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Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services

Briefing on existing evaluation practice and experience

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coordinated by

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The Project in brief

The objective of this project is to assist the European Commission in developing harmonised evaluation methods. It aims to design methods to evaluate the measures implemented to achieve the 9% energy savings target set out in the EU Directive (2006/32/EC) (ESD) on energy end-use efficiency and energy services. The assistance by the project and its partners is delivered through practical advice, technical support and results. It includes the development of concrete methods for the evaluation of single programmes, services and measures (mostly bottom-up), as well as schemes for monitoring the overall impact of all measures implemented in a Member State (combination of bottom-up and top-down).

Consortium

The project is co-ordinated by the Wuppertal Institute. The 21 project partners are:

Project Partner	Country
Wuppertal Institute for Climate, Environment and Energy (WI)	D
Agence de l'Environnement et de la Maitrise de l'Energie (ADEME)	F
SenterNovem	NL
Energy research Centre of the Netherlands (ECN)	NL
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SRC International A/S (SRCI)	DK
Politecnico di Milano, Dipartimento di Energetica, eERG	I
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Österreichische Energieagentur – Austrian Energy Agency (A.E.A.)	A
Ekodoma	LV
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Electricité de France (EdF)	F
Enova SF	N
Motiva Oy	FIN
Department for Environment, Food and Rural Affairs (DEFRA)	UK
ISR – University of Coimbra (ISR-UC)	P
KE Marked A/S (KEM)	DK
Centre for Renewable Energy Sources (CRES)	GR

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1 Summary

This briefing summarises results from the EMEEES project[1]. The purpose is to review and assess existing evaluation practices and thus provide a background and basis for developing and proposing evaluation methods under the EU Directive on energy end-use efficiency and energy services (ESD). The review presented here shows that there is considerable experience of evaluating various types of energy efficiency improvement measures in all sectors. The methodological approaches for quantifying energy savings exist, although accurate quantification and verification of savings has not always been a priority in past evaluations. Evaluation is not only possible – as well as required under the ESD – it is also necessary for the continuous development and refinement of energy efficiency policies and other energy efficiency improvement measures. However, evaluation is an area where a single best method cannot be devised. Methods must evolve and be adapted to the measure and context at hand. The quality of evaluations will improve as experience accrues through learning-by-doing. This will not only benefit the cost-effective implementation of the Directive, but also provide a basis for future and probably more ambitious energy efficiency policy efforts.

[1] The project EMEEES - Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services" has the objective of assisting the European Commission in developing harmonised evaluation methods. More information is available at www.evaluate-energy-savings.org.

2 Background

The EU Directive on energy end-use efficiency and energy services (ESD) requires that energy savings resulting from energy efficiency improvement (EEI) measures, including energy services, are monitored, verified and reported by the Member States. The objective of WP2 in the EMEEES project is to provide a qualified overview of existing practices and experiences in monitoring and evaluation methods. Our purpose here in this briefing is to review the existing experiences, as well as draw and discuss some general conclusions that can guide the development of methods under the ESD. For this purpose, 26 case studies were selected. The cases were selected from a longer list gathered in this project in order to get a balance between sectors, types of EEI measures, and evaluation methods. Other criteria for the selection were the availability of information and the expectation that there would be well documented quantifications of the savings. The cases represent EEI measures that target one or several of the residential, tertiary, industrial, and transport sectors.

3 Evaluation framework

The 26 case studies selected for the review have been organised by sector and classified according to the main element of the respective EEI measure. Since EMEEES is focused on the monitoring, quantification and verification of energy savings, an effort was made to categorise the evaluations according to which method for quantification was used. The classification defines in a first step two broader categories of methods: bottom-up and top-down. The bottom-up evaluation methods are categorised according to the following definitions and methods for calculating energy savings:

- ***Direct measurement*** of energy savings with the subject of evaluation being a participant in a EEI measure;
- ***Energy bills & sales data analysis*** to determine energy savings with the subject of evaluation being a participant. Billing analysis can be based on samples or all participants. It needs a control group and/or a discrete choice modelling approach to identify which energy savings are due to an EEI measure;
- ***Enhanced engineering*** estimate can involve a mix of audit results, energy modelling, and ex-post measurements having either a participant or a certain type of measure or technology as the subject of the evaluation;
- ***Mixed deemed and ex-post evaluation*** concerns the energy savings from a certain type of measure or technology and can be based on equipment sales data, measurements, samples, etc. It is not considered as exact as enhanced engineering estimate;
- ***Deemed estimate*** quantifies the energy savings from a certain type of measure or technology and ascribes the same amount of energy savings to each unit for a specific type of measure. This amount may be more or less carefully determined;
- ***Bottom-up modelling based on surveys*** of population samples is modelling the whole stock of buildings or equipment for modelling the whole energy consumption of an end-use or sector. The surveys are needed to identify which end-use EEI actions have been taken, and why. The surveys can target participants or certain types of measures to determine energy savings. A survey can be full-fledged statistical surveys including control groups but it may also be a simpler effort made to estimate a baseline[2].

