Sensitivity analysis for calculating the ESD energy savings target with the top down method: the French experience of NEEAP2

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Abstract

All Member States have to report their energy savings to the European Commission within the framework of the Energy Services Directive (ESD). The calculation rules may evolve due to the new Energy Efficiency Directive (EED) under negotiation. It is important to understand these changes and their implications particularly in the light of experience gained thanks to the NEEAP2 submitted by the Member States (MS) in June 2011.
Based on main methodologies used in Europe for Top-Down assessment, this paper presents the methodology used by France to calculate the objective of the ESD and discuss sensitivity analyses. The results show that France is at present in the trajectory to achieve the ESD target (5 Mtoe in 2009 against a target of 12.6 Mtoe in 2016). Five types of sensitivity analyses were conducted: 1) choosing indicators called "preferred, minimum and alternative" indicators, 2) level of disaggregation on the amount of energy savings, 3) including the energy saving of the industrial branches engaged in the ETS (Emission Trading Scheme), 4) summation of the energy savings and 5) ability of TD evaluation to tackle yearly energy saving changes in the context of an economic recession.
From the detailed analysis of the pros and cons of TD indicators and the results of sensitivity analyses, we propose recommendations for monitoring the ESD target using TD indicators, in particular on the conditions of its harmonization. We suggest to systematically use preferred indicators when data are available, to include negative savings in the calculation of the total, and, finally, to include savings from the ETS sector in order to get the full and realistic picture of the energy savings which have occurred.

Introduction: the ESD has boosted the methodological reflexions and the institutional practices in calculating energy savings

For over thirty years, researchers and policy implementers have developed methodologies on monitoring energy efficiency. A stream so called "technical-economical" has developed a top-down (TD) methodology for the calculation of energy savings by the decomposition of energy demand by technical and economic effects, mainly at the IEA (International Energy Agency (Howarth et al. 1991, Schipper and Meyer 1992) and at the Fraunhofer ISI (Morovic et al. 1989, Eichhammer and Mannsbart 1997). This expertise has also been widely deployed in France at Université de Grenoble (IEPE) (Chateau and Lapillonne 1982, Bosseboeuf 1995, Bosseboeuf et al. 1997). This work was developed and used institutionally by ADEME (the French public agency for environment and energy efficiency) for the development of the database Datamed and associated analyses in the form of an annual report on energy savings in France (ADEME 2011). This work has been widely disseminated and applied in emerging countries, e.g. in Tunisia (ADEME 2012a) and in Algeria (ADEME 2012b).
In Europe, during the last fifteen years a major effort has been made to develop harmonized TD methods through the ODYSSEE project[1] that develops and calculates over 200 comparable energy efficiency indicators across 29 European countries (ADEME and Enerdata 2012). But this work remained confined to academic experts and policy implementers (the energy efficiency agencies grouped in the club EnR[2]) and the results did not have an official character. The implementation of the ESD (Energy Services

1 www.odyssee-indicators.org
2 www.enr-network.org

Directive 2006/32/EC) has boosted these analyses because it requested from the Member States (MS) to monitor energy savings through two complementary approaches, so called TD and BU (Bottom-Up) (see ESD Annex IV). Therefore the results provided by MS in their NEEAP2 (second round of National Energy Efficiency Plans) become an official reference based on a formal and harmonised data collection that, in practice, Eurostat is not yet able to provide. But the "virtual" characteristic of energy savings (there is no meter, but savings have to be calculated in relation to a counterfactual) makes a final consensus on a harmonized methodology for calculating TD energy savings difficult to achieve. To set the stage, the European Commission (EC) initiated an academic reflection on the calculation of energy savings within the EMEEES project[3] (Wuppertal Institute 2009, Thomas et al. 2012). Combined with the experience of the ODYSSEE project and discussions within the Energy Demand Management Committee (EDMC) related to the ESD, the EC has made available to MS a document on recommendations of calculation rules (EC 2010) for NEEAP2 reporting[4].
The MEDDTL (French Ministry of Ecology, Sustainable Development, Transportation and Housing), in charge of carrying out these calculations for France, has used both TD and BU approaches. This article will focus on the experience gained in the calculation of TD NEEAP2 savings.
Overall the French experts have tried, based on the statistics available, to implement the recommendations in the spirit of the EC, which are very similar to methods used nationally. It soon became apparent that the results obtained were highly dependent on methodological choices that can be classified into five categories: 1) the choice of the efficiency indicators used to calculate the savings, 2) the level of disaggregation, 3) the inclusion of sectors covered by ETS, 4) the aggregate energy savings, 5) the reference year.

The top down approach: MS practices for the NEAAP 2 and the French case

Differentiated practices according to MS

We rapidly reviewed all NEEAPs 2 available on the EC website to identify general practices of TD calculations of energy savings adopted by the MS that can be summarized as follows[5]:

- over 3/4 of countries have used more or less the TD method for the calculation of ESD target;
- most countries have reported both TD and BU assessments;
- there is a minority of countries that have used only one of the two methods (i.e., Belgium and Poland for TD and Finland and UK for BU);
- there is a rather marked preference for the use of TD for transport, high in buildings and lower in industry. This is certainly linked to the fact that BU assessments are particularly limited in transport, due to fewer policies implemented;
- there are different practices on the use of PIs (Preferred Indicators) and MIs (Minimum Indicators) often sector dependent (i.e. MIs in the service sector).

