004-2010 period*



In the period studied, no savings were achieved relative to the use of equipment due mainly to the greater penetration of equipment both in homes and companies in the tertiary sector in recent years. Although efforts made by the Public Administrations and private entities have considerably improved their individual efficiency in recent years, this is cancelled out by the increase in absolute value, when measured with a descending indicator such as a M indicator.

In terms of homes, and although a moderate saving was achieved with respect to white collar electrical appliances, this has been penalised by the significantly elevated penetration rate of brown collar electrical appliances.

In terms of the purchasing behaviour of end users of electrical appliances, it has been reported that when they buy electrical appliances, they take the energy efficiency shown on the energy label into account.

3. Energy renewal of the thermal envelope and improved energy efficiency of thermal installations in residential buildings

The aim of the renewal of the thermal envelope involves reducing the energy required for heating and cooling in existing buildings, through total or partial renewal of the thermal envelope.

The new Regulation on Thermal Installations in Buildings (RITE) makes a periodic inspection of the energy efficiency of this type of installation mandatory, therefore the direct objective of improving thermal installations is the reduction in the final energy consumption of sanitary hot water production plants and heating and air-conditioning in existing buildings.

Methodology

The three uses included in these two measures are heating, cooling and sanitary hot water. To be able to calculate the savings achieved, we need to know the evolution of the unit consumption in the study period.

With the aim of standardising this unit consumption, an activity variable that played a fundamental role in its evolution is required. For the case of heating and cooling, it is considered that consumption is closely linked to the surface area of homes and for the case of sanitary hot water, the number of inhabitants.

According to the variables required for the calculation of the savings, for the present measure it was decided to use the three descending P indicators proposed by the European Commission relative to the household sector: the *P1* "Domestic energy consumption for heating per m^2"; the *P2* "Domestic energy consumption for cooling per m^2"; and the *P3* "Domestic energy consumption for sanitary hot water per inhabitant".

By adding the results obtained from these three indicators (*P1*, *P2* and *P3*), the savings achieved for households through the energy renewal measure relative to the thermal envelope and improved energy efficiency of the thermal installations in existing buildings are obtained.

Heating

The P1 indicator proposed makes reference to unitary domestic energy consumption per m^2in the heating sector. The expression that allows us to calculate this indicator is:

$$\left(\frac{E^{Hel} - FC_1 + E^{Hnon-el} - FC_2}{F}\right)$$

where:

- E^{Hel} : Electric consumption in homes
- *FC*: % del E^{Hel}intended for heating
- $E^{Hnon-el}$: Thermal consumption in homes
- FC_2: % of E^{Hel} intended for heating
- F: m^2 of surface area of permanently occupied households
- $ADD_{Heating}$: Heating Degrees-Days
- $MDD25^{Heating}$:Average^{ADDHeating} over the last 25 years

The heating consumption of homes has been obtained by multiplying the total consumption by the corresponding percentage of the consumption intended for both electrical and thermal heating.

This indicator has been corrected by the effect of climate multiplying the quotient between the heating degree-days measure over the last 25 years by the heating degree-days in the year that the savings are calculated.

Cooling

The P2 indicator makes reference to unitary domestic energy consumption per m^2 in the cooling sector.

$$\left(\frac{E^{Hel} - FC}{F}\right) * \left(\frac{MDD_{25}^{Cooling}}{ADD^{Cooling}}\right)$$

where:

- E^{Hel}: Electric consumption in homes
- *FC*: % del E^{Hel} intended for cooling
- *F*: m^2 of surface area of permanently occupied households
- $ADD^{Cooling}$: Heating Degrees-Days
- $MDD25^{Cooling}$: Average of $ADD^{Cooling}$ over the last 25 years

The expression used to calculate this indicator is very similar to that used in the case of the previous *P1* indicator. The difference stems from the existing cooling systems in homes that only consume electrical energy and therefore only domestic electrician consumption has been corrected by the percentage of domestic electricity consumption for cooling.

In turn, to correct the indicator by climatology factors, cooling and not heating degrees-days were used.

Sanitary hot water

The *P3* indicator makes reference to unitary domestic energy consumption inhabitant for sanitary hot water according to the following expression:

$$P3 = \left(\frac{E^{Hel} * FC_1 + E^{Hnon-el} * FC_2}{P}\right)$$

where:

- E^{Hel}: Electric consumption in homes
- FC_1: % del E^{Hel} intended for cooling
- $E^{Hnon-el}$: thermal consumption in homes
- FC_2: % of the E^{Hel} intended for SHW
- $MDD25^{Cooling}$: Average of $ADD^{Cooling}$ over the last 25 years
- *P:* Population

In this case, energy consumption is corrected for the consumption percentage of sanitary hot water, the number of inhabitants being the activity variable.

Key variables

In this section, you will find all the variables which directly affectthe calculation of the savings achieved in this measure.

Table 60. *Activity variables used in the calculation of savings from P indicators in the measured rehabilitation of the thermal envelope and improvement to thermal installations in existing buildings (households) in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Thermal consumption in homes[ktep]	11.045	11.534	11.103	10.448	11.223
Electricity consumption in homes[ktep]	5.072	5.296	5.098	4.798	5.154
Surface area of homes [km^{2}]	1.350.669,9	1.433.563,1	1.459.322,7	1.477.011,8	1.502.495,9
Population [thousands of people]	43.197,7	45.200,7	46.157,8	46.745,8	47.021,0
Heating Degrees-Days	2546	2378	2431	2242	2305
Reference heating DDs(25 years)	2126	2136	2144	2151	2139
Cooling degree s-days	568	426	568	563	564
Reference cooling DDs(25 years)	560	560	560	560	560

Source: DGT, IDAE

Figure 38. *Evolution of the average surface area of homes and the number of inhabitants (left) and evolution of the degree-days of heating and cooling (right) in the 2004-2010 period*

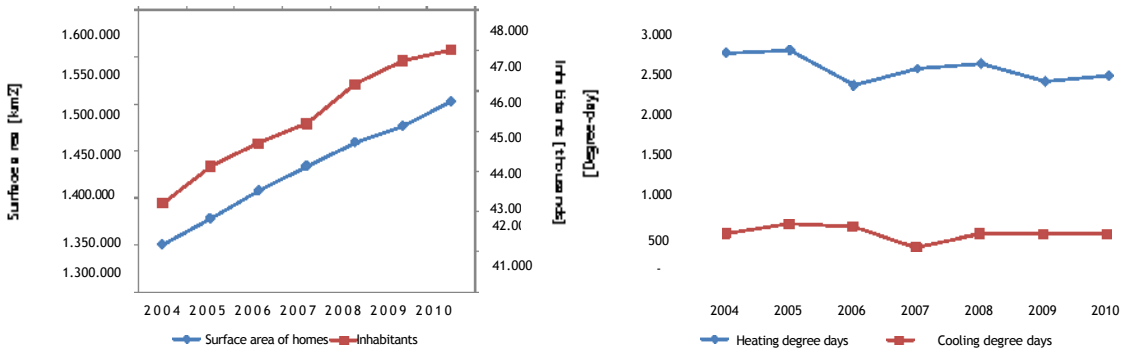


Table 61. *Distribution by domestic uses in the renewal of the thermal envelope and improvement to thermal installations in existing buildings measure (households) in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Domestic thermal use intended for heating[%]	58,2	56,8	57,9	57,1	57,0
Domestic thermal use intended for SHW[%]	34,0	35,4	34,3	35,5	35,7
Domestic electrical use intended forcooling [%]	1,7	2,6	2,8	3,1	3,3
Domestic electrical use intended forheating [%]	28,4	26,1	25,9	25,6	25,4
Domestic electrical use intended for SHW[%]	10,8	11,0	8,8	9,8	9,4

Source: IDAE

3.1. Public aid programmes for the energy rehabilitation of the thermal envelope

The public aid programmes for the energy rehabilitation of the thermal envelope werea mechanism developed within the collaboration agreements signed by IDAE and the Autonomous Communities.

Methodology

To calculate the effect derived from these programmes, use has been made of the annual information collected by the Autonomous Communities on savings achieved through projects that received public support for the renewal of facades, roofs and windows.

It is considered, as proposed by the European Commission, that the useful life of this type of measure is 30 days for facades and windows and 25 years for roofs. This exceeds the period of analysis, therefore the savings achieved in 2010 are a result of the sum of the savings reported every year since 2004 or 2007 depending on the calculation base chosen.

Thus the measure of the saving is given by the following ascending indicator:

$$BU_{et} = \sum^{2010} Ah_{et}$$

where:

- Ah_{et}: Annual savings reports from the Autonomous Communities concerning the public aid programmes for the energy rehabilitation of the thermal envelope

3.2. Public aid programmes for the renovation of thermal installations

The public aid programmes for the energy renovation of thermal installations were a mechanism developed within the collaboration agreements signed by IDAE and the Autonomous Communities.

Methodology

To calculate the effect derived from these programmes, the annual information provided by the Autonomous Communities on savings made through projects subject of public support for the renewal of heating, cooling and SHW systems.

The useful life of this type of measure - 15 years for cooling and 30 years for heating - exceeds the analysis period therefore the savings achieved in 2010 will be the sum of the savings reported since 2004 or 2007 depending on the calculation basis chosen. The indicator is calculated according to the following expression:

$$BU_U = \sum^{2010} Ah_{it}$$

where:

- Ah_{it} :Annual savings reported by the Autonomous Communities relative to public supports for the renewal of thermal installations

3.3. Technical Building Code

The policy on the Technical Building Code (RD 314/2006), hereinafter the TBC, exclusively refers to new buildings and houses built since it entered into force. As a result, the improvements were only applied to new constructions from 2007, giving houses a rating between "A" for those which are most efficient and "E" for those which strictly comply with the policy.

Methodology

The savings achieved in the period were calculated by multiplying, for each type of energy rating (A, B, C and D), the square meters in new build homes by the difference between its consumption (for heating and cooling) and the reference home itself (E). Thus, the measure can be calculated according to the following indicator:

$$\sum_{i}^{D} F_i^{Nuevos} - (C^E - C^x)$$

where:

- F^{Nuevos}: square metres of surface area by floor of new build homes with a heating or cooling system.
- C^E: Heating or cooling consumption of a E-rated home per horizontal surface area
- C^x: Heating or cooling consumption of a home with a rating of A, B, C or D per horizontal surface area

Key variables

In this section, you will find all the variables which directly affect the calculation of the direct savings achieved by this mechanism.

Table 62. *Activity variables used in the calculation of savings linked to the Technical Building Code in the 2004-2010 period.*

	2006	2007	2008	2009	2010
New homes [millions of homes]	N/A	424.844	460.941	326.817	235.392
Average surface area of project housing [m^2]	N/A	98,3	96,8	95,6	94,3
Average surface area of single-family housing [m^2]	N/A	167,6	172,7	175,6	179,1
New project housing [%]	N/A	0,84	0,80	0,77	0,75
New single-family houses [%]	N/A	0,16	0,20	0,23	0,25
Homes/housing ratio [%]	N/A	0,61	0,68	0,76	N/A
Homes with heating equipment [%]	N/A	0,70	0,70	0,70	0,70
Homes with cooling equipment [%]	N/A	0,36	0,36	0,36	0,36

Source: INE, IDAE

Figure 39. *Distribution of heating energy in new households in 2010*

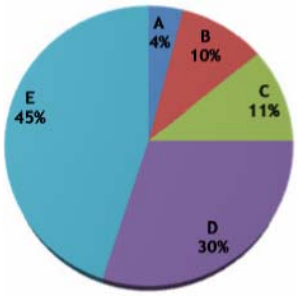


Table 63. *Number of single-family new build homes per rating*

	2007	2008	2009	2010
Single-family homes with rating A [units]	2.639	3.693	2.968	2.314
Single-family homes with rating B [units]	6.599	9.232	7.419	5.784
Single-family homes with rating C [units]	7.259	10.155	8.161	6.362
Single-family homes with rating D [units]	19.796	27.695	22.257	17.351
Single-family homes with rating E [units]	29.694	41.542	33.386	26.027

Source: IDAE

Table 64*. Number of homes in new build housing projects per rating*

	2007	2008	2009	2010
Project housing with rating A [units]	14.354	14.745	10.105	7.102
Project housing with rating B [units]	35.886	36.863	25.263	17.755
Project housing with rating C [units]	39.474	40.549	27.789	19.531
Project housing with rating D [units]	107.657	110.588	75.788	53.266
Project housing with rating E [units]	161.486	165.881	113.682	79.899

Source: IDAE

Table 65. *Total number of new build single-family homes with heating by rating*

	2007	2008	2009	2010
Single-family homes saving A [kWh]	21.592.355	31.221.851	26.209.552	20.842.178
Single-family homes saving B [kWh]	48.474.676	70.095.729	58.838.597	46.789.220
Single-family homes saving C [kWh]	43.914.847	63.508.026	53.302.664	42.386.974
Single-family homes saving D [kWh]	78.061.748	112.928.401	94.737.846	75.336.772
Single-family homes saving E [kWh]	0	0	0	0

Source: IDAE

Table 66. *Total heating savings in newly built housing projects with heating by rating*

	2007	2008	2009	2010
Project housing saving A [kWh]	57.342.175	58.213.158	40.594.981	28.158.251
Project housing saving B [kWh]	130.099.372	132.054.821	92.042.261	63.844.077
Project housing saving C [kWh]	120.444.218	122.226.311	85.127.972	59.048.058
Project housing saving D [kWh]	226.959.607	230.167.429	159.966.901	110.959.237
Project housing saving E [kWh]	0	0	0	0

Source: IDAE

Table 67. *Total cooling savings in newly built single-family homes with cooling by rating*

	2007	2008	2009	2010
Single-family homes saving A [kWh]	1.019.242	1.449.103	1.159.893	922.362
Single-family homes saving B [kWh]	2.189.835	3.113.523	2.491.966	1.981.644
Single-family homes saving C [kWh]	1.889.637	2.686.518	2.150.493	1.710.100
Single-family homes saving D [kWh]	2.452.796	3.486.400	2.792.260	2.220.442
Single-family homes saving E [kWh]	0	0	0	0

Source: IDAE

Table 68. *Total cooling savings in newly built housing projects by heating*

	2007	2008	2009	2010
Project housing saving A [kWh]	2.426.864	2.419.131	1.604.806	1.113.155
Project housing saving B [kWh]	5.242.410	5.225.762	3.466.596	2.404.565
Project housing saving C [kWh]	4.481.259	4.466.575	2.963.463	2.055.573
Project housing saving D [kWh]	5.610.087	5.589.811	3.710.679	2.573.870
Project housing saving E [kWh]	0	0	0	0

Source: IDAE

Table 69. *Output according to energy rating*

	Rating E	Rating D	Rating C	Rating B	Rating A
Seasonal output from traditional boilers	0,70	0,70	0,70	0,70	0,70
Seasonal output from efficient boilers	0,70	0,75	0,80	0,85	0,90
Seasonal output from traditional AACC	1,80	1,80	1,80	1,80	1,80
Seasonal output from efficient AACC	1,80	2,00	2,30	2,50	3,00
Seasonal output from traditional boilers	0,70	0,70	0,70	0,70	0,70

Source: IDAE

3.4. IDAE Grants for Strategic Projects Programme

The IDEA' Grants for Strategic Projects Programme is focused, basically, on the thermal envelope and thermal installations in the tertiary sector, therefore its savings have been associated with this use.

Methodology

To calculate the saving achieved by IDAE's Grants for Strategic Projects Programme, information from IDAE on the same was used, resulting in adding the savings, project by project, relative to all the actions subject of public support.

where:

- *Ahpe*: A
  Progr

2010

Grants for Strategic Projects

3.5. Summary of the direct savings relative to the thermal envelope and thermal installations

Direct savings are those achieved by the development of specific measures in the subsector, as well as for all the mechanisms specifically promoted by the Administration with the aim of improving the efficiency of the thermal envelope and installations.

Table 70. *Results of saving from the measure relative to the energy renewal of the thermal envelope and the improved energy efficiency of the thermal installations in existing buildings (homes)*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Renovation of the thermal envelope and EE	*P1+P2+P3*	706,7	273,9
	Domestic consumption for heating	*P1*	275,1	153,7
	Domestic consumption for cooling	*P2*	-53,8	-76,6
	Domestic consumption for SHW	*P3*	485,5	196,9
Base year 2007 [ktep]	Renovation of the thermal envelope and EE	*P1+P2+P3*	1.126,0	698,6
	Domestic consumption for heating	*P1*	434,9	316,3
	Domestic consumption for cooling	*P2*	38,1	16,9
	Domestic consumption for SHW	*P3*	653,1	365,4

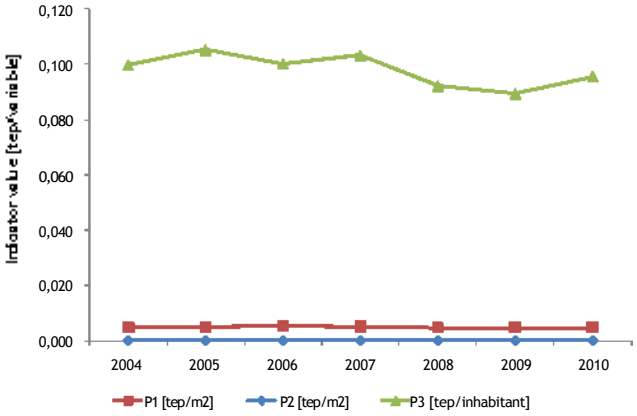
The descending *P* indicators in Table 70 show savings of 273,9 ktep in the domestic sector in the 2004-2010 period (which represents 11% of the buildings sector's total) and 698,6 ktep in the 2007-2010 period associated with the energy renovation of existing homes.