Top-down evaluations are not well represented in our case-studies. Top-down is often taken to mean the use of econometric modelling for the purpose of determining energy savings resulting from taxes or other measures that influence prices. However, in the context of the ESD a top-down calculation method also means analysing various aggregated sector or national indicators without using an economic model. One example is tracking the average national specific energy demand for space heating in

2 However, modelling the whole stock can be considered a top-down method unless the surveys are tracking, which end-use EEI actions have been taken due to EEI measures.

GJ per square meter and year. Hence, in this study, top-down has been extended to include also the use of such aggregated indicators, using the following definitions and methods for calculating energy savings:

- ***Equipment indicators*** for monitoring the diffusion of certain types of technologies, e.g., high efficiency appliances, in order mainly to evaluate single end-use EEI actions. The method involves assessing the effects of autonomous energy savings, hidden structure effects, and earlier EEI measures[3];
- ***End-use or sector indicators*** for monitoring specific consumption indicators for a certain end-use (such as kWh/m^2 for space heating) or a sector in order mainly to evaluate the total effect of packages of EEI measures, but correcting for autonomous energy savings, hidden structure effects, and earlier EEI measures;
- ***Econometric*** or other models using economic indicators for quantifying energy savings resulting mainly from taxes but in principle also to assess the effects of general EEI measures such as voluntary agreements with industry.

In addition to assessing how the energy savings were calculated, the evaluations were also assessed with respect to the use of gross-to-net correction factors, i.e., how calculated energy savings were adjusted to include only such energy savings that can be attributed to the specific EEI measure. For bottom-up methods this includes correcting for double-counting, multiplier effects, free-riders, and direct rebound effects. For top-down methods this includes correcting for hidden structural effects, economic rebound effects, earlier policy and autonomous energy savings.

The review presented here is based mainly on various evaluation reports but also conference papers and information from the web pages of energy agencies and the like. The gathered information has in several cases been complemented through personal communication with relevant individuals. The final categorisation of each evaluation is based on an overall assessment and qualified judgement of the gathered data and information.

[3] However, equipment indicators can be considered a bottom-up method, if the change in the indicator is entirely due to one or a package of EEI measures.

4 Overview of existing methods

The results of the case studies analysis have been summarised in two tables, Table 1 indicating the type of evaluation method, and Table 2 indicating the use of gross-to-net correction of calculated energy savings. Most measures entail regulatory (R), financial (F), informative (I) components at the same time. One is an energy service (S). For example, a white certificates scheme has a strong regulatory component although the financial incentive is also central, rendering it an R/F classification. It should be noted that saving energy is often not the only objective of EEI measures. Other objectives can include social, urban rehabilitation or environmental aspects. For example, the overall objective of one of the KfW buildings programmes was to provide soft loans to the general modernisation of buildings in the Eastern parts of Germany. This means that existing evaluations typically include several aspects other than the energy savings.

It should be noted that one EEI measure may target several sectors, end-uses or technologies. The quantification of energy savings in different parts may be more or less thorough and documented. Hence, the indications given on which bottom-up evaluation method has been used is based on our overall assessment of evaluations of the respective EEI measure. Most evaluations rely on deemed savings, mixed deemed and ex-post, and enhanced engineering estimates. Direct measurements are not common according to Table 1, but this is hiding the fact that deemed estimates can often be based on direct measurements, at least in part, and deemed estimates can therefore be quite accurate, depending on the case.