3 www.evaluate-energy-savings.eu
4 The TD method proposed by the European Commission was on purpose simplified to reach a consensus among MS and only aimed to measure total savings, whatever the origin (market or policy driven). It was not in line with the recommendations by EMEEES (Lapillonne et al. 2009) to have a regression analysis for additional energy savings.
5 We also consulted the summary report "Concrete examples of measuring energy saving impacts: Executive Summary" from CA ESD project: http://www.esd-ca.eu/reports/working-group-excutive-summaries.

The French case: TD calculation demonstrates that France is on track for intermediate indicative target but the conclusion depends on the methodological options taken.

The French case is characterized by the use of both TD[6] and BU approaches but with a preference for TD since this approach covers virtually 100% of non ETS final consumption (excluding air conditioning). In the NEAAP2, the calculation of the intermediate target is only available for 2009 and not for 2010 because of partial data availability and because France did not want to extrapolate indicators in a too much atypical period (e.g. with ODYSSEE short term indicators). This proved damaging because, as discussed below, the calculations are extremely sensitive to the socio-economic factors related to the 2007-2009 financial and economic crisis.
The intermediate indicative energy saving target for France in 2010 was 5 Mtoe (in final energy)[7]. Using the TD calculation, 5.15 Mtoe have been saved in France between 2007 and 2009 exceeding the three years 2010 target. Therefore we can consider that France is on track toward the achievement of the ESD target. However this assessment only takes into account the positive savings. If negative savings are subtracted, France can be still on the tracks depending on methodological choice. This will be developed in the following section through sensitivity analysis.

A prerequisite for a relevant TD application: the data quality

The results and their credibility depend primarily on the availability and the intrinsic quality of primary data used. This has not been mentioned in the NEEAPs so that it is difficult to assess the reliability for example in terms of margin of error. As observed in Europe the availability of statistics needed is the best in industry and the worst in the tertiary sector for example. But the statistical availability is improving over time as well as the country coverage[8] (**table 1**). We therefore expect that TD approaches are used less in services and that more sophisticated indicators such as PIs are less used in transportation and services. France is in a favourable position since it has had all the information required.
The second issue faced by MS is the ability to accept less official data to improve their calculations. Countries often face the following dilemma: either using official data from the energy balance but often not disaggregated enough (e.g. by end-use) or using more disaggregated data but from unofficial sources. The ability to analyze energy savings requires however the highest disaggregation as possible to eliminate as much as possible structural effects and therefore to get calculated savings as close as to energy savings really due to energy efficiency improvements. We examined in detail the quality of data on energy efficiency indicators i.e. the data on energy consumption by end-use and data on drivers for European countries (Lapillonne and Desbrosses 2009, Lapillonne et al. 2009). We have described the data either by their sources (**Figure 1**) or by their level of reliability[9] (as estimated by experts) (**Figure 2**). Official data are not always considered the most reliable by practitioners. It can be said however that the higher the level of disaggregation (e.g. by end-use and type of energy), the better the evaluation.

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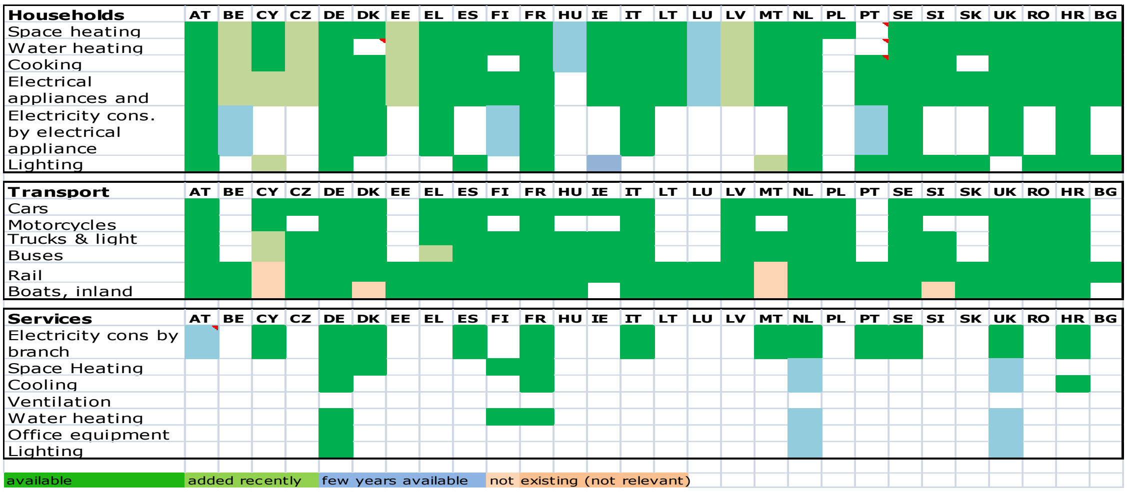
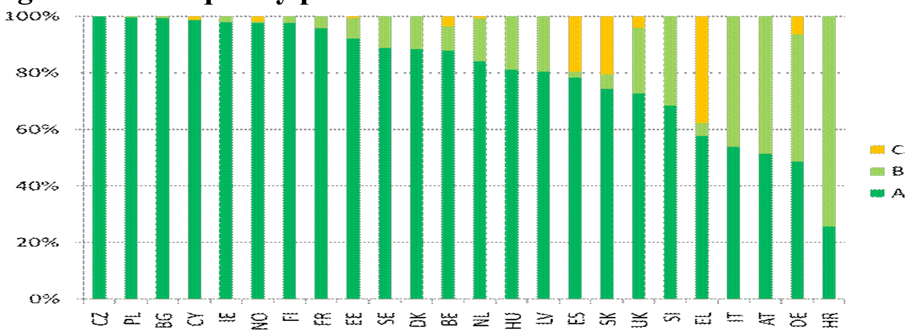
6 TD calculations were performed by the French Ministry in charge of energy, with the support of ADEME and Enerdata, including the different alternative calculations.
7 One of the reasons that France has chosen to use the target expressed in final energy is the fact that the bulk of the energy efficiency policies has been implemented in the final end uses.
8 See more detailed analyses in the ODYSSEE reports (ODYSSEE-MURE 2009, ADEME and Enerdata 2012).
9 The ODYSSEE data have been "labelled" by types of sources and by type of uncertainty of the data. Qualification of sources:
A: Official sources statistics: national statistical office, Eurostat/AIE, Ministries statistics ; model estimations used as official statistics ; all data "stamped" by Ministries**;** **B**: Surveys/ modelling estimates : consulting, research centres, universities, industrial associations; **C**: Estimations made by national teams (for the project).