Table 71. *Evolution of P indicators relative to the energy renewal of the thermal envelope and the improved energy efficiency of the thermal installations in existing buildings in the 2004-2010 period*

	Description	2004	2007	2008	2009	2010
P1	Indicator of unitary domestic consumption for heating per m^2 [tep/m_2]	0,00486	0,00497	0,00468	0,00467	0,00476
P2	Indicator of unitary domestic consumption for cooling per m^2 [tep/m^2]	0,00006	0,00012	0,00010	0,00010	0,00011
P3	Indicator of unitary domestic consumption in SHW per inhabitant [tep/inhabitant]	0,09965	0,10324	0,09211	0,08927	0,09547

Figure 40. *Evolution of the P indicators relative to the energy renewal of the thermal envelope and the improved energy efficiency of the thermal installations in existing buildings in the 2004-2010 period*

Table 72 shows the savings achieved for each of the mechanisms developed which



effect the energy efficiency of the envelope during the period studied.

Table 72. *Results of saving by improving the energy efficiency of the envelope and thermal installations*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Public supports programme - envelope	BU_{et}	15,0	22,3
	Public supports programme – thermal installations	BU_{it}	44,8	61,1
	Technical building Code	BU_{cte}	191,97	231,73
	IDAE's Grants for Strategic Projects Programme	BU_{pe}	53,2	63,5
Base year 2007 [ktep]	Public supports programme - envelope	BU_{et}	10,3	17,6
	Public supports programme - thermal installations	BU_{it}	33,7	50,0
	Technical building Code	BU_{cte}	127,28	167,04
	IDAE's Grants for Strategic Projects Programme	BU_{pe}	53,2	63,5

Table 73. *Grants awarded in the context of the programmes which have affected the improvement to the energy efficiency of the thermal envelope and thermal installations*

	2006	2007	2008	2009	2010
Public supports programme - envelope [k€]	15.329,9	8.244,9	23.967,8	27.380,6	36.576,7
Public supports programme -thermal installations [k€]	13.522,9	12.868,8	41.511,9	38.820,0	38.802,8
IDEA Grants for Strategic Projects Programme [k€]	N/A	N/A	25.158,3	32.552,7	38.834,5

Source: IDAE

As we can see in Table 73, the most significant savings were achieved thanks to the Technical Building Code, -61% of the total saving achieved through all the mechanisms - which should affect all homes constructed since 2007.

4. Improvement in the energy efficiency of interior lighting installationsin existing buildings

The aim of this measure is to reduce the energy consumption of the existing interior lighting installations in buildings, both in the domestic and tertiary sectors. This measure aims to promote the improvement of interior lighting installations in terms of energy efficiency.

The renovation is established by others that comply, as a minimum with the requirements set out in the Technical Building Code, reducing this method of energy consumption.

Methodology

Just as in the other uses, to be able to measure the savings achieved in interior lighting in the domestic sector, we need to know the variation in the unitary electricity consumption with respect to a suitable activity variable, in this case the evolution of the number of homes.

Therefore, to calculate the savings, indicator P5 proposed by the European Commission was used which relates the electricity consumption of interior lighting to the number of homes.

$$P5 = \left(\frac{E^{Hel}}{D}\right) * FC$$

where:

- E^{Hel}: Electric consumption in homes
- D: Number of occupied households
- FC: % of the domestic electric consumption intended for interior lighting

For its calculation, the domestic electricity consumption has been corrected by the percentage ofelectricity consumption in homes intended for lighting. This result has been divided by the number of permanently occupied households (the homes) obtaining the unitary consumption of lighting per home.

Savings achieved by *P5* = $\left[\left(\frac{E^{Hel}_{2004}}{D_{2004}}\right) * FC_{2004} - \left(\frac{E^{Hel}_{2010}}{D_{2010}}\right) * FC_{2010}\right] * D_{2010}$

where:

- E^{Hel} : Electric consumption in homes
- *D*: Number of occupied households
- *FC*: % of the domestic electric consumption intended for interior lighting

Key variables

In this section, you will find all the variables which directly affect the calculation of the savings achieved in this measure.

Table 74. *Activity variables used in the calculation of savings from P indicators in the "Improved energy efficiency of interior lighting installations in existing buildings" measure in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Electricity consumption in homes [ktep]	5.072	5.296	5.098	4.798	5.154
Occupied homes [millions of homes]	14.904	16.280	16.741	17.068	17.304
Domestic electrical use intended for lighting [%]	12,3	12,3	12,8	12,4	12,4

Source: IDAE

4.1. Programme for the distribution of low-consumption lamps

Within the Saving and Energy Efficiency Action Plan (Approved by the Council of Ministers on 1 August 2008), the "Programme for the distribution of low-consumption lamps" was implemented aimed at the domestic sector. Said initiative consisted of the inclusion of vouchers exchangeable for low-consumption bulbs, in electricity bills.

Methodology

To determine the saving obtained thanks to this initiative, the difference in power between the incandescent lamp replaced and the efficient replacement lamp was calculated. Then, this unitary improvement was multiplied by the annual average number of operating hours of a lamp and by the number of efficient lamps distributed through the programme, according to the following expression:

BU_{il}= $\sum_{2010}$ [illegible]

where:

- P^I : Power of an incandescent lamp
- P^E : Power of an efficient lamp
- *H* : Average number of annual operating hours
- *L(Rep)* : Number of lamps distributed each year by the programme

The useful life of low-consumption lamps is, approximately, 15 years, a period which exceeds the present period of analysis, therefore the savings achieved in 2010 will be the sum of the savings reported since 2004 or 2007 depending on the calculation basis chosen.

Key variables

This section discusses all the variables that directly affect the calculation of the direct savings achieved by this mechanism.

Table 75. *Activity variables used in the calculation of savings relative to the "Programme to distribute low-consumption lamps through vouchers provided with electricity bills" mechanism for 2004-2010*

	2004	2005	2006	2007	2008	2009	2010
Number of lamps (vouchers) [units]	-	200.592	-	-	-	7.254.250	6.576.625
Average number of operating hours [h]	-	1.050	-	-	-	1.050	1.050
Power of an incandescent bulb [W]	-	100	-	-	-	100	100
Power of an efficient bulb [W]	-	18	-	-	-	18	18

Source: IDAE

4.2. Programme for the 2-for-1 distribution of low-consumption lamps

The "Programme for the 2-for-1 low-consumption lamps" has been focused on the domestic sector and is also part of the Saving and Energy Efficiency Action Plan (Approved by the Council of Ministers on 1 August 2008).

Methodology

To calculate the savings associated with this mechanism, an ascending indicator similar to the one used in the previous mechanism, was used.

$$BU_{I2} = \sum^{2010} (P^I - P^E)_t * H * L(2x1)_t$$

where:

- P^I: Power of an incandescent lamp
- P^E: Power of an efficient lamp
- H: Average number of annual operating hours
- $L(2x1)$: Number of lamps distributed in the programme

The useful life of low-consumption lamps is approximately 15 years and this exceeds the present analysis period, therefore the savings achieved in 2010 will be the sum of the savings achieved since 2004 or 2007, depending on the calculation basis chosen.

Key variables

This section discusses all the variables that directly affect the calculation of the direct savings achieved by this mechanism.

Table 76. *Activity variables used in the calculation of savings from the 2-for-1 distribution of low-consumption lamps programme mechanism in the 2004-2010 period.*

	2005	2007	2008	2009	2010
Number of lamps (2x1) [units]	-	-	2.400.000	-	-
Average number of operating hours [h]	-	-	1.050	-	-
Power of an incandescent bulb [W]	-	-	100	-	-
Power of an efficient bulb [W]	-	-	15	-	-

Source: IDAE

4.3. Public assistance programme to improve the energy efficiency of interior lighting installations

The public assistance programmes to improve the energy efficiency of interior lighting installations have been a mechanism developed within the collaboration agreements signed by IDAE and the Autonomous Communities.

Methodology

To calculate the effect derived from these programmes, the annual information provided by the Autonomous Communities on savings achieved by projects receiving public support for the renewal of lighting systems has been used.

where:

- Ah_{ii} : Annual savings reported by the A C regarding the public assistance programmes for improving the energy efficiency of interior lighting installations in existing buildings.

The useful life of these types of improvements (15 years) exceeds the period of analysis therefore savings achieved in 2010 will be the sum of the savings achieved since 2004 or 2007 depending on the calculation basis chosen.

4.4. Summary of direct savings in interior lighting

These are considered as the direct savings achieved as a result of the implementation of specific measures to decrease consumption in the interior lighting subsector, as well as the savings achieved by mechanisms developed by the Public Administrations.

Table 77. *Savings from the measure to improve the energy efficiency of interior lighting installations in existing buildings in the 2004-2010 period*

		Associated indicator	2009	2010
Base year 2004[ktep]	Improved EE of interior lighting	P5	116,4	81,0
Base year 2007[ktep]	Improved EE of interior lighting	P5	89,1	53,3

As we can see in Table 77, the savings decreased significantly between 2009 and 2010 (-30%) since, in Spain, there was an increase during those years in both domestic electricity consumption and the number of homes.

Table 78. *Evolution of P indicators relative to the interior lighting subsector in the 2004-2010 period*

	Description	2004	2007	2008	2009	2010
P5	Indicator of electricity unit consumption for lighting per home [tep/home]	0,0417	0,0401	0,0390	0,0349	0,0370

Figure 41. *Evolution of P indicators relative to interior lighting in the 2004-2010 period*

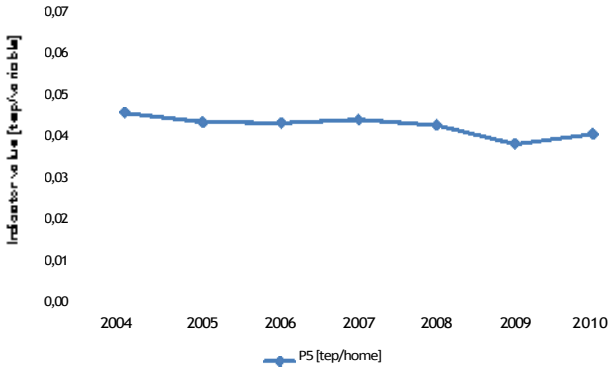


Table 79 shows the savings achieved for each of the mechanisms developed in the interior lighting subsector.

Table 79. *Savings achieved by improving the energy efficiency of interior lighting*

		Associated indicator	2009	2010
Base year 2004[ktep]	Distribution of low-consumption lamps	BU_{i1}	45,1	84,9
	2-for-1 low-consumption lamps	BU_{i2}	13,0	13,0
	Public supports programme - lighting	BU_{i3}	20,0	29,7
Base year 2007[ktep]	Distribution of low-consumption lamps	BU_{i1}	43,9	83,7
	2-for-1 low-consumption lamps	BU_{i2}	13,0	13,0
	Public supports programme - lighting	BU_{i3}	15,2	24,9

Table 80. *Subsidies granted in the framework of the programmes which have improved the energy efficiency of interior lighting*

	2006	2007	2008	2009	2010
Distribution of low consumption lamps [k€]	-	-	-	27.848,34	13.693,43
2-for-1 low consumption lamps[k€]	-	-	3.130,38	-	-
Interior lighting installations [k€]	1.781,89	1.859,89	4.058,23	7.420,91	7.400,26

Source: IDAE

As a result of the public aid programmes to improve the energy efficiency of interior lighting installations in existing buildings, realised within the framework of

IDAE collaboration with the Autonomous Communities, a saving of 30 ktep has been achieved in 2010 with respect to 2004.

On the other hand, we were also able to count, using ascending indicators, two special programmes included in the Saving and Energy Efficiency Action Plan, the "Programme for the 2-for-1 distribution of efficient lamps" (13 ktep) and the "Programme for the free distribution of efficient lamps" (85 ktep).

5. Renewal of electrical appliances

The measure to renew electrical appliances aims to promote the withdrawal of existing electrical appliancesand those with high energy consumption, replacing them with others with A ratings or above according to their energy label.

The ultimate goal of the measure is to reduce electrical energy consumption in the domestic sector, through the renewal of the following electrical appliances: refrigerators, freezers, washing machines, dishwashers and ovens with an energy rating of A or above.

Methodology

Renewal of white goods

The indicator *P4* is characterised, according to the European Commission, as the consumption by type of equipment in their stock.

$$P4 = UEC^X$$

where:

- UEC^x: Annual unitary electricity consumption by type of electrical appliance

To calculate the electricity consumption by type of appliance, the evolution of use has been used which shows the percentage corresponding to each appliance of the total electricity consumption by electrical appliances in homes.

However, the annual stock number for each electrical appliance has been calculated through the evolution of its penetration into homes during the analysis period. Multiplying this value by the number of existing homes in Spain results in the annual number of electrical appliances in the domestic sector; this is understood as permanently occupied homes and disregards uninhabited or second homes.

The indicator *P4* refers to refrigerators, dishwashers and washing machines, that is to say white goods, therefore the creation of a new *"P"* indicator was considered appropriate for the calculation of the savings achieved through the renewal of cookers and ovens, $P4_1$.

Renewal of cookers and ovens

The savings corresponding to indicator $P4_1$ have been calculated in a similar way to indicator *P4* recommended by the European Commission. This is defined as the difference in the unit consumption of each type of electrical appliance multiplied bythe number of cookers and ovens each year.

$P4_1 = UECc^X$

where:

- $UECc^X$: Annual unitary electricity consumption of cookers and ovens

The final result will be the sum of the differences between the unit consumption (consumption by type of appliance in their stock) in the reference and calculation year multiplied by the stock of electrical appliances in the year the savings are calculated.

As an example, for indicator P4:

Savings achieved by *P4* = $\sum_{x=elec.apps.} (UEC^X_{2004} - UEC^X_{2010}) * Stock^X_{2010}$

where:

- UEC^X: Annual unitary electricity consumption by type of appliance
- $Stock^X$: Number of electrical appliances

The total saving associated with the "Renewal of electrical appliances, cookers and ovens"is considered as the sum of the savings achieved for both indicators, *P4* and $P4_1$.

Key variables

This section discusses all the variables that directly affect the calculation of the savings achieved in this measure.

Since 2004, there has been a substantial increase in equipment in homes in Spain, through the penetration of specific electrical appliances which has increased the energy intensity per home.

Table 81. *Activity variables used in the calculation of savings from the P indicators in the "Renewal of electrical appliances" measure in the 2004-2010 period.*

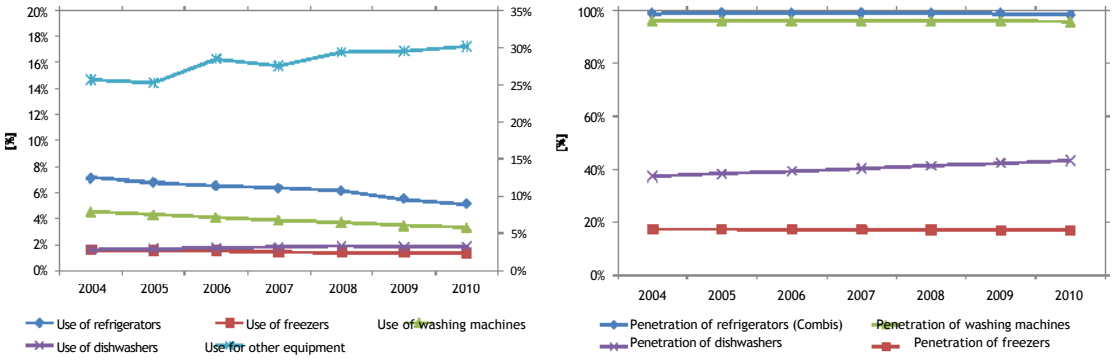
	2004	2007	2008	2009	2010
Thermal consumption in homes [ktep]	11.045	11.534	11.103	10.448	11.223
Electricity consumption in homes [ktep]	5.072	5.296	5.098	4.798	5.154
Thermal consumption in the tertiary sector [ktep]	3.982	3.658	2.903	2.635	2.627
Electricity consumption in the tertiary sector [ktep]	4.619	5.476	5.646	5.414	5.388
Occupied homes [thousands of homes]	14.904	16.280	16.741	17.068	17.304
Full-time employees [thousands of employees]	11.518	13.471	13.786	13.439	13.408
Electrical domestic use intended for electrical appliances and others [%]	40,5	41,0	42,6	41,7	41,8
Domestic thermal use intended for cookers and ovens [%]	6,3	7,0	7,2	7,5	7,7
Domestic electrical use intended for cookers and ovens [%]	7,8	7,8	7,8	7,4	7,3
Thermal use in the tertiary sector intended for cookers and ovens [%]	5,4	5,3	5,2	6,3	6,4
Electrical use in the tertiary sector intended for cookers and ovens [%]	0,4	0,5	0,5	0,6	0,6
Electrical use in the tertiary sector intended for office equipment and appliances [%]	9,2	20,2	20,5	21,0	21,4
Use of refrigerators [%]	7,1	6,4	6,2	5,5	5,1