Table 1. Evaluation methods used for 26 EEI measures

	EEI measure	Country	Main type of measure	Bottom-up evaluation method used						Top-down evaluation method used		
				Direct measurement	Bills & sales data analysis	Enhanced eng. Estimate	Mixed deemed and ex-post	Deemed estimate	Bottom-up modelling	Equipment diffusion	End-use/sector indicators	Econometric
Residential and tertiary	Energy Efficiency Commitment	UK	R/F				X	X	X	X		
	FEMP	US	R		X	X		X	X		X	
	Building EE, Oregon	US	F	X		X			X			
	EPS Building Code	NL	R	X				X	X			
	Building regulation in Carugate	IT	R					X				
	Elsparefonden	DK	F		X		X	X				
	Applicance labelling	NL	I/F						X	X		
	Energy+ – Europe	EU	I				X			X		
	KfW buildings programme	DE	F			X		X				
	Helles NRW	DE	F/I				X					
	Technology Procurement	SE	I/F					X	X			
Industry	Free energy audits	DK	I/F		X	X		X				
	Investment Deduction Scheme	NL	F/R				X					
	Voluntary Agreement	DK	F/R				X	X				
	Programme for EEI in industry	SE	F/R			X		X				
	Energy Audit Program	FI	I/F			X	X					
	Industrial EE Network	NO	I/F			X		X				
Transport	ACEA	EU	R							X	X	
	Ecodriving	NL	I					X	X			
	Congestion charging Stockholm	SE	F/R	X	X	X	X		X	X	X	
	Car sharing[4]	DE	S					X	X			
General	Energy taxes	SE	F									X
	White certificates	IT	R/F				X	X				
	White certificates	FR	R/F				X	X				
	RUE Obligations	BE	R/F				X	X				
	EE Portfolio, California	US	R/F	X	X	X	X	X	X			

It appears that technology-focused EEI measures in the residential sector are generally easier to evaluate than measures in other sectors. In promotional campaigns combined with financial incentives for improved lighting, insulation retrofits, or efficient

4 Car sharing means in this context that a fleet of cars is made available to members of a car share group that typically is organised as a company or a cooperative. The term “car pooling” is sometimes used with the same meaning.

appliances, participation rates can be monitored, free-riders estimated, and average energy savings calculated on the basis of measurements and samples. EEI measures in industry on the other hand are typically based on voluntary approaches and entail energy audits, energy management systems, and sometimes financial support for investments. However, in industry it may be more difficult to isolate the impact of a EEI measure. Frequently, the energy savings are calculated based on self-reported information concerning investments made and ex-ante enhanced engineering estimates resulting from the energy audit. It may be difficult to establish if EEI investments would have, or should have, been made without the EEI measure. Required rates of return may vary with business cycles, non-energy benefits may be an important motivation for investments made, and changes in production may complicate ex-post evaluations.

Although many of the evaluations lack rigor concerning quantification and verification, **our assessment shows that energy savings can be calculated bottom-up**. Depending on the type of measures, their interaction and their sector specific conditions, various uncertainties can be associated with them. In the case of free energy audits in Denmark, an effort was made to validate the effect also with a second method, i.e., by comparing aggregate indicators such as electricity use per employee of companies that received an energy audit with that of a control group. However, this billing analysis was inconclusive, whereas an incomplete but detailed evaluation based on a non-representative sample of participants was able to quantify energy savings in the sample.

In addition to assessing how energy savings are calculated, the use of gross-to-net correction factors was investigated. Direct rebound effects that are well known, for example increased indoor temperature due to lower heating bills, are typically considered. The level of free riders can be relatively easily estimated against a baseline in a campaign which is limited in time. It is more difficult to determine in a long-running program such as the one by Elsparefonden in Denmark, where subsidies are given for switching away from electric heating with simultaneous market transformation effects that reduce investment costs. It is likely that multiplier effects from lower prices compensate for free riders, but in cases such as this it is difficult to establish a clear baseline. Generally, the gross-to-net correction is discussed only in qualitative terms in the case-studies, or is based on assumptions or incomplete information.

Table 2. The use of gross-to-net correction factors in evaluations [5]

	EEI measure	Country	Main type of measure	Typical gross-to-net correction factors in bottom-up evaluations				Typical gross-to-net correction factors in top-down evaluations			
				Double counting	Multiplier effect	Free-rider effect	Direct rebound effect	Hidden Strucutre effects	Economic rebound effect	Earlier policy	Autonomous savings
Residential and tertiary	Energy Efficiency Committment	UK	R/F	X	X	X					
	FEMP	US	R	X	X	X					
	Building EE, Oregon	US	F		X	X					
	EPS Building Code	NL	R	X	X		X				
	Building regulation in Carugate	IT	R								
	Elsparefonden	DK	F		X		X				
	Applicance labelling	NL	I/F	X	X	X					
	Energy+ – Europe	EU	I	X							
	KfW bldgs program	DE	F	X							
	Helles NRW	DE	F/I		X	X					
	Tech. Procurement	SE	I/F			X					
Industry	Free energy audits	DK	I/F			X					
	Investment Deduction Scheme	NL	F/R	X	X	X					
	Voluntary Agreement	DK	F/R		X	X					
	Program for EEI in industry	SE	F/R								
	Energy Audit Program	FI	I/F	X		X					
	Industrial EE Network	NO	I/F			X					
Transport	ACEA	EU	R				X				
	Ecodriving	NL	I			X				X	
	Congestion charging [6]	SE	F/R	X	X			X		X	
	Car sharing [6]	DE	I				X	X			
General	Energy taxes	SE	F								
	White certificates	IT	R/F								
	White certificates	FR	R/F			X					
	RUE Obligations	BE	R/F								
	EE Portfolio, California	US	R/F		X	X					

[5] The correction factors used in bottom-up and in top-down methods tend to be different. *Autonomous savings* and the effect of *earlier policies* can be implicitly considered in the bottom-up methods when setting baselines.