Table 1: Data availability in EU countries for calculating energy efficiency indicators



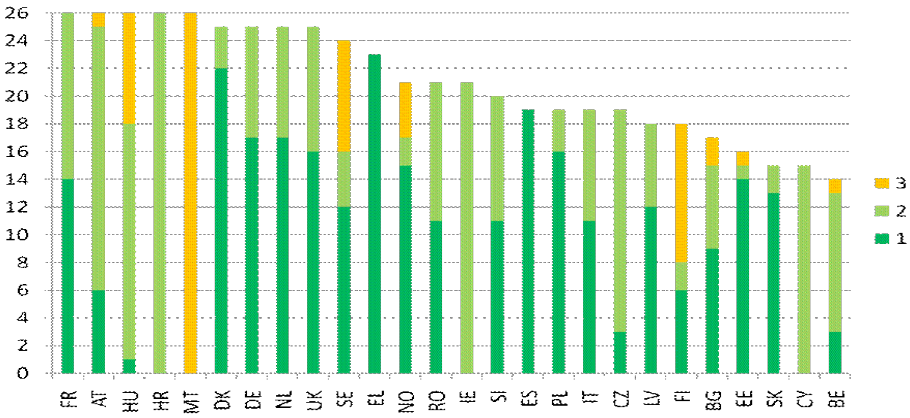
Source: Odyssee.

Figure 1: Data quality per source in the EU countries.



Source: ODYSSEE.

Figure 2: Qualification of the ODYSSEE database according to the level of uncertainty[10].



Source: ODYSSEE.

As it can been seen for France for instance, 95 % of the data used for the calculation comes from official data, the other 5% come from modelling data. Similarly, the data quality is qualified as good or semi good. From these 2 graphs, we can consider that the French case constitutes a good reference for a relevant application of the TD approach.

10 Data uncertainty: **1** Good: low uncertainty; **2** Medium: medium uncertainty; **3** Poor: large uncertainty.

Sensitivity analysis on TD energy saving calculation

In this paper we mean by sensitivity analysis the differences on energy savings due to methodological choices such as the kind of indicator chosen. We deal not with the statistical quality of the assessments or the statistical margins of error attached to a number, i.e. reliability. The most convincing of such an approach has been carried out by Gerdes and Boonekamp (2011) on the Dutch case.

Influence of the type of indicator on the TD calculation of energy savings.

Often it is established that the calculation of energy savings depends on the type of indicator used. But this issue covers different concepts. We can use, at the broadest level of a country or sector, an economic indicator such as the energy intensity or a composite index based on physical indicators, such as ODEX[11], to assess energy efficiency trends. They differ mainly by the fact that in the first case the driver (the denominator) is a macro-economic indicator (GDP, Value Added for instance) and in the second case a physical indicator (level of production, stock of equipment). In the TD approach used for the calculation of ESD savings, only physical indicators are selected. However there may be several indicators "eligible" to compete for evaluating energy savings of the same end-use[12.] Their evolution over time varies in different ways, and so do the calculated energy savings, depending on the indicator, as discussed below.

In the recommendations of the EC, there is a distinction between PIs and MIs. In principle, the PIs should reflect a better proxy of energy efficiency, mainly because part of the impact of activity is sort out from the indicators. However PIs are more data demanding than MIs. The use of PIs was meant by the EC to deliver more energy savings than MIs because these indicators are cleaned from the impact of factors generally increasing with the economic development, such as the size of dwellings or an increasing car mileage. This was assumed as an incentive to use more sophisticated or disaggregated indicators (PIs) counterbalancing the extra costs of data collection. This situation may create a dilemma for the government about the right choice of indicators. This is illustrated by sector-based analysis below.

The case of residential sector: France has retained only PIs for the ESD calculations. In the case of the residential sector the discussion on the main difference between PIs and MIs should be separated between thermal uses and specific electric uses. As in all sectors, indicators are designed so that the sum of consumption covered by MIs is equal to that of PIs. A more detailed comparison is not possible because P1-P3 indicators relate to all forms of energies while MIs are separated by energy (fossil vs. electricity) (see Table 2 for the meaning of the indicators mentioned here). The two indicators that could be reconciled are M2 and P4 but in the specific case of France, there is a significant share of electrical heating (more than half the consumption of housing) that is included in M2 and excluded from P4. France does not have reliable data on air conditioning. The indicator has not been calculated as this end-use remains marginal at the moment, which does not distort the overall assessment. **Table 2** below summarizes the calculations of energy savings based on these indicators for France.
In 2009, energy savings from MIs are estimated at 3.57 Mtoe in the residential sector against 3.06 Mtoe from PIs. Here, the MIs generate more energy savings. This difference disappears if negative electricity savings are removed from M2[13]. We would then have some convergence of the results which can be