Use of freezers [%]	1,6	1,4	1,4	1,4	1,4

	2004	2007	2008	2009	2010
Use of washing machines [%]	4,5	3,9	3,7	3,5	3,3
Use of dishwashers [%]	1,6%	1,8%	1,9%	1,8%	1,8%
Use of ovens [%]	3,2%	3,3%	3,5%	3,6%	3,8%
Use of dual cookers [%]	0,6%	0,6%	0,5%	0,4%	0,3%
Use of electrical cookers [%]	2,5%	3,0%	3,0%	3,1%	3,1%
Use of non-electrical cookers [%]	7,8%	6,9%	7,8%	7,8%	7,8%
Use of other appliances [%]	25,6%	27,5%	29,4%	29,5%	30,2%
Penetration of refrigerators [%]	99,0%	99,1%	99,1%	99,0%	98,4%
Penetration of freezers [%]	17,4%	17,1%	17,1%	17,0%	16,9%
Penetration of washing machines [%]	96,4%	96,1%	96,1%	96,1%	95,8%
Penetration of dishwashers [%]	37,3%	40,2%	41,2%	42,2%	43,2%
Penetration of ovens [%]	52,2%	54,3%	56,3%	58,4%	60,5%
Penetration of dual cookers [%]	10,6%	8,9%	7,5%	6,1%	5,0%
Penetration of electrical cookers [%]	44,4%	46,3%	48,2%	50,1%	51,9%
Penetration of non-electrical cookers [%]	44,0%	43,8%	43,3%	42,8%	42,1%

Source: IDAE

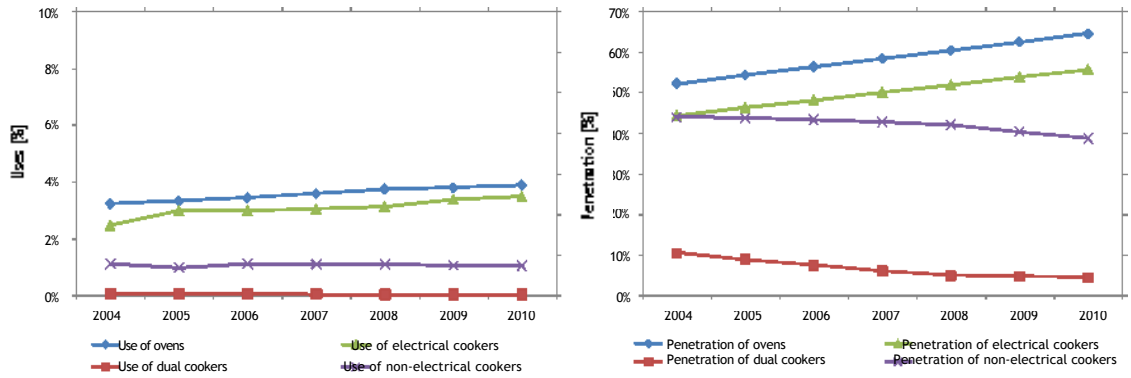
Figure 42. *Evolution of the use and penetration of electrical appliances in the domestic sector in the 2004-2010 period*



There is a group of domestic electrical appliances (freezers, washing machines and ovens) with their percentage of use having stayed practically constant throughout the period studied. Despite their increasing penetration in homes, this is compensated for by a technological improvement to energy efficiency.

On the other hand, refrigerators (-2,0%) and washing machines (-1,2%) reduced their percentage of use with respect to total electricity consumption in homes. This type of electrical appliance has achieved market saturation therefore a decrease in the percentage of use is caused by the improved energy efficiency of the equipment. Its evolution in sales is basically linked to the increase in the number of homes, opposite to audiovisual and office equipment, which has grown considerably in recent years.

Figure 43. *Evolution of the use and penetration of ovens and cookers in the domestic sector during the 2004-2010 period*



The penetration of dual cookers in homes decreased considerably in the analysis period (-6,1%), caused by a fall in their use. However, a conflicting effect is observed in electrical cookers due to their greater penetration increasing their percentage of use.

Table 82. *Activity variables used in the calculation of savings from the P indicators in the "Renewal of electrical appliances" measure in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Consumption of refrigerators (ktep)	360,1	336,7	313,9	263,9	262,8
Consumption of freezers [ktep]	82,2	76,2	70,2	66,8	69,7
Consumption of washing machines (ktep)	229,5	206,4	190,2	165,8	170,7
Consumption of dishwashers [ktep]	82,2	95,1	95,9	86,9	94,4
Consumption of ovens (ktep)	164,4	175,1	176,7	190,3	191,8
Consumption of dual cookers [ktep]	30,0	30,3	23,9	19,7	15,4
Consumption of electrical cookers [ktep]	126,2	157,2	153,3	162,1	159,9
Consumption of non-electrical cookers [ktep]	866,1	789,5	872,2	898,9	870,9
Refrigerator stock [thousands of units]	14.752	16.135	16.584	16.899	17.027
Freezer stock [thousands of units]	2.593	2.792	2.857	2.899	2.924
Washing machine stock [thousands of units]	14.362	15.651	16.091	16.402	16.577
Dishwasher stock [thousands of units]	5.554	6.550	6.901	7.205	7.475
Oven stock [thousands of units]	7.781	8.318	8.933	9.508	10.123
Dual cooker stock [thousands of units]	1.574	1.368	1.190	991	837
Electrical cooker stock [thousands of units]	6.624	7.100	7.642	8.152	8.697
Non-electrical cooker stock [thousands of units]	6.557	6.706	6.865	6.974	7.040

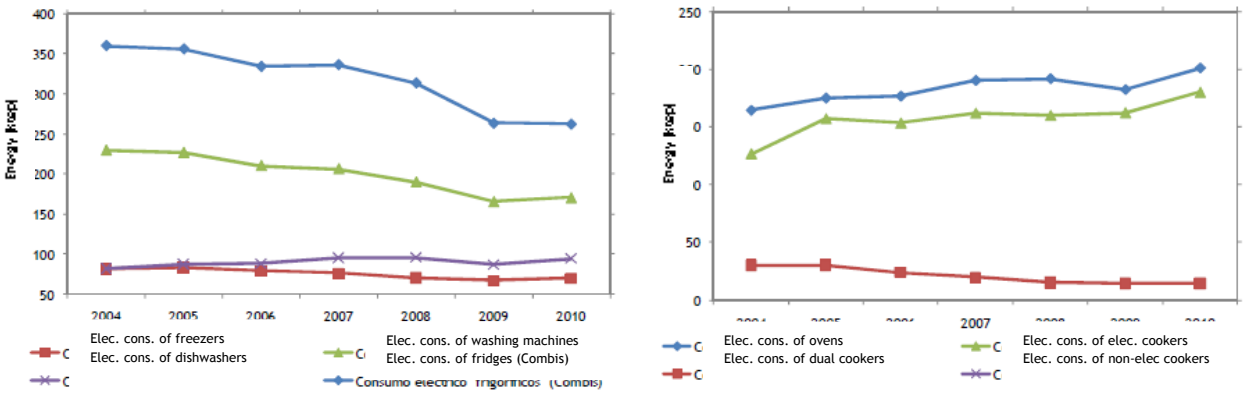
Source: IDAE

To estimate the specific consumption of each type of electrical appliance, the total consumption relative to electrical appliances in homes was taken and multiplied by the percentage of use of each type.

The stock of appliances was obtained through the link between the number of occupied homes and their penetration in homes.

As we can see in Table 82, generally, the unitary consumption of electrical appliances in Spain in recent years has become increasingly efficient, consuming less energy to offer the same service. The number of electrical appliances has seen an ascending evolution due to greater penetration in homes linked to the increase in the number of homes.

Figure 44. *Evolution of the energy consumption of electrical appliances, cookers and ovens in the 2004-2010 period*



5.1. Renove Plan for Electrical Appliances

The "Renove Plan for Electrical Appliances" is a mechanism within the "Renewal of household electrical appliances" measure and was developed within the collaboration agreements signed by IDAE and the Autonomous Communities.

Methodology

To calculate the savings from the "Renove Plan", an ascending indicator has been established for white goods and another for cookers and ovens.

This type of indicator measures the unitary saving for the replacement of an appliance, that is to say the difference between the consumption of the less efficient replaced appliance and the more efficient replacement.

$BU = UFES^X$ where:

- $UFES^X$: Annual unitary electricity saving achieved by replacement by type of appliance

The final result of the "Renove Plan" for electrical appliances will be the multiplication of the number of replacements reported by the Autonomous Communities in each year the action is in force times the saving achieved by replacing a non-efficient electrical appliance with an efficient one.

$$\text{Savings achieved by } BU = \sum_{X=\text{electrical appliance}} (UFES^X - Replacements)$$

where:

- $UFES^{X}$: Unitary electricity saving achieved by replacement by type of appliance
- Replacements: Number of replaced electrical appliances

Key variables

This section discusses all the variables which directly affect the calculation of the direct savings achieved by this mechanism.

Table 83. *Number of units replaced as a result of the mechanism from the RENOVE Plan for electrical appliances and cookers*

	2004	2007	2008	2009	2010
Refrigerators [units]	-	211.322	246.619	238.994	222.651
Freezers [units]	-	20.138	35.298	34.206	31.867
Washing machines [units]	-	285.018	439.765	426.168	397.025
Dishwashers [units]	-	86.862	118.649	114.980	107.118
Ovens [units]	-	-	56.775	55.020	51.257
Hobs [units]	-	-	26.846	26.016	24.236

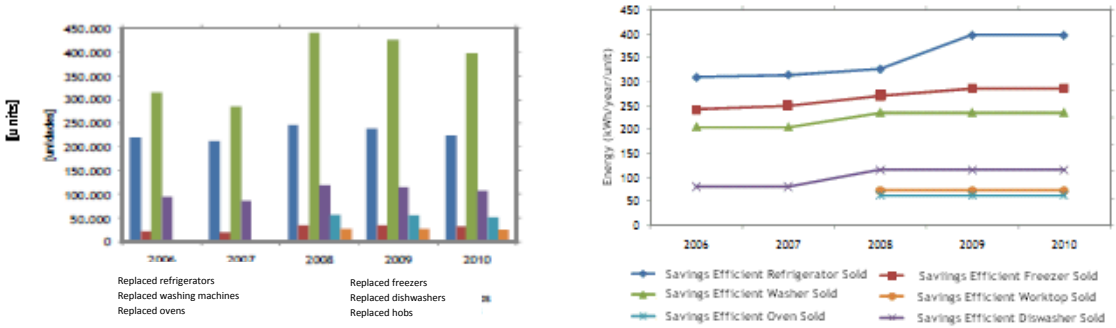
Source: IDAE

Table 84. *Final energy saving by efficient unit sold (UFES)*

	2004	2007	2008	2009	2010
Refrigerators [kWh/year/unit]	-	313,9	325,8	397,0	397,0
Freezers [kWh/year/unit]	-	249,7	270,5	285,9	285,9
Washing machines [kWh/year/unit]	-	205,2	234,9	234,9	234,9
Dishwashers [kWh/year/unit]	-	121,9	153,1	153,1	153,1
Ovens [kWh/year/unit]	-	-	62,4	62,4	62,4
Hobs [kWh/year/unit]	-	-	72,6	72,6	72,6

Source: IDAE

Figure 45. *Replaced electrical appliance units and saving achieved within the context of the Electrical Appliances RENOVE Plan, from 2006 to 2010*



5.2. Summary of the direct savings relative to household appliances

In the same way as for the previous subsectors, direct savings are those considered to be achieved through the development of concrete measures relative to equipment and those achieved through initiatives realised specifically by the Administration.

Table 85. *Saving results from the "Renewal of electrical appliances" measure*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Renewal of electrical appliances	*P4+ P4₁*	**481,3**	**389,1**
	White goods	*P4*	289,7	286,1
	Cookers and ovens	*P4₁*	191,56	102,98
Base year 2007 [ktep]	Renewal of electrical appliances	*P4+ P4₁*	**335,3**	**242,4**
	White goods	*P4*	169,3	164,6
	Cookers and ovens	*P4₁*	165,98	77,79

Table 86. *Evolution of P indicators in the equipment subsector*

	Description	2004	2007	2008	2009	2010
P4	Indicator of unit consumption per electrical appliance [tep/electrical appliance]	0,0869	0,0759	0,0692	0,0608	0,0622
P4₁	Indicator of unit consumption of cookers and ovens per home [tep/cooker]	0,1913	0,1830	0,1870	0,1887	0,1794

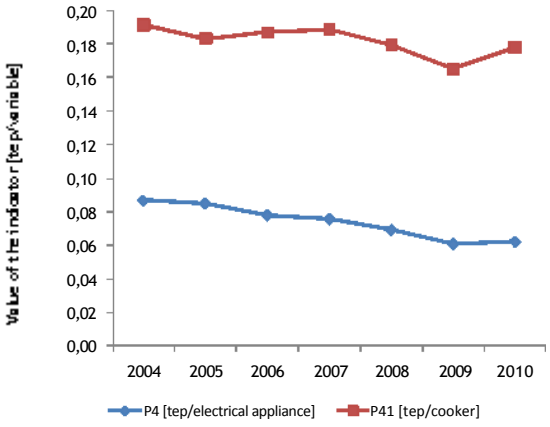


Figure 46. *Evolution of the P indicators relative to the Renewal of electrical appliances in the 2004-2010 period*

Table 85 shows that, in the analysis period, savings of 389.1 ktep were achieved in 2010 compared with 2004, 17% of the total for the buildings sector (10% compared with 2007). 74% came from the renewal of white goods and the remaining 26% from cookers and ovens.

Table 87 shows the savings achieved through the "Renove Plan" mechanism aimed at the household appliance subsector.

Table 87. *Results of savings from mechanisms in the equipment subsector*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Electrical appliance RENOVE Plan	BU_e+BU_c	63,1	81,4
	Renewal of white goods	BU_e	62,2	80,0
	Renewal of cookers and ovens	BU_c	0,9	1,4
Base year 2007 [ktep]	Electrical appliance RENOVE Plan	BU_e+BU_c	38,2	56,5
	Renewal of white goods	BU_e	37,3	55,1
	Renewal of cookers and ovens	BU_c	0,9	1,4

Table 88. *Grants for mechanisms in the equipment subsector*

	2006	2007	2008	2009	2010
Household Electrical appliances RENOVE Plan [k€]	55.231,26	51.279,81	61.100,15	59.394,49	55.332,88

Source: IDAE

Table 87 shows that, in absolute terms, the savings achieved in 2010 with respect to the situation in 2004 through the renewal of electrical appliances measure are 81,4 ktep; this represents a percentage saving of 4% on the total saving achieved in the buildings sector.

The renewal of cookers achieves much more moderate savings than the renewal of white goods; this is mainly due to:

- The aids for the replacement of cookers and ovens which started being offered in 2008, therefore the early years of the measure will only relate to the replacement of white goods.
- From 2008, the aids and quotas allocated to the renewal of cookers and ovens were a lot lower than for white goods, therefore at the end of the period, a smaller number of units had been replaced.

6. Savings made in the buildings and equipment sector in 2010

The buildings sector achieved savings of 2.232,49 ktep in the 2004-2010 period; 73% of these savings were achieved in the thermal envelope and thermal installations subsector. The equipment subsector, influenced by the increase in the amount of equipment in homes and businesses, achieved negative savings of -199,1 ktep.

Table 89. *Results of savings in the buildings sector*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Buildings and equipment sector		**2.692,1**	**2.232,5**
	Thermal envelope and installations	$P1+P2+P3+M3_{11}+M3_{12}+M4_{11}+M4_{12}+M4_{13}$	2.084,2	1.637,7
	Interior lighting	$P5+ M4_2$	691,8	793,9
	Equipment	$P4+P4_1+M_{33}+M_{43}+M_{44}$	-83,9	-199,1
Base year 2007 [ktep]	Buildings and equipment sector		**2.984,7**	**2.529,1**
	Thermal envelope and installations	$P1+P2+P3+M3_{11}+M3_{12}+M4_{11}+M4_{12}+M4_{13}$	2.461,8	2.020,6
	Interior lighting	$P5+ M4_2$	198,4	301,2
	Equipment	$P4+P4_1+M_{33}+M_{43}+M_{44}$	324,6	207,3

6.1. Indirect and non-quantifiable effects

Through the differences between the saving boundaries achieved through the different indicators, it is possible to define specific indirect effects and other effects associated with the measures but it was not possible to count them. In relation to these effects observed in the differences between the different boundaries, the following will be included in each of the subsectors studied:

Thermal envelope and thermal installations

In the thermal envelope and installations subsector, certain indirect effects in the domestic sector were quantified. Therefore, 635,1 ktep is estimated between the external boundary and those associated with measures in homes whilst for the tertiary sector it is 627 ktep.

The difference between the external boundary calculated using M indicators, and that calculated using P indicators for the domestic sector, relates to the activity variables in question, this difference being caused by the average size of households in the period analysed, as well as the decrease in the average number of inhabitants per home.

The following effects are considered as non-quantifiable effects associated with the measures:

- Firstly, the promotion of the purchase of climate control equipment (air-conditioning equipment and heaters etc) with high ratings, induces increased demand for more efficient equipment, encouraging economies of scale from producers and, therefore, the eventual reduction in price of the same, enables the achievement of results in terms of the presence of this equipment on the market. This causes an induced improvement to the sector's efficiency.

- Secondly, an indirect effect may be considered as the increased efficiency of the electricity consumption of heating and cooling appliances which may bring about the start of the incorrect use of the equipment. In this sense, if the consumer knows that their climate control equipment is more efficient and that, therefore, it consumes less energy, they may start forgetting about its consumption and using it more thus increasing the level of comfort in their home. The effect of consumption efficiency would be cancelled out by increased usage.

- Likewise, savings achieved for the rest of the mechanisms that cannot be calculated as a direct effect of the IDAE's dissemination and communication programmes will also be considered as indirect effects, RD 47/2007 concerning the energy certification of buildings and the new Regulation relating to thermal installations in buildings.

Interior lighting

Despite not being able to quantify the indirect effects numerically, their behaviour can be associated with the following effects.

- The promotion of the purchase of more efficient lamps focuses demand on class A lamps, promoting economies of scale from producers and, therefore, the eventual reduction in price of the same; a result of this may be the presence of only efficient lamps on the market. This causes an induced improvement in efficiency in the interior lighting sector.

- However, this improvement in the efficiency of lamps used in homesmay mean they start to be used in the wrong way due to the desire to improve comfort in homes. This would mean that the consumer, being aware of the fact that the new lamps consume less energy, would not mind using them for more hours or using more light so as to be more comfortable.

  In this case, the efficiency achieved by the lamps due to better technology would be counteracted by an increase in operating hours, meaning more energy is consumed than previously using traditional lamps.

Equipment

In the equipment subsector between the outer boundaries and those delimited by the measures, indirect effects were considered in both senses. Whilst in terms of white goods, indirect effects are estimated at -52,7 ktep in 2010, in the case of cookers and ovens for the domestic and tertiary sector, these effects are positive at 101,6 ktep.

- The increase in the penetration of specific appliances during the analysis period caused an increase in energy intensity per household and therefore, a negative saving; this is the case for brown goods in homes. However, if there is a decline in penetration -like for dual cookers for example- the intensity relative to said appliances per home decreases and results in positive savings. Likewise, we can see the size of the increase in the use of office equipment in the tertiary sector in relation to the number of full-time employees in recent years has led to smaller savings.

The non-quantifiable effects associated with the renewal of equipment measures have a direct effect on unit consumption and are summarised below:

- The promotion of the purchase of electrical appliances with more efficient ratings focusesdemand on electrical appliances with rating A, encouraging economies of scale from the producers and, therefore, the eventual reduction in price of the same. The end result is a greater presence of efficient electrical appliances on the market.

- Finally, between 2004 and 2010, changes in users' habitsoccurred due to:

- A fall in the consumption of appliances which may cause less optimised use on the part of the consumer due to a search for increased comfort in homes. This may mean that the saving achieved through the use of a more efficient electrical appliance is lost due to its increased use.

- The acquisition of a high-rated electrical appliance may lead to an increase in the user's consciousness with respect to its energy consumption and therefore, reduced consumption in homes.

6.2. Double counting

The possibility of double counting relative to the savings achieved by these measures for the equipment and interior lighting subsectors has not been observed. However, in the mechanism concerning the Technical Building Code for energy ratings for the thermal envelope and installations subsector, only the savings achieved by newly built homes from 2007 were counted, with the legislation entering into force, against which this measure applies, since it also requires the renewal of buildings with a series of specific surface area and consumption characteristics.

In this case, renewed buildings were not considered, since renewal assumes a change on the part of the concepts included in the measures concerning the thermal envelope and installations.

V. PUBLIC SERVICES SECTOR

1. Summary of savings in the public services sector

THE PUBLIC SERVICES SECTOR

The energy savings achieved during the 2004-2010 period in the public services sector, structured according to use: public lighting and water cycle; 31.8 ktep. This sector's consumption represented 1% of national final energy consumption in 2010.

Sector consumption

	Final energy 2010 [ktep]
TOTAL CONSUMPTION IN THE PUBLIC SERVICES SECTOR	764,4
USE OF EXTERNAL LIGHTING	325,7
USE OF THE WATER CYCLE	438,7

Result of savings achieved

	Final energy saving 2010 [ktep]		Primary energy saving 2010 [ktep]		Emissions of C02 avoided 2010 [ktCO2]	
	Base year 2004	Base year 2007	Base year 2004	Base year 2004	Base year 2007	Base year 2004
TOTAL SECTOR SAVINGS	31,8	28,6	79,6	67,4	161,0	144,3
EXTERNAL LIGHTING	4,6	11,3	11,5	26,5	23,2	56,8
WATER CYCLE	27,2	17,3	68,2	40,9	137,8	87,5

Conclusions

The public services sector achieved savings of 31.8 ktep in the 2004-2010 period. Of these savings, 86% corresponds to the use of the water cycle, more specifically to the use of desalination. However, the saving achieved for public lighting between 2007 and 2010 increased relative to the total (from 14% to 39%). This result was achieved, in part, through the measures proposed by the Saving and Energy Efficiency Plan, supported by different policy-related actions (R.D. 1890/2008) which have stimulated energy efficiency in the public services sector. The initiatives introduced were based around a collaboration agreement between IDAE and the Autonomous Communities which has encouraged the improved energy efficiency of external lighting installations as well as current drinking water, supply, purification of waste water and desalination plants. These actions achieved total savings of 121,0 ktep; 64% of these savings came from the "Renewal of external lighting installations", 36% from the "Traffic light replacement programme" and the remaining 0,1% from "Strategic projects" implemented in 2010. Within the public services sector, the use of public lighting has been one of the items most affected by the current situation since the construction of new homes and buildings is directly related to the establishment of new public lighting systems in cities. However, the introduction of the Regulation concerning energy efficiency and external lighting installations (R.D. 1890/2008) has encouraged improved efficiency in this sector. In addition, there are other non-quantifiable effects that may be negative. In terms of the renewal of external lighting, despite the direct savings achieved by the measures, the global saving calculated is considered as the increase in electricity consumption per home due to new urban development's and the installation of new light points.

Measures-mechanisms matrix

Measures \ Mechanisms		IDEA-Autonomous Communities collaboration agreements	Strategic projects	Programmes to replace traffic lights with new LED technology	Natural renewal of the fleet	Communication and dissemination programmes	R.. of e. efficiency and ext. lighting installations and their TBC (RD 1890/2008)	2008-2011 Saving and Energy Efficiency Action Plan	Non-quantifiable effects	TOTAL
2010 Base year04 [ktep]	Improved external lighting installations	77,7		43,3		-116,4				4,6
	Improved efficiency of the water cycle	7,0	0,2		20,0					27,2
	TOTAL	84,7	0,2	43,3	-96,4					31,8
2010 Base year 07 [ktep]	Improved external lighting installations	55,0		43,3	-87,0					11,3
	Improved efficiency of the water cycle	3,8	0,2		13,3					17,3
	TOTAL	58,8	0,2	43,3	-73,7					28,6

Direct savings achieved by the mechanisms

Indirect savings achieved by the mechanisms

EXTERNAL LIGHTING USE

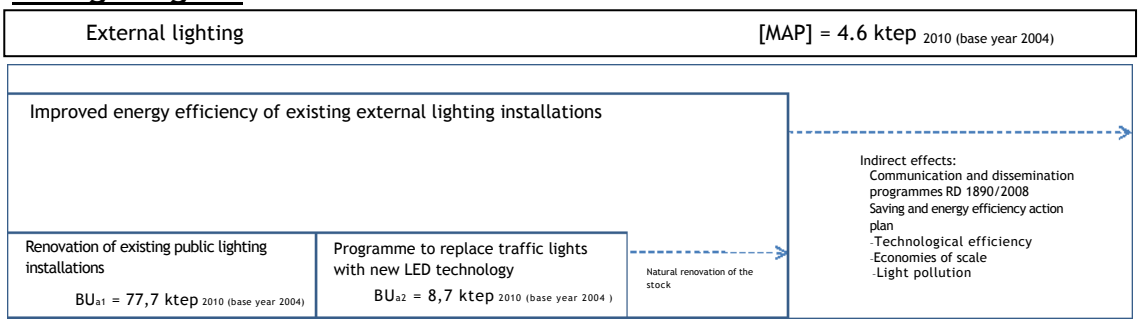
The savings relative to final energy consumption for the use of public lighting within the public services sector was 4,6 ktep in the 2004-2010 period.

To calculate the external boundary, a descending indicator similar to those proposed by the European Commission for other sectors and one which focuses on external lighting has been created. With respect to the concrete measures of use, "Improved energy efficiency of existing public lighting installations", the effect of the renewal of the stock induced by IDAE through the "Renove Plans" as well as the "Programme to replace traffic lights with LED technology" were calculated using ascending indicators.

Results achieved

		Final energy saving 2010 [ktep]	
		Base year 2004	Base year 2004
MAP	Public lighting consumption per household	4,6	11,3
BUa1	Renovation of existing external public lighting installations	77,7	55,0
BUa2	Programmes to replace traffic lights with new LED technology	43,3	43,3
TOTAL USE OF EXTERNAL LIGHTING ***(MAP)***		4,6	11,3

Savings diagram



Conclusions

According to the descending M indicator, savings of 4.6 ktep were achieved in the study period, greater if the 2007-2010 period is considered (11,3 ktep) due to the fact that the introduction of the mechanisms started in 2007.

The ascending BU indicators show that the initiatives achieved direct savings (121 ktep). Basically, from 2007, when an improvement in the saving trend in this sector was achieved.

Indirect effects can be distinguished from the differences between the external and internal saving boundaries (-116,4 ktep). Despite the fact that the sector has improved its efficiency, the urban development experienced in Spain since 2008 has considerably increased consumption relative to external lighting. However, the improved efficiency of external lighting installations and their lower cost may give rise to greater light pollution.

WATER CYCLE USE

The savings relative to final energy consumption for use of the water cycle within the public services sector was 27.2 ktep in the 2004-2010 period.

To calculate the external boundary, the use has been structured into two main activities: desalination and purification. As no indicator referring to this concept exists in the European Commission's catalogue of indicators, two descending M indicators were created for each activity. The sum of the savings according to said indicators relates to the use of the water cycle. Finally, the savings achieved through measures from the Action Plan and the "Strategic projects" developed by IDAE are calculated using an ascending BU indicator.

Results achieved

		Final energy saving 2010 [ktep]	
		Base year 2004	Base year 2004
MAG	Saving in desalination and purification	27,2	17,3
MDS	Saving in desalination	26,6	15,2
MDP	Saving in purification	0,7	2,1
BUc1	Improvement in the energy efficiency of drinking water, supply, waste water purification and desalination plants	7,0	3,8
BU_{pr}	Strategic projects	0,2	0,2
TOTAL FOR THE WATER CYCLE SUBSECTOR ***(MAG)***		27,2	17,3

Savings diagram

Water cycle [MAG] = **27,2ktep**$_{2010\ (Base\ year\ 2004)}$

Desalination [MDS] = **26,6 ktep**$_{2010(base\ year\ 2004)}$

Purification [MDP] = **0,7 ktep**$_{2010(base\ year\ 2004)}$

Drinking water and supply

Improved saving and energy efficiency in the water cycle

Improved energy efficiency of drinking water, supply, waste water purification and desalination plants

BU_{CI} = **7,0 ktep**$_{2010\ (base\ year\ 2010)}$

Strategic projects

BU_{pe} = **0,2 ktep**$_{2010(base\ year\ 2004)}$

Indirect effects:
Natural renewal of the stock
Communication and dissemination programmes
-Technological efficiency
-Economies of scale

Conclusions

According to the descending *M* indicator, savings were achieved in the use of the water cycle (27,2 ktep) during the period studied. From the two activities analysed, desalination was responsible for all the savings achieved (26,6 ktep) since the purification activity presented practically no savings.

The ascending *BU* indicators show that the saving was achieved as a result of the development of measures from the Action Plan and strategic projects in this use on the part of IDAE (7,2 ktep). Finally, indirect effects can be distinguished from the differences between the external and internal saving boundaries (20 ktep). Concentration of the demand in more efficient water cycle installations has encouraged economies of scale from producers and therefore the eventual reduction in price of the same, causing an induced non-quantifiable improvement.

2. Outer boundaries

The public services sector achieved energy consumption savings thanks to the improvement in external lighting and the activities performed relative to the water cycle.

Figure 47 shows the energy savings diagram for the public services sector with the 2010 saving values with base year 2004; this shows structuring between uses (external lighting and water cycle) and where the initiatives promoted by the Administration and the possible effects have been included.

Figure 47. *Diagram of the energy savings in the public services sector in 2010 with base year 2004*

<table>
<tr><td colspan="5">Public Services [MAP] + [MAG] = 31,8 ktep$_{2010\ (Base\ year\ 2004)}$</td></tr>
<tr><td colspan="5">External lighting [MAP] = 4,6 ktep$_{2010\ (Base\ year\ 2004)}$</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="4">Improved energy efficiency of existing external lighting installations</td><td rowspan="2">Indirect effects:
Communication and dissemination programmes
RD 1890/2008
Saving and energy efficiency action plan
- Technological efficiency
-Economies of scale
-Light contamination</td></tr>
<tr><td>Renewal of existing public lighting installations

BU_{a1} = 77,7 ktep$_{2010\ (base\ year\ 2004)}$</td><td>Programme to replace traffic lights with new LED technology

BU_{a2} = 43,3 ktep$_{2010\ (base\ year\ 2004)}$</td><td colspan="2">Natural renewal of the stock</td></tr>
<tr><td colspan="5">Water cycle [MAG] = 27,2 ktep$_{2010\ (Base\ year\ 2004)}$</td></tr>
<tr><td rowspan="3">Desalination [MDS] = 26,6 ktep$_{2010\ (base\ year\ 2004)}$</td><td colspan="2">Purification [MDP] = 0,7 ktep$_{2010\ (base\ year\ 2004)}$</td><td colspan="2">Drinking water and supply</td></tr>
<tr><td colspan="3">Improved saving and energy efficiency in the water cycle</td><td rowspan="2">Indirect effects:
Natural renewal of the stock
Communication and dissemination programmes
-Technological efficiency
-Economies of scale</td></tr>
<tr><td>Improved energy efficiency of drinking water, supply, waste water purification and desalination plants

BU_{c1}= 7,0 ktep$_{2010\ (base\ year\ 2004)}$</td><td>Strategic projects

BU_{pe} = 0,2 ktep$_{2010\ (base\ year\ 2004)}$</td></tr>
</table>

The following sections will show the methodologies used for each savings calculation according to the structural elements in the public services sector: external lighting and water cycle.

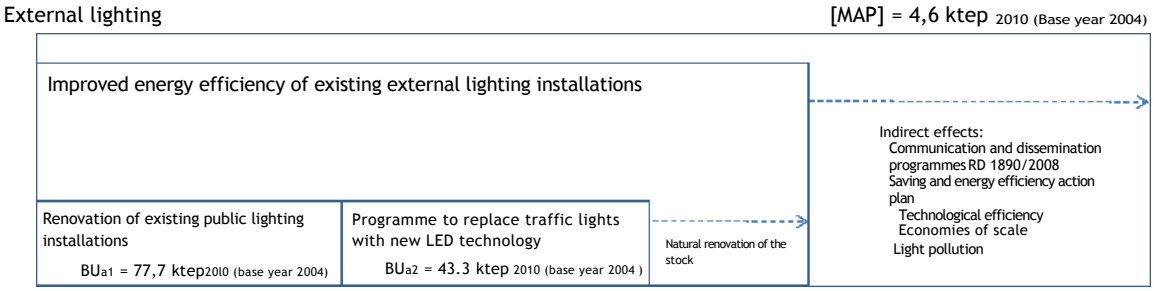
2.1. External lighting

The measures associated with this energy use promote the improvement of all public lighting systems in cities, infrastructures and streets. It is not just changing to more efficient lamps that were promoted but energy audits were also performed as well as the training of energy managers in the Administration.

Methodology

Firstly, the final energy saving achieved in the use was calculated using a descending M indicator according to the methodology proposed by the European Commission. Then, the savings achieved by different mechanisms promoted by the Administration through collaboration agreements between IDAE and the Autonomous Communities brought to fruition through the "Renewal of external lighting installations" and "The programme to replace traffic lights with new LED technology" were calculated; these savings were calculated using ascending indicators (BU_{a1} and BU_{a2}).

Figure 48. *Diagram of energy saving in external lighting use in 2010 and base year 2004*



To be able to estimate the savings achieved, we need to know the electrical energy consumption intended for this use. In addition, we need to find a suitable variable so as to normalise said consumptions and thus determine the improvement in energy consumption as the difference in said unit consumption.

The deployment of new external lighting installations and therefore their consumption is closely linked to urban development. Consequently, the evolution of the number of homes is considered as a priority activity variable for the calculation of the savings. The indicator MAP was created from these two variables.

The indicator MAP "Unit electricity consumption of public lighting per home" is expressed by the quotient between the electricity consumption relative to external lighting and the number of homes at national level, the result of which is the average unit consumption relative to public lighting per home.

$$MAP = \left(\frac{E^{EA}}{V}\right)$$

where:

- E^{EA}: Electricity consumption relative to external lighting
- V: Number of homes

The saving relative to the external boundary concerning public lighting use is the result of the multiplication of the difference between the values of unit consumption for the reference year (2004 or 2007) and the calculation year (2010) and the value of the activity variable relative to the indicator (number of homes in 2010).