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11 ODEX is a composite indicator which is calculated from the variation of physical energy efficiency indictors defined at each end uses weighted by the respective share of each end-use in the final consumption (Bosseboeuf et al. 2005).
12 For instance for cars, we can use l/100 km, l/kg of car, toe/car, goe/pkm. However, they correspond to a different interpretation , one including the yearly mileage, the other one referring to the delivered service, etc.
13 Negative savings come from the fact that the electricity consumption per household is increasing because of the increase in equipment ownership and also because of a shift to electrical heating.

explained by the fact that the correction for heating per m² (P1) does not ultimately play against an indicator of type M1, which includes the surface of the housing. It is true that over 2 years the average dwelling size changes very little. The main difference is related to heating (2.9 Mtoe). There is also evidence that electrical appliances (P4)[14] generate almost no energy savings despite the proactive policies of labels and Minimum Energy Performance Standards (MEPS) and the beginning of the implementation of white certificates (Bosseboeuf 2011). This is due to the fact that even the P4 indicators include other effects, such as the size of equipment that hides technical gains. Finally we observe that in this end-use that on short time PIs and MIs converge because the structural effects, which distinguishes them, have been marginal despite the economic crisis. The French government has retained the PIs option, considered as more representative of energy savings.

Table 2: Sensitivity analysis - impact of the choice of indicators in the energy savings (a) of the housing sector (France 2007-2009).

Code ESD	Energy efficiency indicators	Indicator units	2007-2008 savings (ktoe)	2007-2009 savings (ktoe)
M1	Non electric consumption per dwelling (climate adjusted)	toe/dw	2 200	3 566
M2	Electricity consumption per dwelling	kWh/dw	-403	-481
	Total 1 with Minimum Indicators		**2 200**	**3 566**
P1	Space heating consumption per m² (climate adjusted)[15]	koe/m²	1 785	2 972
P2	Space cooling consumption per m² (climate adjusted)	koe/m²	0	0
P3	Unit consumption for water heating per inhabitant	toe/inhab	23	13
P4	Specific electricity consumption per appliance	kWh/yr		
	Refrigerators		11	23
	Freezers		7	14
	Washing machine		0	0
	Dish washers		0	0
	TV		0	0
	Dryers		0	4
P5	Electricity consumption for lighting per dwelling	kWh/dw	16	35
	Total 2 with Preferred Indicators		**1 842**	**3 061**

(a) energy savings are positive
Source: MEDDTL 2011, and authors of French NEEAP2.

Transport sector: the use of alternative indicators. In this sector, the EC has added a new category of indicators so called "Alternative" (AIs) to PIs and designed to be more accurate than MIs but less than PIs (**Table 3**). The AIs require a disaggregation of fuel sales by vehicle type as for PIs (e.g. A1 and P8). AIs are somehow indicators of hybrid categories of MIs and PIs. Although considered as a MI, the construction of M5 and its interpretation are more sophisticated than the indicator P8 for instance. Created by Lapillonne in the early 1990's under the REDP project in Asia[16], the indicator "Energy consumption of road vehicles per car equivalent" overcomes the lack of information on consumption per vehicle and can exclude the structural effect of the type of vehicle that remains in an indicator like toe / vehicle. It has been applied by Bosseboeuf (1995) and is also used in Odyssee. This indicator includes mileage as A1. This is the mileage and the structural effects of the stock that create most of the differences between the two categories of indicators. France has a comprehensive statistical system

14 For electrical appliances , TD savings are calculated from the reduction in the average electricity consumption per year (in kWh/ appliance).
15 The large savings for space heating are the results of various factors: more efficient buildings and appliances (linked to policies) and high energy prices. In 2009, the crisis probably contributed to additional behavioral savings.
16 REDP : Regional Energy Development Program of UNDP/ESCAP.

(consumption per vehicle type and energy, corrected for the effects of foreign vehicles and border fuel purchases, for example) which allows the use of PIs in good conditions.
Table 3 shows a significant difference between the sum of MIs (2.74 Mtoe) and PIs (0.63 Mtoe), i.e. a factor 4. Indicators of road transport explain most of the differences because of their preponderance in the consumption. The difference is due to several factors related to the nature of indicators that is amplified by the short term variations due to the economic crisis: PIs are indicators that represent the concept of energy service (in pkm or tkm) and by construction include the impact of mileage and occupancy rates.

Table 3: Sensitivity analysis - impact of the choice of indicators on the energy savings for the transport sector (France 2007-2009).

CODE ESD	Energy efficiency indicators	Indicator units	2007-2008 savings (ktoe)	2007-2009 savings (ktoe)
M5	Energy consumption of road vehicles per car equivalent	toe/eq car	1374	2574
M6	Energy consumption of rail transport in grams of oil equivalent	toe/tkbr	-2	-68
M7	Energy consumption of domestic water transport	toe/tkm	0	0
	Total 1 energy savings (Minimum)		**1374**	**2574**
P8	Energy consumption of car per passenger km	toe/pkm	67	167
A1 FOR P8	Energy consumption of car	l/100km	-4	116
P9	Energy consumption of trucks and light vehicles per ton-km	toe/tkm	-107	-1368
A2 FOR P9	Energy consumption of trucks and light vehicles per vehicle	toe/veh	831	1763
P10	Energy consumption of passenger rail transport	toe/pkm	-1	-46
P11	Energy consumption of rail transport per gross ton-km	toe/tkbr	-6	-170
P12	Share of public transport in total passenger transport	%	153	132
P13	Share of rail, water transport in total freight transport	%	26	-75
	Total 2 with preferred indicators		**250**	**630**

Energy savings are in positive terms. Total only adds up positive savings
Source: MEDDTL 2011, and authors of French NEEAP2.