For the MAP indicator it will be:

Savings achieved by *MAP* $\left[\left(\frac{E^{EA}_{2004}}{V_{2004}}\right) - \left(\frac{E^{EA}_{2010}}{V_{2010}}\right)\right] \cdot V_{2010}$

where:

- E^{EA}: Electricity consumption relative to external lighting
- V: Number of homes

Key variables

Table 90 shows all the variables that directly affect the calculation of the savings achieved relative to this energy use.

Table 90. *Activity variables used in the calculation of savings from M indicators in the use of external lighting in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Electricity consumption for public lighting [ktep]	290	320	330	323	326
Homes [units]	22.623	24.496	25.129	25.557	25.789

Source: NSI, IDAE

Figure 49. *Evolution of electricity consumption in the use of external lighting and evolution of the number of homes from 2004 to 2010*

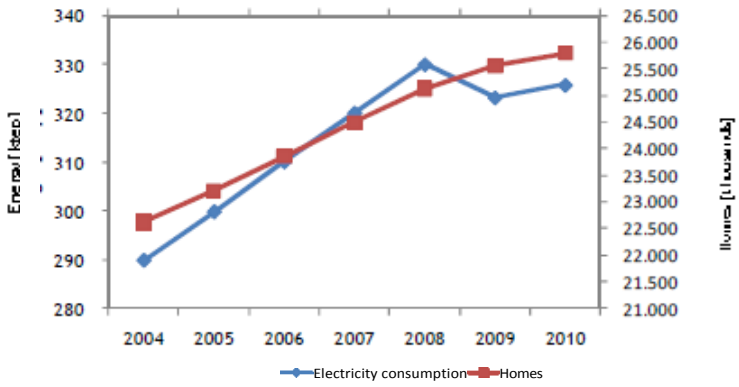


Figure 49 shows how electricity consumption for lighting presented a very pronounced upward trend in the early years of the series; the same can be said for the number of homes. However, from 2008, this trend was broken since electricity consumption in public lighting decreased at the same time as the upward trend in the number of homes slowed down.

This situation is the result of the introduction of measures aimed at this public services subsector which has significantly improved its efficiency.

Total savings achieved for external lighting

The total savings achieved in this use relate to both direct and indirect savings.

To calculate the energy saving achieved in the period, the aforementioned *MAP* indicator was used applying the sector's variables and the macroeconomics required presented in Table 90. The results are shown in Table 91 and the evolution of the indicatoris shown in Table 92 and Figure 50.

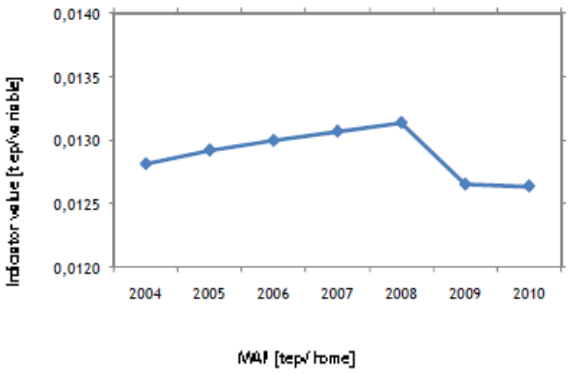
Table 91. *Results of saving in the use of external lighting in 2009 and 2020 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004	External lighting	*MAP*	4,1	4,6
Base year 2007	External lighting	*MAP*	10,7	11,3

Table 92. *Evolution of M indicators relative to use of public lighting between 2004 and 2010*

Description		2004	2007	2008	2009	2010
MAP	Total for public lighting per home [tep/home]	0,0128	0,0131	0,0131	0,0126	0,0126

Figure 50. *Evolution of the M indicator relative to use of external lighting between 2004 and 2010*



The results of the descending *M* indicator in Table 92 show thata saving of 4,6 ktep was achieved in the study period (14% of the sector's total saving). Despite the improved efficiency achieved in the use of external lighting and the efforts of the Administration, the saving was counteracted by urban development during this period.

$$MDS = \left[\frac{E^{DS}}{A}\right]$$

2.2. Water cycle

The measures associated with the use of the water cycle are designed to improve energy efficiency both in terms of processes and in terms of current drinking water, supply, waste water purification and desalination plants.

Methodology

Firstly, the use was structured according to the desalination, purification, drinking water and supply activities as shown in Figure 51.

Then, with respect to the mechanisms developed, the savings associated with the measures in the Action Plan and the "Strategic projects" promoted by IDAE using ascending indicators (BU_{c1} and BU_{pe}) were quantified using the annual reports sent by the Autonomous Communities and the sector's companies.

Figure 51. *Diagram of energy saving in the use of the water cycle in 2010 with base year 2004*

<table>
<tr><td colspan="4">Water table [MAG] = 27,2ktep$_{2010\ (Base\ year\ 2004)}$</td></tr>
<tr><td colspan="2">Desalination [MDS] = 26,6 ktep$_{2010(base\ year\ 2004)}$</td><td>Purification [MDP] = 0,7 ktep$_{2010(base\ year\ 2004)}$</td><td>Drinking water and supply</td></tr>
<tr><td colspan="3">Improved saving and energy efficiency in the water cycle</td><td></td></tr>
<tr><td></td><td>Improved energy efficiency of drinking water, supply, waste water purification and desalination plants

BU_{CI} = 7,0 ktep$_{2010\ (base\ year\ 2010)}$</td><td>Strategic projects

BU_{pe} = 0,2 ktep$_{2010(base\ year\ 2004)}$</td><td>Indirect effects:
Natural renewal of the stock
Communication and dissemination programmes
-Technological efficiency
-Economies of scale</td></tr>
</table>

To be able to estimate the savings achieved in the use of the water cycle, it is necessary to know the associated electrical energy consumption and to find a suitable variable to be able to normalise said consumption determining the improved energy efficiency as the difference in unit consumption.

Consequently, two M indicators have been established, in the same way as for the use of public lighting, for the different activities of purification and desalination.

- Firstly, the consumption relative to use in desalination is directly proportional to the volume of water treated therefore an effort has been made to obtain historical data. Said indicator, MDS "Unit electricity consumption in desalination per hm3 of treated water" is expressed by the quotient between electrical energy intended for the activity and the total volume of desalinated water.

$$MDS = \left(\frac{E^{DS}}{A}\right)$$

where:

- E^{DS}: Electric consumption in desalination
- *A:* Volume of water treated through desalination

- In the same way as for the purification of urban water, the *MDP* indicator"Unit electricity consumption for purification per inhabitant" was created. The indicator being the quotient between electrical energy intended for the activity and the number of inhabitants, since the population is a variable directly proportional to the volume of urban water.

$$MDP=\left[\frac{E^{DP}}{H}\right]$$

where:
- E^{DP}: Electric consumption in purification
- *H:* Number of inhabitants

The savings relating to these indicators are the result of multiplying the resulting values for the reference year (2004 and 2007) and the calculation year (2010) and the value of the activity variable relative to the indicator.
For example, for indicator *MDS*, it would be:

$$\text{Savings achieved by } MDS = \left[\left(\frac{E^{DS}_{2004}}{A_{2004}}\right) - \left(\frac{E^{DSI}_{2010}}{A_{2010}}\right)\right] . A_{2010}$$

where:

- E^{DS}: Electric consumption in desalination
- *A*: Volume of water treated through desalination

The sum of the savings calculated according to the two indicators is a result of the total value of the energy saving achieved in the use of the water cycle represented by the indicator *MAG*.

$$MAG = MDS + MDP$$

Key variables

Table 93 shows all the variables that directly affectthe calculation of the savings achieved in this use.

Table 93. *Activity variables used in the calculation of savings from M indicators in the water cycle subsector in the 2004-2010 period.*

	2004	2007	2008	2009	2010
Electricity consumption in desalination [ktep]	113	163	186	208	209
Electricity consumption in purification [ktep]	211	223	225	226	230
Volume of water treated using desalination [hm3]	233,6	355,9	419,7	483,6	489,4
N° of inhabitants [units]	43.198	45.201	46.158	46.746	47.021

Source: DGT, IDAE

The activity variables used to calculate the descending M indicators show an upward trend. The volume of water treated through desalination increased by 210% between 2004 and 2010, which assumes an increase in the activity's consumption depending on periods of drought.

Figure 52. *Evolution of electricity consumption in desalination and evolution of the volume of water treated from 2004 to 2010*

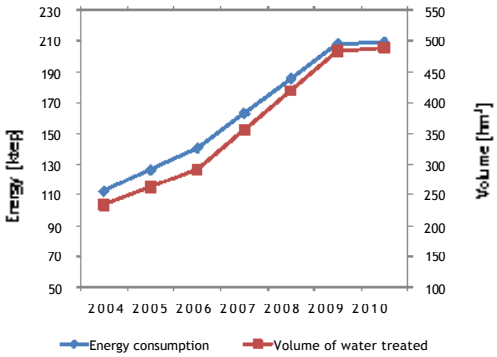
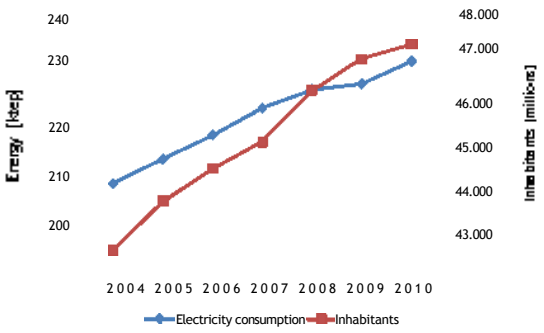


Figure 53. *Evolution of electricity consumption in purification and evolution of the number of inhabitants from 2004 to 2010*



Total savings achieved in the water cycle

The total savings achieved for this use relate to both direct and indirect savings.

To calculate the energy saving achieved in the period, the aforementioned indicators (MDS and MDP) were used applying the sector variables presented in Table 93. The results are shown in Table 94 and the evolution of the indicators is shown in Table 95 and Figure 54.

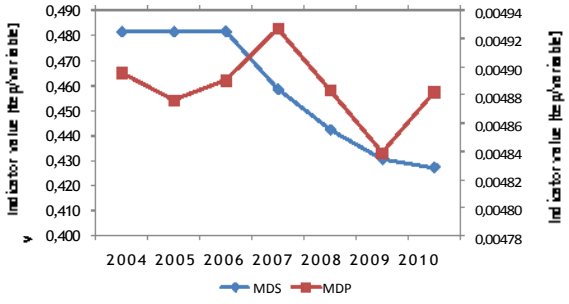
Table 94. *Results of saving in use in the water cycle in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Water cycle subsector	*MAG=MDS+MDP*	**27,4**	**27,2**
	Desalination	*MDS*	24,7	26,6
	Purification	*MDP*	2,7	0,7
Base year 2007 [ktep]	Water cycle subsector	*MAG=MDS+MDP*	**17,6**	**17,3**
	Desalination	*MDS*	13,5	15,2
	Purification	*MDP*	4,1	2,1

Table 95. *Evolution of M indicators relative to use in the water cycle between 2004 and 2010*

	Description	2004	2007	2008	2009	2010
MDS	Consumption for desalination by volume of water treated [tep/hm3]	0,482	0,458	0,442	0,430	0,427
MDP	Consumption for purification per inhabitant [tep/inhabitant]	0,005	0,005	0,005	0,005	0,005

Figure 54. Evolution of the M indicator for use in the water cycle between 2004 and 2010



Savings of 27.2 ktep were achieved relative to energy use associated with the water cycle in 2010 with respect to the situation six years earlier; 86% of the savings achieved in the public services sector.

The greatest savings achieved were in the desalination sector, since the purification activity did not achieve significant savings in this period. This is due to the fact that the construction of new marina desalination plants has promoted technological improvement (see Table 95).

3. Improved efficiency of existing external lighting installations

The main aim of this measure is to promote the replacement of existing external public lighting units, which are based on obsolete technologies, with other more current and more efficient ones. The same applies to all newly built external lighting installations.

It not having been possible to quantify the saving achieved by the natural renewal of external lighting and the non-induced technological improvement, those savings achieved thanks to specific actions developed by IDAE are presented below.

3.1. Renewal of existing public lighting installations

The "Renewal of existing public lighting installations" is a mechanism that forms part of the "Improved efficiency of existing external lighting installations" measure developed within the collaboration agreement signed by IDAE and the Autonomous Communities.

Methodology

To calculate the effect produced by the mechanism, the information provided by the Autonomous Communities on savings achieved through public supports intended for this measure was used.

The savings achieved in 2010 were the result of the sum of annual savings from 2004 or 2007 depending on the calculation base year chosen.

$$BU_{et} = \sum_{t=2004-2007}^{2010} Ah_{et}$$

where:

- Ah_{et}: Annual savings reported by the Autonomous Communities in relation to the "Renewal of existing public lighting installations".

3.2. Programme to replace traffic lights with new LED technology

The "Programme to replace traffic lights with new LED technology" took place during 2009 to help local councils to change their traffic lights over from traditional technology to other LED technologies.

Methodology

To calculate the savings associated with this initiative, an ascending indicator has been developed to characterise the mechanism in a more disaggregated manner. The number

of LED optics replaced annually by the programme during its lifetime is used as this indicator's main variable, multiplied by the difference in unit consumption between conventional technology and LED technology.

where:

- C^T: Annual consumption of a traffic light using conventional technology
- C^{LED} : Annual consumption of a traffic light using LED technology
- O: Number of optics replaced

$$\sum_{\cdot}^{2010} (C^T - C^{LED})$$

Key variables

Table 96 shows all the variables that directly affectthe calculation of the direct savings achieved by this mechanism.

Table 96. *Activity variables used in the calculation of savings from the Programme to replace traffic lights with new LED technology in the 2004-2010 period*

	2004	2005	2006	2007	2008	2009	2010
LED optics replaced [units]	-	-	.	-	-	461.791	-
Conventional technological consumption [kWh/year]	-	-	.	-	-	1.226	-
LED technology consumption [kWh/year]	-	-	.	-	-	135	-

Source: IDAE

3.3. Summary of direct savings through improving existing external lighting installations

These are considered as direct savings produced as a result of the introduction of specific measures to decrease consumption in the use, as well as the savings achieved through the mechanisms developed by the Public Administrations.

Table 97 shows the savings achieved through each of the mechanismsduring the study period.

Table 97. *Results of saving from the mechanisms relative to use of public lighting in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Renovation of ext. lighting installations	BU_{a1}	58,6	77,7
	Programme to replace traffic lights	BU_{a2}	8,7	8,7
Base year 2007 [ktep]	Renovation of ext. lighting installations	BU_{a1}	35,9	55,0
	Programme to replace traffic lights	BU_{a2}	8,7	8,7

Table 98. *Grants for mechanisms in the external lighting subsector in the 2006-2010 period*

	2004	2005	2006	2007	2008	2009	2010
Renovation of ext. lighting installations[k€]	-	-	17.185,3	17.892,7	26.320,8	28.900,6	25.622,8
Traffic light replacement programme[k€]	-	-	-	-	-	31.794,0	-

Source: IDAE

The results achieved for the different mechanisms analysed show that, in 2010, the IDAE-Autonomous Communities collaboration agreements helped achieve an energy saving of 77,7 ktep whilst the programme to replace traffic lights with new LED technology saved8,7 ktep.

The total savings achieved in the use of public lighting between 2004 and 2010(4,6 ktep) are considerably lower than the direct savings achieved by the two mechanisms developed in this subsector (86,4 ktep). This is due to the precise character of the initiatives although thanks to their useful life, their result is calculated up to the end of the period. However, the total saving in the subsectorwas negative in the early years which has affected the final result, since the unit consumption of public lighting per home shows a very pronounced upward trend.

4. Improved saving and energy efficiency in the water cycle

The aim of this measure is to replace existing technologies in water purification and desalination plants with more efficient technologies.

It not having been possible to quantify the saving achieved by the natural renewal of the water cycle as well as the non-induced technological improvement, those achieved thanks to specific actions developed by IDAE are presented below.

4.1. Improvement in the energy efficiency of drinking water, supply, waste water purification and desalination plants

The "Improvement of the energy efficiency of drinking water, supply, waste water purification and desalination plants" is a mechanism that forms part of the Action Plan measures developed within the collaboration agreements signed by IDAE and the Autonomous Communities.

Methodology

To calculate the effect produced by the mechanism, the information provided by the Autonomous Communities on savings achieved through public supports intended for this measure was used.

The savings achieved in 2010 were the result of the sum of annual savings from 2004 or 2007 depending on the calculation base year chosen.

$$BU_{c1} = \sum_{t=2004-2007}^{2010} Ah_{et}$$

where:

- Ah_{et}: Annual savings reported by the Autonomous Communities in relation to the "Improved energy efficiency of drinking water, supply, waste water purification and desalination plants".

4.2. Strategic projects

With respect to the promotion of "Strategic projects" by the IDAE, it is important to mention that this relates to packages of improvement measures covering all the structural elements of buildings.

A basic requirement in order to benefit from this type of initiative is the sending of a final report to the IDAE presenting the actions implemented and the savings achieved.

Methodology

To calculate the effect produced by the "Strategic projects" mechanism, the annual reports provided by beneficiary companies on aids and savings were used.

BU_{et}

where:

- Ah_{et}: Annual savings reported by beneficiary companies in relation to "Strategic projects".

4.3. Summary of direct savings relative to the water cycle

These are considered as direct savings produced as a result of the introduction of specific measures which decrease consumption in the use of the water cycle, as well as the savings achieved through the initiatives developed by the Administration.

Table 99. *Results of saving from the mechanisms relative to use of the water cycle in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Strategic projects	BU_{pe}	0,0	0,2
	Improvement of current drinking water, supply, waste water purification and desalination plants	BU_{c1}	6,0	7,0
Base year 2007 [ktep]	Strategic projects	BU_{pe}	0,0	0,2
	Improvement of current drinking water, supply, waste water purification and desalination plants	BU_{c1}	2,8	3,8

Table 100. *Grants for mechanisms relative to use in the water cycle in the 2006-2010 period*

	2006	2007	2008	2009	2010
Improvement to drinking water, supply, waste water purification and desalination plants [k€]	2.718,6	2.158,8	1.920,0	2.426,0	1.571,7
Strategic projects [k€]	-	-	-	-	355,9

Source: IDAE

5. Savings achieved in the public services sector up to 2010

The public services sector achieved savings of 31.8 ktep in the 2004- -2010 period. 86% of these savings were achieved in use relative to the water cycle. Within the water cycle, desalination is the activity that achieved most savings in the period with a total of 26,6 ktep.

Table 101. *Results of saving in the public services sector in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Public services sector	*MAP+MAG*	3[1],5	31,8
	Public lighting	*MAP*	4,1	4,6
	Water cycle	*MAG = MDS+MDP*	27,4	27,2
	Desalination	*MDS*	24,7	26,6
	Purification	*MDP*	2,7	0,7
Base year 2007 [ktep]	Public services sector	*MAP+MAG*	28,3	28,6
	Public lighting	*MAP*	10,7	11,3
	Water cycle	*MAG = MDS+MDP*	17,62	17,35
	Desalination	*MDS*	13,52	15,25
	Purification	*MDP*	4,09	2,10

Analysis of the savings achieved between 2007 and 2010 shows that the saving derived from public lighting increased relative to the total (from 14% to 39%) due to the slowdown in urban development and the implementation of measures intended to improve energy efficiency.

5.1. Indirect effects

Indirect effects can be distinguished through the differences between the saving boundaries achieved for the different indicators. In the case of public services, the following should be included according to the energy use studied: External lighting.

With respect to lighting between the external boundary and that associated with the mechanisms, it is estimated at -116,4 ktep and is justified below.

- Firstly, the improvement in the energy efficiency of external lighting installations may give rise to an increase in their use causing an increase in light pollution in cities. The improved efficiency at lower consumptions is nullified by the increase in operating hours.

- Secondly, urban development has played a key role in the result of savings achieved, with public lighting installations being proportional to new constructions although the results improved from 2008.

- Finally, the savings achieved by the remaining mechanisms which cannot be quantified as IDAE dissemination and communication programmes and RD 1890/2008 concerningenergy efficiency and external lighting installations and its TBCs will also be considered as non-quantifiable savings.

Water cycle

In terms of energy use associated with the water cycle, certain indirect effects were able to be estimated which amounted to 20.0 ktep. This difference is the result of the savings achievedby the rest of the mechanisms however; their savings could not be quantified. This can, in part, be justified by the natural renewal of installations and the promotion of public programmes that benefit from economies of scale and promote technological efficiency.
The possibility of double counting the savings achieved in this sector was not observed.

VI. AGRICULTURE AND FISHERIES SECTOR

1. Summary of the savings in the agriculture and fisheries sector

AGRICULTURE AND FISHERIES

Energy savings achieved during the 2004-2010 period in the agriculture and fisheries sector are mainly due to improvements made in terms of agriculture and greenhouse crops and in terms of irrigation systems and the fishing fleet. Final energy consumption in this sector in 2010 was 3.313,7 ktep, 3.7% of the national total.

Savings diagram

The saving relative to the agriculture and fisheries sector has been structured according to two main subsectors: agriculture, livestock, hunting and forestry on the one hand and fisheries and aquaculture on the other.

Agriculture and Fisheries			[M8'] = 425,5 ktep 2010(Base year 2004)	
Agriculture, livestock farming, hunting and forestry [M8$_1$] = 240,1 ktep			Fisheries and aquaculture M8$_2$ = 146,4 ktep	Change of weight in the consumption structure 39,1 ktep
Farms [PMa + PCl] = -65,63 ktep 2010(Base year 2004)	Irrigation [PRe] = 73.5 ktep 2010(Base year 2004)	' Climate control Technological improvement Production 339,8 ktep 2010(B..e2004)	Fisheries [PPe] = 38.8 ktep 2010(Base year 2004)	Technological improvement Production 107.6 ktep 2010(Base year 2004)

Sector consumption

	Final energy 2010 [ktep]
TOTAL CONSUMPTION IN THE AGRICULTURE AND FISHERIES SECTOR	3.313,66
AGRICULTURE, LIVESTOCK FARMING, HUNTING AND FORESTRY	2.829,80
FISHERIES AND AQUACULTURE	483,87

Result of savings achieved

	Final energy saving 2010 [ktep]		Primary energy saving 2010 [ktep]		Emissions of CO_2 avoided 2010 [ktCO_2]	
	Base year	Base year 2007	Base year 2004	Base year 2004	Base year	Base year 2004
TOTAL SECTOR SAVINGS	425,5	466,7	535,5	580,4	1.526,3	1.673,2
AGRICULTURE, LIVESTOCK FARMING, HUNTING AND FORESTRY	240,1	359,7	374,7	544,5	947,1	1.417,1
SAVING RELATIVE TO FISHERIES AND AQUACULTURE	146,4	121,6	163,9	136,2	501,0	416,1

Conclusions

According to the descending indicators, the final energy savings achieved in the study period were 425,5 ktep, due, basically, to a fall in production and technological improvement in terms of agriculture, livestock, hunting and forestry (62% of the total savings) and in fisheries and aquaculture (38%).

Through the differences between the sum of each subsector's external boundaries (240,1 ktep and 146,4 ktep) and the sector's external boundary (425,5 ktep), the energy saving achieved through the change in weight of each of the livestock and fisheries subsectors is shown (39,1 ktep).

In the agriculture subsector, positive savings were achieved through energy improvements to agricultural machinery (146,8 ktep) and changes to irrigation systems (73.5 ktep). However, the increase in the degree of conditioning with climate control equipment for livestock farms and greenhouses meant that energy intensity increased and therefore for this reason, negative savings of -212,4 ktep were achieved. As a result, globally, no savings were achieved relative to farms, livestock and greenhouses, but negative savings of -65,6 ktep were achieved.
The savings made in the fisheries and aquaculture subsector correspond to direct actions to reduce the energy consumption of different types of ships (38,8 ktep) and the fall in economic activity and the natural technological evolution of the fishing fleet (107.6 ktep).

2. Outer boundaries

Despite its reduced weight in national energy consumption, the agriculture and fisheries sector is a strategic sector where energy efficiency measures contribute to the sector's sustainability and competitiveness.

The diagram of energy savings in the sector can be seen in Figure 55, which shows the values achieved in 2010 using 2004 as a base year and where it is possible to see the basic structure of the two main subsectors.

Figure 55. *Diagram of the energy savings in the agriculture and fisheries sector in 2010 with base year 2004*

<table>
<tr><td colspan="5">Agriculture and Fisheries [M8'] = 425,5 ktep 2010(Base year 2004)</td></tr>
<tr><td colspan="3">Agriculture, livestock farming, hunting and forestry [M8₁] = 240,1 ktep</td><td colspan="2">Fisheries and aquaculture M8₂ = 146,4 ktep
Change of weight in the consumption structure 39,1 ktep</td></tr>
<tr><td>Farms
[PMa + PCl] = -65,63 ktep 2010(Base year 2004)</td><td>Irrigation
[PRe] = 73.5 ktep 2010(Base year 2004)</td><td>Climate control
Technological improvement
Production
339,8ktep 2010(Base year 2004)</td><td>Fisheries
[PPe] = 38.8 ktep 2010(Base year 2004)</td><td>Technological improvement
Production
107.6 ktep 2010(Base year 2004)</td></tr>
</table>

The methodologies used for the calculation of each of the saving boundaries are described in the following section.

Methodology

As a first approximation, the efficiency of an activity sector can be measured as the evolution of consumption compared with its more global level of activity, Gross Value Added (GVA).

Therefore, to determine the sector's total savings, an adjusted indicator M8 recommended by the European Commission for the industrial sector in the "Recommendations on measurement and verification methods" document was used. For each economic sector, said indicator is calculated as the quotient between energy consumption and the associated GVA, understood as the net result of the production at basic prices less intermediate consumption, as shown in the following expression:

$$M8' = \left[\left(\frac{E_{\_}}{VAB_{\_}}\right)\right]$$

where:

- *E:* Energy consumed
- *VAB:* Gross Value Added at basic prices

Consequently, the energy saving is calculated as the difference between the result of indicator *M8* in the base year (2004 or 2007) and the calculation year multiplied by the GVA associated with the latter (2010 in this case) according to the following expression:

$$M8' = \left[\left(\frac{E_{2004}}{VAB_{2004}} - \frac{E_{2010}}{VAB_{2010}}\right)\right].$$

where:

- *E:* Energy consumed
- *VAB:* Gross Value Added at basic prices

Additionally and equivalently, the energy saving for each of the two large subsectors has been described: agriculture, livestock, hunting and forestry (agriculture hereinafter) using the new indicator *M8₁* and fisheries and aquaculture (fisheries hereinafter) with *M8₂*.

$$M8' = \left[\left(\frac{E_t^{Subsector}}{VAB^{Subsector}}\right)\right]$$

where:

- $E^{Subsector}$: Energy consumed by the subsector
- $VBA^{Subsector}$: Gross Value Added at basic prices relative to the subsector

Key variables

Table 102 shows all the variables that directly affect the calculation of the savings achieved in this sector using descending indicators *M8', M8₁'* and *M8₂'*.

Table 102. *Activity variables used in the calculation of savings from M indicators in the agriculture and fisheries sector in the 2004-2010 period*

	2004	2007	2008	2009	2010
Total sector energy consumption [ktep]	3.681,1	3.877,9	3.381,6	3.094,5	3.313,7
Energy consumption relative to agriculture [ktep]	3.007,5	3.278,2	2.817,5	2.597,0	2.829,8
Energy consumption relative to fisheries [ktep]	673,6	599,8	564,0	497,5	483,9
Total GVA for the sector [M€]	23.896,7	24.900,5	24.370,9	24.597,2	24.273,7
Total GVA for agriculture [M€]	22.505,5	23.611,1	23.167,4	23.224,0	22.972,1
GVA for fisheries [M€]	1.391,2	1.289,4	1.203,5	1.373,2	1.301,6

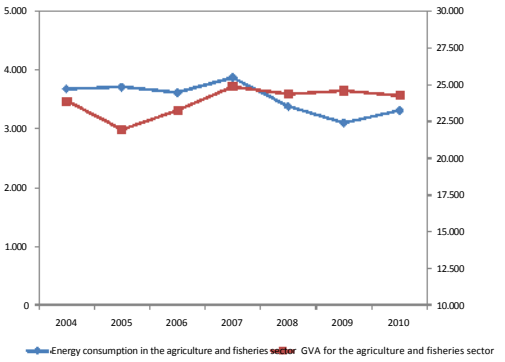
Source: MINISTRY OF INDUSTRY, TRADE AND TOURISM, MINISTRY OF ENVIRONMENT, RURAL AND MARINE ENVIRONMENT

Final energy consumption in the period shows a downward trend (-10% between 2004 and 2010) due to the technological improvement in the two main subsectors together with a fall in production.

However, the evolution of GVA showed an upward trend up to 2007 (a 4% increase), presenting a slight fall in the last four years (-2,5%), as shown in Figure 56.

The fact that consumption fell whilst activity increased generated savings in this subsector.

Figure 56. *Evolution of energy consumption and total GVA in the agriculture and fisheries sector in the 2004-2010 period*



Total savings achieved

To calculate the energy saving achieved in the period (Table 103), indicators *M8'*, *M8₁'* and *M8₂'* were used applying the macroeconomic variables relative to the agriculture and fisheries sector required for its calculation shown in Table 102.

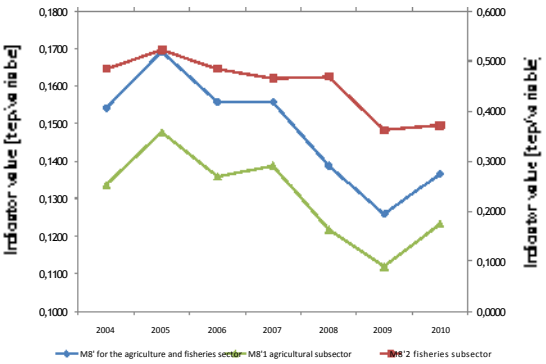
Table 103. *Results of saving in the agriculture and fisheries sector in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Total for the agriculture and fisheries sector	*M8'*	694,5	425,5
	Agriculture, livestock, hunting and forestry	*M8'₁*	506,5	240,1
	Fisheries and aquaculture	*M8'₂*	167,4	146,4
Base year 2007 [ktep]	Total for the agriculture and fisheries sector	*M8'*	736,2	466,7
	Agriculture, livestock, hunting and forestry	*M8'₁*	627,4	359,7
	Fisheries and aquaculture	*M8'₂*	141,2	121,6

Table 104. *Evolution of the M8' indicators for the agriculture and fisheries sector and M8₁' and M8₂' for the two main subsectors in the 2004-2010 period*

		2004	2007	2008	2009	2010
M8'	Energy consumption in the agriculture and fisheries sector per unit of GVA [ktep/M€]	0,1540	0,1557	0,1388	0,1258	0,1365
M8₁'	E. consumption relative to agriculture, livestock, hunting and forestry per unit of GVA	0,1336	0,1388	0,1216	0,1118	0,1232
M8₂'	Energy consumption in the fisheries and aquaculture subsector per unit of GVA	0,4842	0,4651	0,4686	0,3623	0,3717

Figure 57. *Evolution of the M8' indicators for the agricultural and fisheries sector and M81' and M82' for the* two main subsectors in the 2004-2010 period.



According to the evolution in the 2004-2010 study period, the descending M8' indicators (Table 104) achieved savings of 425,5 ktep. The subsector that achieved the greatest savings was agriculture, livestock, hunting and forestry (240,1 ktep) compared with fisheries and aquaculture (146,4 ktep).

In the following sections, the result of energy saving achieved thanks to the concrete measures realised within the Energy Saving Action Plan in the agriculture and fisheries sector is analysed:

- Improvement to irrigation systems through migration from irrigation by spraying to localised irrigation systems.
- Improved saving and energy efficiency in the fisheries sector through audits and encouragement to change engines, propellers and other mechanical components in fishing boats.
- Modernisation through the RENOVE Plan and energy labelling for the national fleet of tractors and improved energy efficiency on farms.

3. Migration from irrigation by spraying systems to localised irrigation systems

The aim of this measure was to reduce energy consumption relative to crops which is possible through replacing irrigation by spraying systems with localised irrigation systems. Therefore measures such as modification of the policy relative to the use of water or the technical and economic aid required for migration to localised irrigation were adopted.

Methodology

To calculate the savings in this sector, the indicator *PRe* was created which shows the evolution of unit consumption for an irrigated area, understood as the relationship between total energy consumption for irrigation and the number of hectares of land irrigated.

$$Pre = \left(\frac{E^{Reg}}{Has}\right)$$

where:
- E^{Reg}: Energy consumption for irrigation
- *Has*: total number of hectares of surface area irrigated

Key variables

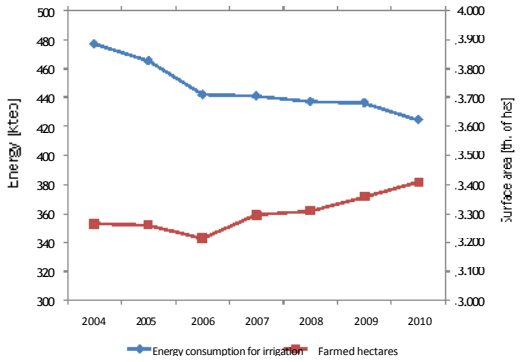
Energy consumption for irrigation in the period showed a downward trend (-11% since 2004 and -4% between 2007 and 2010) due to the technological improvement to irrigation systems. For its part, the evolution of the number of hectares of crops presented a slightly upward trend going from 3,26 Mhas in 2004 to 3,41 Mhas in 2010, a 4% increase, as shown in Figure 58.

Table 105. *Evolution of the activity variables used in the calculation of savings in use for irrigation in the 2004-2010 period*

	2004	2007	2008	2009	2010
Energy consumption for irrigation [ktep]	477	441	437	436	425
Hectares of crops [has]	3.264.149	3.294.685	3.308.643	3.357.970	3.407.953

Source: IDAE

Figure 58. *Evolution of the activity variables used in the calculation of savings in use for irrigation in the 2004-2010 period*



Direct savings achieved

The total savings achieved in the irrigation sector cover both direct savings and indirect consequences and are a result of multiplying the difference of the values of the associated indicator between the reference year (2004 or 2007) and the calculation year (2010) by the value of the activity variable relative to the indicator.

As an example, for indicator *PRe*:

$$\text{Savings achieved by } Pre = \left[\frac{F_{2004}^{Reg}}{Has_{2004}} - \frac{F_{2010}^{Reg}}{Has_{2010}}\right] . Has_{2010}$$

To calculate the energy saving achieved in the period (Table 106) the *PRe* indicator was used applying the irrigation subsector's specific variables presented in Table 108.