The economic crisis has had two effects not reflected in the evolution of indicator M5 but particularly affecting P8 and P9 and to a lesser extent A1 and A2: reduction in the annual mileage of cars, as a result of the combined effect of rising fuel prices since 2000 and of the economic crisis, and sharp drop of road freight traffic (-30% in 2009) and of the load factor which is included in P9 but not in A2.
Beyond these effects, it is clear that the results differ greatly in a direction contrary to the spirit of the EC since the PIs generate much less energy savings. In detail, we also find that AIs provide sometimes the same result (and in the same direction) as PIs (A1 and P8) and sometimes differ widely (A2 and P9). In this case, the crisis certainly explains the gap. The French government has opted for a mixed choice between PIs and AIs (P8, P10, P11, P12 and P13). The choice that has the most effect on the result is between A2 (1.73 Mtoe) and P9 (-1.36 Mtoe). Considering these too erratic figures, it was preferred to build up an indicator P9bis, based on the annual average trend of P9 over a longer period from 2000 to 2009, and extrapolated for the two years 2008 and 2009 (i.e. 0.33 Mtoe). Overall, energy savings retained are equal to 0.63 Mtoe (total 2). This is the area that allows large fluctuations in the results depending on the choice of indicators especially when drivers experienced rapid change (economic crisis and strong growth of road vehicle stock).

The impact of the level of disaggregation: **case of the service sector**

Many studies have shown the impact of the level of disaggregation on the amount of energy savings. This affects the sectors where structural changes occurred among different end-uses with large discrepancies in their respective unit consumption. It concerns the industrial sector (i.e. chemical versus equipment in industry for instance), the service sector (e.g. share between offices and other types of buildings for instance) or the transport sector (modal shift or change in the road vehicles stock structure between truck and lights trucks for instance). It can be also used to evaluate the impact of the fuel substitution (i.e. between diesel and gasoline cars). However it should be clearly understood that if the results depend on the level of disaggregation, the impact of these structural changes will actually depend on their types (in terms of both direction and level). This issue has been mainly evaluated in the industry sector because some energy efficiency or industrial policies may affect the industrial structure.
As shown in **Table 1**, the service sector is the worst in terms of data availability in Europe. This is reflected somehow in the proposed list of indicators. In particular the breakdown by end-use and by branch only exists in a few countries. Fortunately, France is able to provide such information as it can be seen in **Table 4,** in particular for the indicators P6 and P7.

Table 4: Sensitivity analysis - impact of the choice of indicators on energy savings for service (France 2007-2009).

	Energy efficiency indicators	Indicator units	2007-2008 savings ktoe	2007-2009 savings ktoe
M3	Non electric consumption per employee (climate adjusted)	toe/employee	281	429
M4	Total unit consumption of electricity per employee [17]	kWh/emp	-223	-438
	Total 1 bis with minimum indicators*		**281**	**429**
P6	**Non electricity consumption of sub sector per employee**			
	Hotel, restaurants	toe/emp	69	80
	Health and social action	toe/emp	97	212
	Education, research	toe/emp	15	2
	Offices and administration	toe/emp	-13	24
	Trade (wholesale and retail)	toe/emp	56	98
	Total 2 with preferred indicators (non electricity)		**237**	**415**
P7	**Total unit consumption of electricity by per employee**			
	Hotel, restaurants	kWh/emp	-21	-38
	Health and social action	kWh/emp	-24	-42
	Education, research	kWh/emp	-17	-25
	Offices and administration	kWh/emp	-109	-224
	Trade (wholesale and retail)	kWh/emp	-53	-94
	Total 2 bis with preferred indicators*		**237**	**415**

Energy savings are positive; non electricity consumption: climate adjusted *excluding uses without savings
Source: MEDDTL 2011 and authors of French NEEAP2.

Here the main difference between MIs and PIs comes from the difference in the level of disaggregation by branch because the same driver is taken (employees). Therefore the impact of the indicator choice depends firstly on the importance of the structural effect among branches (which itself depends on the level of disaggregation) and secondly on the direction of the structural effect (more hotels versus fewer hospitals for instance). Therefore we cannot predict the level and direction of differences on the amount of energy savings according to the indicators. However, according to the EC principle, it is preferable to

17 Negative savings come from the fact that the electricity consumption per employee is increasing because of the increase in IT and office equipment, in air conditioning and also because of a shift to electrical heating.

use PIs as they exclude some of the inter-branch structural effect and therefore represents a better proxy of energy efficiency. The results show that energy savings for both fossil fuels and electricity are not affected by the level of disaggregation by sector (respectively 0.43 Mtoe and 0.42 for M3 and P6 and 0.44 and 0.42 Mtoe for M4 and P7). However, such results depend on the context and cannot be generalised. These effects are obviously more visible on a longer period. The French government has retained PIs for fuels only.

Impact of the sector coverage: case of industry

As shown in Table1, the data coverage in the manufacturing sector is rather good in most MS. Therefore France, as many MS, has used PIs for the assessment of energy savings. The only difference between PIs and MIs relies on the selection of the activity driver: VA (Value Added) for MI versus IPI (Industrial Production Index) for PI. However generally for the energy intensive industries the activity expressed in term of production is preferred. This last methodology could have been applied in France since these data are available and is applied in DATAMED and ODYSSEE (Bosseboeuf and Chedin 2010). Nevertheless, the French government preferred to stick to the EC recommendations using PIs as shown in **Table 5**.

Table 5: Sensitivity analysis - impact of ETS consumption on energy savings assessment in manufacturing industry (France 2007-2009).

			2007-2009	2007-2009
			With ETS	**Without ETS**
	Energy consumption per unit of production index	Units	ktoe	ktoe
P14	Chemical (NACE 24)	ktoe/IPI	1064	532
P14	non-ferrous metals	ktoe/IPI	-129	-13
P14	iron and steel	ktoe/IPI	-1	0
P14	Non metallic minerals (NACE 26)	ktoe/IPI	-52	-5
P14	Wood (NACE 20)	ktoe/IPI	-559	-476
P14	Paper Printing (NACE 21-22)	ktoe/IPI	206	51
P14	Food (NACE13-14)	ktoe/IPI	211	225
P14	Textile (NACE 17-19)	ktoe/IPI	-14	-12
P14	Machinery (NACE 28-32)	ktoe/IPI	-285	-242
P14	Transport equipment (NACE 34-35)	ktoe/IPI	-19	-16
P15	Construction (NACE 45)	ktoe/IPI	288	-359
P14	Others	ktoe/IPI	-399	245
	Total with preferred indicators (excluding industrial branches without savings)		**1839**	**1053**
	Total with preferred indicators (including branches without savings)		**311**	**-70**

Energy savings are positive ; IPI: Industrial Production Index
Source: MEDDTL 2011 and authors of French NEEAP2.

In the ESD, it is stipulated that the part of the final consumption which is under the ETS is not eligible in the calculation of the energy savings target. This option is under negotiations in the future EED (Energy Efficiency Directive). Therefore we have tested the impact of this option in the case of France. To perform this calculation, it is crucial to assess the share of the consumption under ETS. This is a big challenge for all MS and our experience in ODYSSEE shows that only few countries are able to provide such statistics. In France if the CO2 emissions under the ETS are statistically determined, it is not the case for the final energy consumption. Therefore an ad-hoc expert assessment has been carried out

differentiating this share according to the branches (e.g. 90% for steel and 15% for the equipment branch for instance). These estimates should be taken with caution. Despite these difficulties, results are coherent since there are more savings when the ETS sectors are taken into account (1.83 Mtoe including ETS against 1.05 Mtoe without ETS or 0.31 Mtoe versus -0.07 Mtoe including negative savings). The weight of the chemical industry is crucial in this figure as well as the branch “other industries”, which is difficult to interpret. The negative savings in most other branches are directly a result of the economic crisis that resulted in lower load factor and thus efficiency of industrial equipment.
The French government has retained PIs excluding ETS branches generating positive saving only (1.05 Mtoe). Due to the methodological limits and the cost of the calculation of the non related ETS final consumption, we suggest that a proper monitoring should encompass the full final consumption.

The issue of the re-aggregation: how to calculate total energy savings for the target

There were lively discussions between experts and government on the concept of "total savings" in relation to policy-induced savings. We consider that the benefit of top-down approach is precisely to allow calculation of all energy savings, whatever their origin (energy efficiency policies, other policies, energy prices, autonomous progress, market forces, etc.). Total TD savings correspond to the resultant of all components of energy savings and are, if the data are statistically reliable, representative of the national level. Beyond this debate, there is still another dimension that affects the results: the re-aggregation of energy savings calculated at level of each end-use. A careful reading of the previous table on industry shows that out of the 12 branches concerned, only 5 generated energy savings. So if the re-aggregation takes into account only the branches that produce energy savings, the savings that can be claimed under the ESD rule amount to 1.05 Mtoe. They however become negative (-0,07 Mtoe) if the aggregation takes into account all branches. There is therefore a strong temptation for MS to retain only the end-uses and sub-sectors that produce energy savings following EC recommendations. **Table 6** and **Table 7** illustrates this issue in a systematic way for the French case for 2007-2008 and 2007-2009 respectively. ESD savings only add up positive savings while total savings is the sum of positive and negative savings.

Table 6: Sensitivity analysis - ESD savings versus total savings (France 2007-2008).

Mtoe	Industry (a)	Industry (b)	Household	Services	Transport	Total (c)
ESD savings (minimum)		73	2200	281	1374	**3928**
ESD savings (preferred)	389	73	1842	237	250	**2402**
Total savings (minimum)			1797	57	1372	**3226**
Total savings (preferred)	-2254	-1628	1842	223	132	**569**

Table 7: Sensitivity analysis - ESD savings versus total savings (France 2007-2009).

Mtoe	Industry (a)	Industry (b)	Household	Services	Transport	Total (c)
ESD savings (minimum)		1053	3566	429	2574	**7622**
ESD savings (preferred)	1839	1053	3061	415	630	**5159**
Total savings (minimum)		-70	3085	-9	2506	**5512**
Total savings (preferred)	311	-70	3061	-8	-1368	**1915**