Table 106. *Results of saving in the use of irrigation in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004	Irrigation use	*PRe*	54,6	73,5
Base year 2007	Irrigation use	*PRe*	13,3	31,7

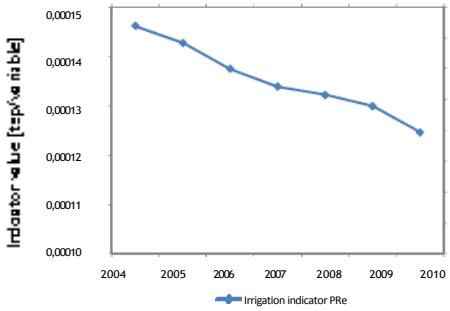
Consequently, both for 2009 and 2010 with base year 2004 or 2007, final energy savings were achieved, basically, through an improvement in the ratio linking the evolution of the consumption associated with irrigation with the area of crops expressed in hectares.

It should be noted that despite there being a slight increase in the area irrigated during the period, there was an improvement in the final energy consumption associated, basically, with improvement requirements from some Autonomous Communities such asCastillas (a -18% fall between 2004 and 2010) andValencia (-13%).

Table 107. *Evolution of the PRe indicator relative to the use of irrigation in the 2004-2010 period*

		2004	2007	2008	2009	2010
PRe	Energy consumption associated with irrigation per hectare [ktep/ha]	0,000146	0,000134	0,000132	0,000130	0,000125

Figure 59. *Evolution of the PRe indicator relative to the use of irrigation in the 2004-2010 period*



IDAE, through the funds associated with the Energy Efficiency Action Plan, has supported the replacement of irrigation by spraying systems with localised irrigation systems with a total of 6,52 M€ in the period.

Table 108. *Grant relative to the use of internal irrigation in the 2006-2010 period*

	2006	2007	2008	2009	2010
Promotion of migration from gravity irrigation by spraying systems to localised ones [k€]	-	2.800	946	1.391	1.749

Source: IDAE

4. Improved saving and energy efficiency in the fisheries sector

The improved energy efficiency in the fisheries subsector has been focused on the investment in efficient technologies within fishing boats together with technical and economic aids for studies and audits required for its development.

Therefore, initiatives have been developed in different action sectors such as for example, fishing equipment, routes and associated logistics and the technical systems. Within this last section, the following should be mentioned: improvements in propulsion, (electric and hybrid engines, exhaust fumes, reducers and propellers), improvements in energy management, alternative fuels together with aids relative to other energy sources.

Methodology

To be able to estimate the savings achieved in the "Improved saving and energy efficiency in the fisheries sector" measure, we need to know the consumption of diesel B relative to the fishing fleet. In addition, we need to find a suitable variable so as to normalise said consumption and thus determine the improvement in energy consumption as the difference in said unit consumption.

Likewise, the global savings relative to the promotion of energy efficiency in the fisheries sector have been calculated using indicator *PPE*, this being understood as the relationship between the consumption of diesel B for fishing and the number of ships considering tall, coastal and artisanal ships.

$$PPe = \left(\frac{E^{Pesca}}{B}\right)$$

where:
- E^{Pesca}: Energy consumption in the fisheries subsector
- B: number of national fishing boats

Key variables

The consumption of diesel relative to the fishing fleet has been established thanks to audits performed by different administrations on the fishing fleet including tall, coastal and artisanal boats.

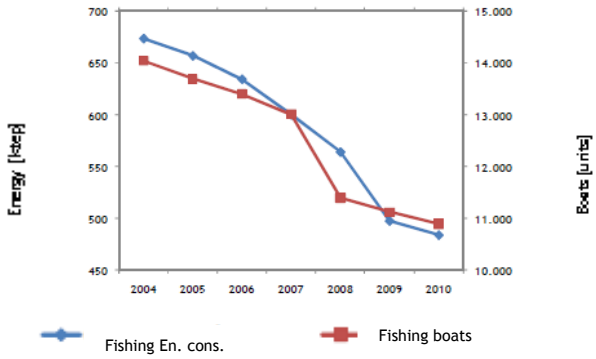
Table 109 shows that the consumption of diesel B relative to fishing boats in the period experienced a significant decrease (-28% since 2004 and -18% between 2007 and 2010) due, mainly, to the fall in activity. This decrease is reflected in the evolution of the number of fishing boats; this experienced a decrease of -22% in the last four years.

Table 109. *Evolution of the activity variables used in the calculation of savings in use for the fishing fleet in the 2004-2010 period*

	2004	2007	2008	2009	2010
Consumption of diesel B relative to the fishing fleet [ktep]	673,6	599,8	564,0	497,5	483,9
Tall, coastal and artisanal fishing fleet [number of boats]	14.041	13.006	11.394	11.116	10.893

Source: MINISTRY OF ENVIRONMENT, RURAL AND MARINE ENVIRONMENT, CETPEC, ICAEN, IDAE

Figure 60. *Evolution of the activity variables used in the calculation of savings in use for the fishing fleet in the 2004-2010 period*



Direct savings achieved

The total saving achieved in the fishing sector relates to both direct and indirect savings relative to final energy consumption.

To calculate said energy saving achieved in the period (Table 110) the *PRe* indicator was used applying the fisheries subsector's specific variables required for its calculation, presented in Table 109.

Table 110. *Results of saving in use for the fishing fleet in 2009 and 2010 with base years 2004 and 2007*

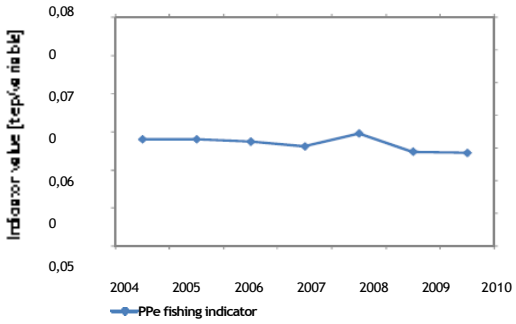
		Associated indicator	2009	2010
Base year 2004	Use for Fishing	*PPe*	35,8	38,7
Base year 2007	Use for Fishing	*PPe*	15,1	18,5

Consequently, both for 2009 and 2010 with base year 2004 or 2007, final energy savings were achieved, basically, through an improvement in the ratio (see Table 111) linking the evolution of the consumption of diesel B with fishing boats.

Table 111. *Evolution of the PPe indicator relative to use for the fishing fleet in the 2004-2010 period*

		2004	2007	2008	2009	2010
PPe	Energy consumption associated with fishing per vessel [ktep/boat]	0,04797	0,04611	0,04950	0,04476	0,04442

Figure 61. *Evolution of the PPe indicator relative to use for the fishing fleet in the 2004-2010 period*



IDAE, through the funds associated with the Energy Efficiency Action Plan, has supported efficient technologies within fishing boats with a total of 2.73 M€ in the period.

Table 112. *Grant relative to use in the fishing fleet in the 2006-2010 period*

	2006	2007	2008	2009	2010
Improved saving and energy efficiency in the fisheries sector [k€]	-	-	1.003	459	611

Source: IDAE

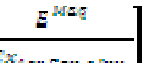
5. Tractor RENOVE Plan and improvement in the energy efficiency offarms, livestock and crop greenhouses

The specific objective of this measure included in the Action Planwas the transfer of part of the current fleet of tractors to new and more efficient units. Therefore, the mechanisms set out in Royal Decree 1539/2006 were developed to regulate the awarding of aid from the Tractor RENOVE Plan between 2007 and 2009 based on objective criteria relative to better energy efficiency. However, to complete the analysis of the use of machinery, the study has been extended to all machinery used on farms since the machinery may have a multimodal character andbe dedicated to various uses using tools in different agricultural or livestock farming activities.

In addition, it was considered useful to analyse the evolution of energy consumption associated with climate control of livestock farms and crop greenhouseswith theaim of completing the study on the agriculture and fisheries sector.

Methodology

To calculate the global energy savings from the promotion measure for the RENOVE Plan for tractors and machinery, indicators have been established. The first of them, *PMa*, considers the energy consumption associated with machinery designed for agricultural, forestry and livestock uses and the number of arable farms, livestock farms and crop greenhouses.



where:

- E^{Maq} : Energy consumption associated with agricultural machinery
- $Ex_{Agr.Gan\ e\ Inv.}$: number of arable farms, livestock farms and crop greenhouses

Secondly, to calculate the savings achieved in terms of climate control for livestock farms and crop greenhouses, indicator *PCI* has been established using energy consumption associated with climate control and the number of livestock farms and greenhouses.

$$PCI = \left(\frac{E^{Climat}}{Ex_{Gan\ e\ Inv.}} \right)$$

where:

- E^{Climat}: Energy consumption associated with climate control on farms
- $Ex_{Gan\ e\ Inv.}$: number of livestock farms and crop greenhouses

Key variables

Table 113 shows that the data relative to energy consumption associated with agricultural, forestry and livestock machinery in the period suffered a significant decrease due, mainly, to a fall in the activity. This decrease is reflected in the evolution of the total number of farms which showed a -13% decrease in the last four years(see Figure 62).

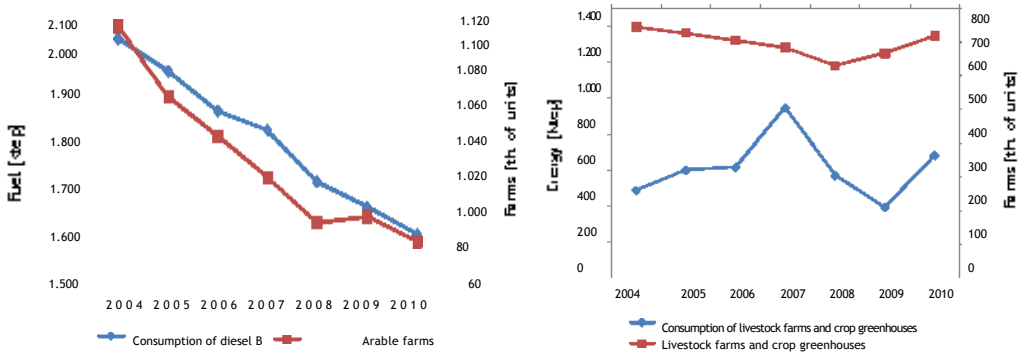
With respect to the second calculation boundary, energy consumption associated with farms and crop greenhouses increased by 40% between 2004 and 2010 due, mainly, to increased energy requirements aimed at increasing production. This increased intensity is reflected in the comparison between the evolution of consumption and the most stable of the number of farms and crop greenhouses, which has showed a slight decrease of -4% in the last four years (see Figure 62).

Table 113. *Evolution of the activity variables used in the calculation of savings in use for farms in the 2004-2010 period*

	2004	2007	2008	2009	2010
Energy consumption associated with agricultural machinery [ktep]	2.041,3	1.891,7	1.807,5	1.765,4	1.720,9
Arable farms, livestock farms and crop greenhouses [farms]	1.110.050	1.043.900	1.024.282	1.026.784	1.015.648
Energy consumption associated with farms [ktep]	489,22	945,42	572,78	395,39	684,41
Livestock farms and crop greenhouses [farms]	743.739	683.913	628.920	666.424	717.510

Source: IDAE

Figure 62. *Evolution of the activity variables used in the calculation of savings in use for farms in the 2004-2010 period*



Direct savings achieved

To calculate the energy saving achieved in the period (Table 114) the *PMa* and *PCl* indicators were used applying the specific variables relative to use for farms, required for its calculation, presented in Table 113.

Table 114. *Results of saving in use for farms in 2009 and 2010 with base years 2004 and 2007*

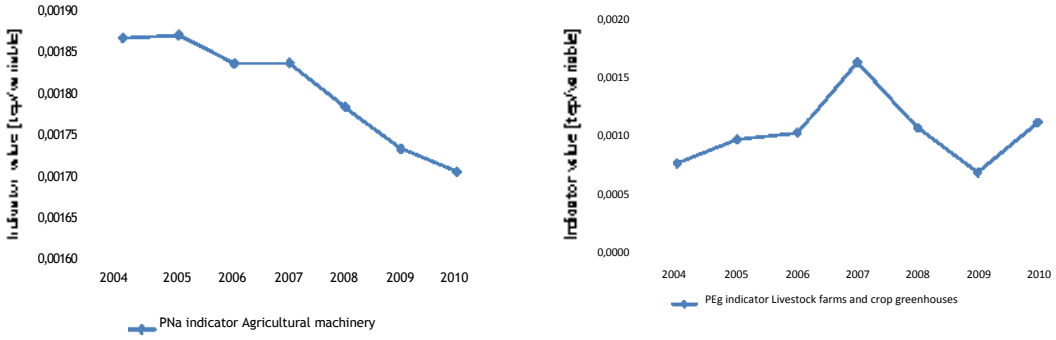
		Associated indicator	2009	2010
Base year 2004 [ktep]	Use for arable and livestock farms and crop greenhouses	*PMa +PCl*	165,7	-65,6
	Machinery	*PMa*	122,7	146,8
	Climate control	*PCl*	43,0	-212,4
Base year 2007 [ktep]	Use for arable and livestock farms and crop greenhouses	*PMa +PCl*	621,1	427,1
	Machinery	*PMa*	95,3	119,6
	Climate control	*PCl*	525,8	307,5

Consequently, both for 2009 and 2010 with base year 2004 or 2007, final energy savings were achieved, basically, through an improvement in the ratio (see Table 115) linking the evolution of the consumption of diesel B with the area of crops expressed in hectares.

Table 115. *Evolution of the PMa and PCl indicators relative to arable and livestock farms and crop greenhouses in the 2004-2010 period*

		2004	2007	2008	2009	2010
PMa	Energy consumption of machinery per farm [ktep/farm]	0,001839	0,001812	0,001765	0,001719	0,001694
PCl	Energy consumption of climate control per farm [ktep/farm]	0,000658	0,001382	0,000911	0,000593	0,000954

Figure 63. *Evolution of the PMa and PCl indicators relative to arable and livestock farms and crop greenhouses in the 2004-2010 period*



As mentioned at the beginning of this section, IDAE, through funds associated with the Energy Efficiency Action Plan, has supported the improved energy efficiency of arable and livestock farms and crop greenhouses, including the Tractor RENOVE Plan, with a total for the period of 118,2 N€.

Table 116. *Grant relative to use in arable and livestock farms and crop greenhouses in the 2006-2010 period*

	2004	2005	2006	2007	2008	2009	2010
Promotion-training techniques efficient energy use [k€]	-	-	935	1.355	956	-	859
Energy audits and action plans to improve arable farms [k€]	-	-	362	308	982	1.522	2.138
Tractor RENOVE Plan and improved energy efficiency [k€]	-	-	1.508	34.912	48.887	20.138	1.215
Aid for migration to conservation agriculture [k€]	-	-	-	-	93	464	1.580

Source: MINISTRY OF ENVIRONMENT, RURAL AND MARINE ENVIRONMENT, IDAE

Table 117. *Number of tractors forming part of the aid from the 2006 to 2010 RENOVE Plan*

	2004	2005	2006	2007	2008	2009	2010
Tractor RENOVE Plan and improved energy efficiency [tractors]	-	-	548	2.164	3.558	1.948	123

Source: MINISTRY OF ENVIRONMENT, RURAL AND MARINE ENVIRONMENT, IDAE

6. Savings achieved in the agriculture and fisheries sector in 2010

Therefore, the agriculture and fisheries sector achieved savings of 425,5 ktepin the 2004-2010 period. 38% of these savings were in the fisheries subsector and 62% in the agriculture subsector.

It is understood that, for the agriculture and fisheries subsector, the most suitable indicator for measuring energy saving is M8'. This is due to the fact that despite a large variety in its effects, its activity variables are more consistent than in the case of *PRe, PPe, PMa* and *PCl*.

Table 118. *Results of saving in the agriculture and fisheries sector and its main subsectors in 2009 and 2010 with base years 2004 and 2007*

		Associated indicator	2009	2010
Base year 2004 [ktep]	Total for the agriculture and fisheries sector	*M8'*	694,5	425,5
	Agriculture, livestock farming, hunting and forestry	$M8'_1$	506,5	240,1
	Fisheries and aquaculture	$M8'_2$	167,4	146,4
Base year 2007 [ktep]	Total for the agriculture and fisheries sector	*M8'*	736,2	466,7
	Agriculture, livestock farming, hunting and forestry	$M8'_1$	627,4	359,7
	Fisheries and aquaculture	$M8'_2$	141,2	121,6

In addition, it is possible to distinguish between total savings associated with the external boundaries and the natural or induced direct savings. Finally, in the last section, the possible indirect effects achieved in the sector are described.

6.1. Indirect effects

Between the external boundary (425,5 ktep), a result of indicator M8' and the internal boundaries (386,4 ktep), a result of the sum of *M81'* and *M82'*, there is a difference of 39.1 ktep associated with the change achieved in the weight of each subsector relative to global consumption. The percentage representing consumption in the agriculture subsector went from 82% in 2004 to 85% in 2010 taking consumption per unit of GVA in 2010 into account, (0,12 ktep/GVA) less than in the fisheries sector (0,37 ktep/GVA).