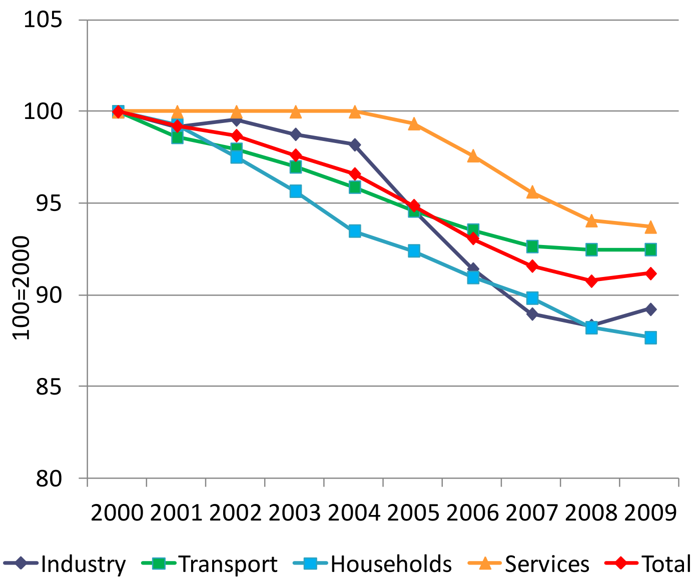
(a) Total industry; (b) Industry without ETS sectors; (c) Total without ETS;
Source: MEDDTL 2011 and authors of French NEEAP2.

At the most global level, whatever the year and the sector, total savings are always lower than total ESD related energy savings requirement (5.16 Mtoe compared with 1.92 Mtoe for PIs over 2007-2009). This is mainly due to two factors: 1) the sectors which have specific electrical end- uses (housing and services) generally provide negative savings due to data limitations which do not allow to properly clean out some structural effects such as the size effect for electrical appliances which have a larger impact than technical efficiency on the unit consumption; 2) for transport, cars generate positive energy savings often offset by negative savings for trucks and LDVs (Light Duty Vehicles). This is also due to data limitations and to the fact that the economic situation can negatively affect the level of service (here the traffics expressed in tkm). MS have the choice to select the energy saving of each of the end-use so as to optimize the savings to be reported in the NEEAP. The French government has selected the PIs for all end-uses but only accounted for positive energy savings. This estimate is in the range indicated in tables **6 and 7**.

The issue of the yearly variation of TD savings.

In the long term energy savings evolve smoothly even if we can find some exceptional developments more pronounced on some end-uses and countries due to national circumstances. This is what is observed in **figure 4** which shows the energy efficiency gains from the last 15 years (calculated excluding transportation, by reference to the definition of the new EED, and based on the index ODEX presented above)[18]. There are good reasons for these changes to fluctuate slightly as the system of efficient technologies is slowly changing to suit the penetration of new equipment (1% per year in France for new housing, for instance) and business cycles in industry and services. Behavioural savings in nature are more volatile and reversible. The rebound effect incorporated by construction in TD calculation also contributes to smooth the overall changes.

Figure 4: Energy efficiency index (ODEX) for final consumers (EU-27).



Source: ODYSSEE

However, around these trends (about 1.2% annual efficiency gain in Europe since 1990), energy savings evolve according to the socio-economic and energy contexts. The results reported by the MS in NEEAP2 only incorporate the results of two or three years (2008-2010). But these years were marked by atypical economic and energy developments. The most recent sectoral results of energy savings available in Europe (ADEME and Enerdata 2012) show very volatile and surprising trends, especially in industry.

18 Transport has been excluded as it is not included under the EED.

This evaluation highlights the discrepancies which will certainly go beyond the reality of changes in physical systems.

We have provided in Tables 6 and 7 all assessments over the two years 2008 and 2009. At the broadest level, if one refers to PIs finally, the annual rate of energy savings within the meaning of ESD is close to the 2010 target (2.5 Mtoe). It is less so if one counts all energy savings, including negative savings, using preferred indicators (0.6 Mtoe in 2008, 1.3 Mtoe in 2009). This can be explained by the significant impact shown by energy-intensive sectors that were badly affected by the crisis. But these results hide large differences between sectors and uses that will not be commented in detail. We observe, however, that the most significant fluctuations between 2008 and 2009 are found in industry and particularly in energy intensive industries and in trucking sector. These sectors are traditionally the most affected by economic fluctuations. From the analysis of the French case, one can conclude that the TD approach is relevant for annual assessments but that its interpretation is difficult when large fluctuations occur especially in the sectors most affected by abrupt economic changes. We consider the use of TD approach more relevant for long term analysis than for short term evaluations. One solution is to make an annual assessment based on a three years moving average[19].

Conclusions

France has an efficient statistical system that allows for a comprehensive implementation of the TD methodology proposed by the Commission. The TD calculation of energy savings reported in the French NEEAP2 shows that France has exceeded the interim target set by the ESD: 5.2 Mtoe in 2 years for a 3 years target (2008-2010) of 5 Mtoe. The presentation of results is quite transparent since it indicates the various optional calculations depending on the type of indicators (PIs, MIs or AIs) and the type of aggregation by end-use. The French government has followed three principles for the methodological choices: 1) preference for PIs when data permitted, 2) summing only positive energy savings and 3) no evaluation based on national indicators. We discussed the robustness of the results from five sensitivity analyzes that show significant differences depending on the options chosen. To minimize these differences that can lead to controversy, our analysis suggests some recommendations to be followed when reporting TD savings[20].
1) The same methodological choices must be kept throughout the reporting period[21]; 2) The TD method should not be understood as a default method compared to BU, but as the method that gives the image the more statistically representative of total energy savings. 3) We must try to disaggregate as much as possible to come close to the actual energy efficiency improvements in promoting enhanced statistics in key areas[22]. 4) The use of PIs is much better even though it may generate fewer savings than MIs or AIs under specific conditions. 5) It is recommended to take into account positive and negative savings, especially for electrical vs. thermal end-uses. 6) In transportation, MIs provide results which seem far from the reality of energy savings. It would be better to convince MS to survey their consumption per vehicle, which would allow calculating the PIs. 7) To avoid erratic results when too rapid changes occurs (crisis), it seems preferable to calculate yearly savings based on the concept of 3 years moving average. The ESD has clearly boosted the knowledge of the French administration in monitoring energy savings with TD. TD will be more effective as far as the statistics will improve. In that respect, Eurostat should be the entity able to provide such results in the European countries.

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19 This is the approach followed in ODYSSEE : savings in year t are the average of savings in year t-1, t and t+1.
20 This sensitivity analysis supports the EMEEES conclusions that the calculation proposed by the Commission only measures total savings and that a regression analysis to calculate policy-induced savings would be preferable.
21 With respect to either the choice between preferred and minimum indicators and as to the integration or not of negative savings in the total by sector.
22 This goes in favor of using preferred instead of minimum indicators and to go into more detail with these preferred indicators, for instance by separating savings in existing and new buildings.

References

ADEME 2012a. *Assistance à l'ANME (tunisie) pour la mise en place d'ndicateurs innovants d'efficacité énergétique.* Report prepared by Enerdata, Paris: ADEME.

ADEME 2012b. *Assistance à l'Aprue pour le monitoring de l'efficacité énergétique.* Report prepared by Enerdata, Paris: ADEME.

ADEME 2011. *Energy savings for France 2010 based on DATAMED a technico-economic database for energy saving calculation.* Report prepared by Enerdata, Paris: ADEME.

ADEME, Enerdata 2012. *Recent energy efficiency trends in EU 27, The ODYSSEE data base. 4-sectoral*, Report prepared by Enerdata under the coordination of Didier Bosseboeuf, Paris: ADEME.

Bosseboeuf, D. 2011. Financial schemes attached to the French white certificates scheme. Presentation for the EU Parliament, Brussels.

Bosseboeuf, D. 1995. *L'analyse technico-économique de la demande d'énergie du secteur transport: quels enseignements peut-on tirer de l'expérience occidentale pour les PVD asiatiques?* PhD-thesis, Grenoble, France: Université Pierre Mendès-France.

Bosseboeuf, D., Chedin, G. 2010. *Recent trend in energy efficiency in France based on ODYSSEE database.* Paris: ADEME.

Bosseboeuf, D., Lapillonne, B., Eichhammer, W. 2005. "Measuring energy efficiency progress in the EU: the energy efficiency index ODEX". *In Proceedings of the ECEEE 2005 Summer Study*, paper 5,211, 1127-1135, Stockholm: European Council for an Energy Efficient Economy.

Bosseboeuf, D., Chateau, B., Lapillonne, B. 1997. "Cross-country comparison on energy efficiency indicators: the on-going European effort towards a common methodology". *Energy Policy*, 25(7-9), 673-682.

Chateau, B., Lapillonne, B. 1982. *Energy demand: facts and trends: a comparative analysis of industrialized countries*. Vienna: Springer-Verlag.

EC 2010. *Recommendations on measurement and verification methods in the framework of Directive 2006/32/EC on energy end-use efficiency and energy services*. Brussels: European Commission.

Eichhammer, W., Mannsbart, W. 1997. "Industrial energy efficiency: Indicators for a European cross-country comparison of energy efficiency in the manufacturing industry". *Energy Policy*, 25(7-9), 759-772.

Gerdes, J., Boonekamp, P.G.M. 2011. *Uncertainty in Odyssee indicators and energy savings – Development of a methodology and first results*. ECN research report, Petten, The Netherlands: Energy Research Centre of the Netherlands.

Howarth, R.B., Schipper, L., Duerr, P.A., Ström, S. 1991. "Manufacturing energy use in eight OECD countries: Decomposing the impacts of changes in output, industry structure and energy intensity". *Energy Economics*, 13(2), 135-142.

Lapillonne, B., Desbrosses, N. 2009. *Top down evaluation methods and energy savings. Case studies*. Summary report for the EMEEES project, Grenoble: Enerdata.

Lapillonne, B., Bosseboeuf, D., Thomas, S. 2009. *Top down evaluation methods of energy savings*. Summary report for the EMEEES project, Grenoble : Enerdata.

MEDDTL 2011. *Second National Energy Efficiency Action Plan of France*. Paris: Ministry of Ecology, Sustainable Development, Transport and Housing, Ministry of the Economy, Finance and Industry.

Morovic, T., Gerritse, G., Jaeckel, G., Jochem, E., Mannsbart, W., Poppke, H., et al. 1989. *Energy conservation indicators-II*. New York, NY: Springer-Verlag New York Inc.

ODYSSEE-MURE 2009. *Energy Efficiency Trends and Policies in the EU27. Results of the ODYSSEE-MURE project*. Report prepared by Bruno Lapillonne (ENERDATA), Wolfgang Eichhammer (Fraunhofer ISI) and Piet Boonekamp (ECN) under the coordination of Didier Bosseboeuf (ADEME), October 2009, Paris: ADEME.

Schipper, L., Meyer, S. 1992. *Energy efficiency and human activity: past trends, future prospects*. Cambridge, UK: Cambridge University Press,.

Thomas, S., Boonekamp, P., Vreuls, H., Broc, J.-S., Bosseboeuf, D., Lapillonne, B., Labanca, N. 2012. "How to measure the overall energy savings linked to policies and energy services at the national level?", *Energy Efficiency*, 5(1), 19-35.

Wuppertal Institute on behalf of the EMEEES Consortium 2009. *Measuring and reporting energy savings for the energy service directives-how it can be done*. Results and recommendations from the EMEES project, Wuppertal: Wuppertal Institute for Climate, Environment, Energy.