Agriculture, livestock farming, hunting and forestry

In this subsector, certain indirect effects were able to be considered between the external boundary and the saving measures quantified at 232,2 ktep, due, basically, to:

- A fall in agricultural production (-2,2% in the 2004-2007 period) due to the economic situation.
- A non-quantifiable natural improvement in the efficiency of energy consumption due to technological improvement both in terms of farming machinery and irrigation systems.

Likewise, the savings achieved through the introduction of the rest of the mechanisms developed by the Action Plan will also be considered as indirect effects:

- Sustainable rural development programme (PDRS) according to RD 752/2010.
- Communication and dissemination programmes (training courses). Energy audits and improvement action plans relative to arable and livestock

farms and crop greenhouses.

- Aid for migration to conservation agriculture

Fisheries and aquaculture

In relation to the indirect or non-quantifiable effects in the fisheries and aquaculture subsector, 131.1 ktep was counted, due, basically, to:

- A fall in catches due to legal restrictions to control populations of marine species and the current economic situation.
- A natural non-quantifiable improvement in the efficiency of energy consumption due to technological improvement relative to boats through their components: propellers and electric-hybrid engines etc.

Likewise, the savings achieved through the introduction of the rest of the mechanisms which cannot be quantified:

- Promotion and training of technicians for the efficient use of energy in the fisheries and aquaculture subsector.

- Improved saving and energy efficiency in the fisheries sector: Like for example, the aids for modifications to engines, propellers and alternative fuels in the fishing fleet and in the "Green Fishing" Project.

6.2. Double counting

The possibility of double counting the savings achieved in this sector through these measures in the subsectors studied was not observed.

VII. ENERGY TRANSFORMATION SECTOR

7. Summary of savings

ENERGY TRANSFORMATION SECTOR

The Energy Transformation Sector encompasses those activities with the purpose of converting primary energy into final energy. This covers electricity generation, oil refining and cogeneration.

The Energy Transformation Sector generated primary energy savings of 9.767 ktep in 2010 with base year 2004, which is mainly due to the improved efficiency of electricity generation.

Sector consumption

	Final energy [ktep]	Primary energy [ktep]
	2010	2010
TOTAL SECTOR CONSUMPTION	77.294	108.032
ELECTRICITY GENERATION	22.861	49.249
OIL REFINING	54.433	58.783

Result of total savings

	Final energy saving 2010 [ktep]		Primary energy saving 2010 [ktep]		Emissions of CO_2 avoided 2010 [ktCO_2]	
	Base year 2004	Base year 2007	Base year 2004	Base year 2004	Base year 2007	Base year 2004
TOTAL SECTOR SAVINGS	N/A	N/A	9.767	7.019	51.797	53.254
GENERATION	N/A	N/A	9.482	6.909	51.466	52.947
OIL REFINING	N/A	N/A	72	39	38	186
COGENERATION	N/A	N/A	213	71	293	121

Conclusions

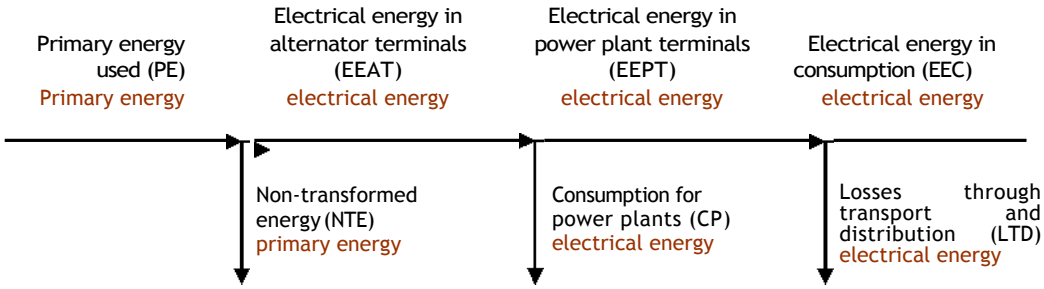
In 2010, out of total primary energy consumption of 131.927 ktep in Spain, 62.358 ktep (47%) was from oil, mostly processed in Spanish refineries and 49.249 ktep (37%) was consumed by national electricity production. These amounts demonstrate the strategic importance of energy efficiency in the energy transformation sector.

In the period studied, practically all of the savings are due to the improved global return from electricity generation. Thus, in 2010, savings in electricity generation were 9.482 ktep, taking 2004 as a reference year. The refining sector presents savings, in 2010, of 72 ktep with respect to 2004, mainly due to the fall in losses. The cogeneration sector achieved primary energy savings of 213 ktep, derived from the high efficiency of the simultaneous production of heat and electricity with respect to the separate production of these energy flows.

1. Electricity generation

1.1. Methodology

The methodology for obtaining the primary energy saving associated with the electricity generation subsector is described as disaggregated which refers to the activity of energy transformation itself, consumption of the power plants and the activity relative to transport and distribution. The following diagram shows the flow of the various energy magnitudes.



Likewise, the total primary energy saving in the electricity generation subsector is obtained by the sum of the three contributors as shown by the following formula:

$$AEP_a = AEP_{ENT\text{-}a} + AEP_{CP\text{-}a} + AEP_{PTD\text{-}a}$$

where:

- AEP_a: primary energy saving in electricity generation in the year with respect to the reference year
- $AEP_{ENT\ a}$:primary energy savings through efficiency in transformation in year 'a' with respect to the reference year
- $AEP_{CP\ a}$:primary energy saving through efficiency in consumption in year 'a' with respect to the reference year
- $AEP_{PTD\ a}$:primary energy saving through the efficiency of transport and distribution networks in year 'a' with respect to the reference year

Primary energy saving through the efficiency of energy transformation

The primary energy saving achieved through greater efficiency in the activity of transforming primary energy into electrical energy is obtained as follows:

$$AEP_{ENT\text{-}a} = \frac{EEBA_a}{\eta EEBA_{EP}} - EP_a$$

where:

- $EEBA_a$: total electrical energy in alternator terminals produced in year 'a'
- EP_a: total primary energy used in year 'a'
- $\eta EEBA/EP_{ref}$:Output between EEBA and EP in the reference year calculated as follows:

$$\eta EEBA/EP\text{-}ref = \frac{EEBA_{ref}}{EP_{ref}}$$

Primary energy saving through less consumption

The savings due to the reduction in consumption relative to generation plants is estimated using the following expression:

$$AEP_{CP\text{-}a} = \frac{EEBC_a}{\eta EEBC/EP-ref} - \frac{EEBA_a}{\eta EEBA/EP-ref}$$

where:

- *EEBCa:* total electrical energy in the power plant's terminals in year 'a'
- *EEBAa:* total electrical energy in the alternator's terminals in year 'a'
- ηEEBA/EP-ref: output between EEBA and EP in the reference year
- ηEEBC/EP-ref: output between EEBA and EP in the reference year, calculated as follows:

$$\eta EEC/EP\text{-}REF = \frac{EECref}{EP\ ref}$$

Primary energy saving due to fewer losses due to transport and distribution

Similarly, the savings due to a reduction in losses from transport and distribution are evaluated as follows:

$$AEP_{POTD\text{-}a} = \frac{EEC_a}{\eta EECEP - ref} - \frac{EEBC_A}{\eta EEBCEP - ref}$$

where:

- EECa: total electrical energy in the consumer terminals in year 'a'
- EEBCa: total electrical energy in power plant terminals in year 'a'
- ηEEBC/EP-ref: output between EEBA and EP in the reference year
- ηEEC/EP-ref: output between EEC and EP in the reference year, calculated as follows:

$$\eta EEC/EP-ref = \frac{EEC_{ref}}{EP_{ref}}$$

1.2. Key variables for the calculation of savings

To calculate the primary energy saving from the electricity generation sector obtained in the period according to the aforementioned savings and methodology, the relationship of the activity variables in Table 120 were used.

Table 119. *Activity variables used in the calculation of savings in the electricity generation sector.*

	2004	2007	2008	2009	2010
Primary energy used [ktep]	53.096	57.352	56.172	50.995	49.249
Hydraulic	2.952	2.625	2.246	2.510	3.898
Nuclear	16.576	14.360	15.368	13.750	16.102
Coal in ordinary scheme	17.839	17.298	11.109	8.218	5.977
Fuel and natural gas in OS (without CCGT)	4.115	3.704	3.178	3.153	2.342
Combined cycle in OS	5.414	11.287	15.237	13.406	10.680
Coal, oil and NG in OS	3.717	4.150	4.527	4.572	4.183
Biomass and waste	1.079	1.512	1.487	1.560	1.497
Thermoelectric solar	0	3	6	40	271
Other renewable energies	1.404	2.414	3.013	3.787	4.299
Electrical energy in alternator terminals [GWh]	276.358	311.125	317.862	296.457	300.241
Hydraulic	34.324	30.519	26.117	29.184	45.321
Nuclear	63.606	55.102	58.971	52.761	61.788
Coal in OM	80.097	74.203	49.018	36.106	24.730
Fuel and natural gas in OM (without CCGT)	17.912	11.731	11.309	11.227	10.544
Combined cycle in OS	28.974	72.219	95.529	82.253	68.303
Coal, oil and NG in OS	32.097	35.639	37.240	36.012	33.986
Biomass and waste	3.023	3.635	4.625	4.781	4.891
Thermoelectric solar	0	8	16	103	691
Other renewable energies	16.325	28.069	35.037	44.030	49.987
Own consumption [GWh]	11.399	11.995	11.679	10.462	9.956
Transport and distribution losses [GWh]	24.635	27.649	27.438	25.830	24.456

Source: MITYC

1.3. Savings achieved

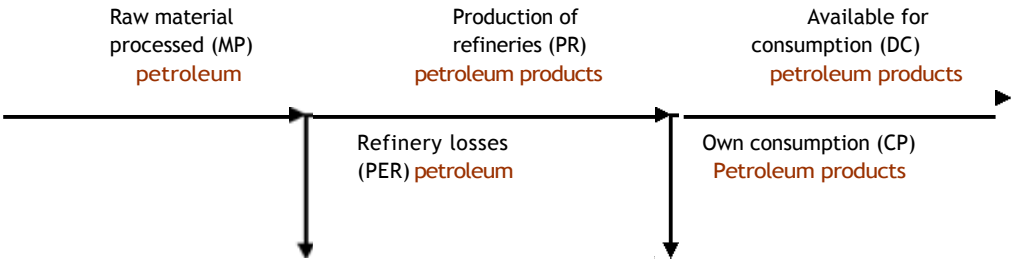
The total primary energy savings in the electricity generation sector in 2010 with respect to 2004 amounted to 9.482 ktep. These savings are the result of adding the improvement in the efficiency of energy transformation (8.435 ktep), the lowest power consumption from power plants (487 ktep) and the reduction in losses due to transport and distribution (560 ktep).

With respect to base year 2007, in 2010, a total primary energy saving of 6.909 ktep was achieved. This saving amounted to 6.097 ktep for energy transformation, 310 ktep for lower consumption of power plants and 502 ktep for the reduction in losses through the transport and distribution network.

2. Oil refining

2.1. Methodology

The improved efficiency in the oil refining sector is due to the reduction in losses from the refineries and the variation in the consumption of said refineries. The following diagram shows the relationship between primary energy consumption, refinery production and the amount of petroleum products intended for self-consumption.



The calculation of the primary energy saving is performed as follows:

$$AEP_a = \frac{DC_a}{DCMP-ref} - MP_a$$

where:

- *AEPa*: primary energy saving in oil refining year 'a' with respect to the reference year
- *DCa*: energy relative to petroleum products produced in refineries destined for final consumption in year 'a'
- *MPa*: raw material energy (petroleum) consumed in refineries in year 'a'
- ηDC/MP-ref: output between DC and MP in the reference year, calculated as follows:

$$DC/MP\text{-}ref = \frac{DC_{ref}}{MP_{ref}}$$

2.2. Key variables for the calculation of savings

To calculate, in the period, the primary energy saving in the oil refinery sector according to the methodology described, the relationship of the activity variables presented in Table 121 was used.

Table 120. *Activity variables used in the calculation of savings in the oil refining sector*

	2004	2007	2008	2009	2010*
Raw material processed [ktep]	61.201	61.539	62.253	58.835	58.783
Refinery losses [ktep]	610	528	599	528	526
Refinery production [ktep]	60.591	61.011	61.653	58.307	58.257
Own consumption [ktep]	3.988	4.063	4.132	4.028	3.824
Available for consumption [ktep]	56.603	56.948	57.521	54.279	54.433

Source: CORES

* 2010 was estimated using the MITYC's database (losses and self consumption) and the AOP values (available for consumption).

2.3. Savings achieved in oil refining

In 2010, with respect to 2004, a primary energy saving of 72 ktep was achieved in the oil refining subsector whilst, with respect to 2007, the saving was 39 ktep.

3. Promotion of cogeneration

3.1. Methodology

In the case of cogeneration, the calculation of the primary energy saving was performed by comparing the efficiency generation systems using conventional energy and thermal energy. The following expression is used:

$$AEP_a = \frac{E_a}{Ref\ E_{ref}.Fc_{ref}} + \frac{H_{CHP-a}}{RefH_{ref}}, Fa$$

where:

- *AEPa*: total primary energy through new cogenerations in year 'a'
- *Ea*: total electrical energy generated through new cogenerations in year 'a'
- *Ref Eref*: electrical output of conventional electricity generation in the reference year
- *FCref*: conversion factor relative to connection voltage in the reference year[12],
- *HCHPa*: useful heat generated by new cogenerations in year 'a'
- *Ref Href*: electrical output of conventional thermal generation in the reference year
- *Fa*: primary energy consumption of new cogenerations in year 'a'

3.2. Key variables for the calculation of savings in cogeneration

To calculate the savings relative to the different cogeneration measures, according to the aforementioned methodology and criteria, the activity variables presented in Table 122 were used.

Table 121. *Activity variables used in the calculation of primary energy savings in the cogeneration sector*

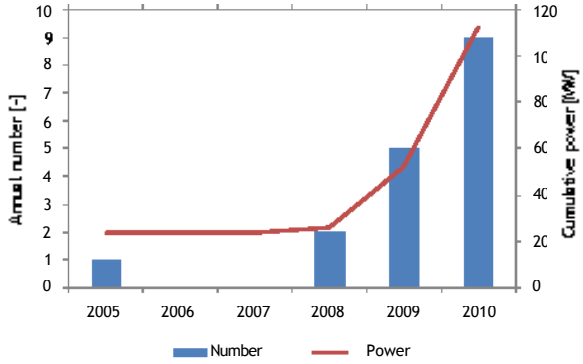
		2007	2008	2009	2010
Promotion of small-capacity installations					
Base year 2004	Electrical energy generated (GWh)	-	-	0,29	0,29
	Total heat produced (Gcal)	-	-	502	502
	Total fuel consumed (TJ)	-	-	3,66	3,66
Base year 2007	Electrical energy generated (GWh)	-	-	0,29	0,29
	Total heat produced (Gcal)	-	-	502	502
	Total fuel consumed (TJ)	-	-	3,66	3,66
Promotion of installations in non-industrial activities					
Base year 2004	Electrical energy generated (GWh)	558	522	920	920
	Total heat produced (Gcal)	485.653	468.259	825.303	825.303
	Total fuel consumed (TJ)	5.628	5.321	9.407	9.405
Base year 2007	Electrical energy generated (GWh)	-	-	229	316
	Total heat produced (Gcal)	-	-	299.271	283.831
	Total fuel consumed (TJ)	-	-	2.792	3.235
Promotion of installations in industrial activities					
Base year 2004	Electrical energy generated (GWh)	1.285	1.614	2.312	2.331
	Total heat produced (Gcal)	1.368.838	1.450.098	2.447.601	2.467.562

[12] In accordance with annex IV concerning the Decision from the Commission on 21 December 2006 complying with that set out in Directive 2004/8/EC.

		2007	2008	2009	2010
	Total fuel consumed (TJ)	14.274	16.507	25.497	25.700
Base year 2007	Electrical energy generated (GWh)	-	232	915	1.033
	Total heat produced (Gcal)	-	183.426	1.169.258	1.093.719
	Total fuel consumed (TJ)	-	2.255	11.129	11.391

With regard to substantial change, 17 cogeneration plants that benefitted from the renewal of equipment between 2005 and 2010 were considered. The number and annual power of the actions is reflected in Figure 63.

Figure 64. *Number and power of substantial changes in cogeneration plants in the 2005-2010 period. Source: Ministry of Industry, Trade and Tourism*



To quantify the savings relative to the substantial changes, increases in the electrical output of the renovated plants with respect to the original ones were considered as were operating hours according to the technical characteristics of the 17 plants. The technology of each of the plants was taken into account as was the subsector with which they are associated.

3.3. Savings achieved in cogeneration

The total primary energy saving in cogeneration in special scheme in 2010 with respect to 2004 was 213 ktep. This saving is broken down according to the size of the cogeneration plant and the economic sector to which the user of the heat belongs. Thus, the contribution of small-capacity cogeneration (< 150 kW) is 32 tep, that associated with non-industrial activities is 49 ktep, and that linked to industrial activities represented the biggest saving in the period (159 ktep). In addition, up to 60MW has undergone a substantial change in the period. The savings derived from these renovations amount to 6 ktep.

In terms of primary energy savings in 2010 with respect to 2007, a total saving of 71 ktep was achieved, 10 ktep due to small-capacity cogeneration, 10 ktep due to cogeneration in non-industrial activities, 55 ktep in industrial activities and 6 ktep due to substantial change.