[6] Car sharing means in this context that a fleet of cars is made available to members of a car share group that typically is organised as a company or a cooperative. The term "car pooling" is sometimes used with the same meaning.

5 Evaluations in different sectors

The conditions in terms of end-uses, technical options, actors and organisational factors vary widely across different sectors. It is therefore useful to present and discuss the results of the analysis by sector: the residential, tertiary, industrial and transport sectors, as well as for general EEI measures and EEI mechanisms such as white certificate schemes. Energy taxes, for which there is only one case study, are typically evaluated top-down through econometric modelling. Evaluation of taxes is not included below. For each sector we briefly present the EEI measures, the methods used for quantification, and the issue of gross-to-net correction factors.

5.1 Residential sector

Space and water heating, as well as electricity use in appliances and lighting dominate energy use in the residential sector. The energy using products and systems are more standardised than in the industrial and the tertiary sector. Most of the EEI measures are information oriented (e.g., labelling), sometimes with subsidies, and regulatory (e.g., minimum efficiency standards and building codes). Another characteristic of the residential sector is the social aspect since end-users –households - have very different purchasing power. In many cases, EEI measures are addressing also social issues by financing energy efficiency as a way of increasing comfort standards or reducing fuel poverty.

The residential sector is addressed by 14 of the evaluation case studies analysed, the majority covering also the tertiary sector. The evaluation methods cover different types of EEI measures, some addressing many end-uses while others are end-use specific. Several evaluations cover broad instruments including two tradable white certificates systems (Italy and France), non-tradable obligations on energy companies (RUE Obligations in Flanders and the UK EEC), and funds collected from energy companies (Elsparefonden and the California EE Portfolio). These address almost all end-uses and several individual measures (subsidies, audits, information, energy services etc) and therefore are composed of many evaluation methods. There are two case studies evaluating building minimum energy performance requirements (EPS in the Netherlands and Carugate building regulation), which address both the building shell and the heating systems. There are also methods evaluating specific programmes providing subsidies to building refurbishment like the KfW programme or targeting electric appliances (energy labelling in the Netherlands, and Energy Plus). One case, Helles NRW in Germany, concerns efficient lighting (compact fluorescent lamps). The Swedish technology procurement evaluation covers several technologies and sectors but the most important technology from an energy savings perspective is ground source heat pumps.

The most common method used is deemed savings, i.e. estimations based on assessments of unitary energy savings multiplied by the number of units, which is used in all instruments and for all end-uses. It is in some cases complemented by other methods such as stock modelling for example in the UK EEC and in the labelling program in the Netherlands. Direct measurements are used as a complement in the EPS building codes in the Netherlands. Mixed deemed and ex post was also used in the lighting programme Helles NRW in Germany and ex-post estimates are used in Energy+. The evaluation of EEI measures targeting the building shell and heating systems –retrofit or new construction - is also dominated by deemed savings, complemented by building energy models and in some cases stock modelling and with some direct measurements (UK EEC and in the EPS building code in the Netherlands). This combination of models and measurements for validation seems particularly appropriate since building energy can vary considerably with user habits. The only EEI measure where all kinds of bottom-up evaluation methods are used is the EE portfolio in California.

Gross-to-Net corrections of energy savings are frequently assessed mainly for multiplier effects and for direct rebound effects. Multiplier effects are mostly market transformation effects resulting from a higher penetration of energy-efficient products (e.g. appliances, windows, boilers, lighting equipment) and practices (installation of insulation, switching from direct electric heating to heat pumps or district heating), often due to a higher demand driving down the prices. The correction for the direct rebound effect is mostly done for space heating as a result of measures targeting improvements in the building shell or in the heating system. Both effects – multiplier and direct rebound effect – are mainly taken into account in the UK EEC, in Elsparefonden in Denmark and in the two case studies from the Netherlands. Free-riders are taken into account mainly when subsidies are involved, whereas they do not apply to minimum energy performance requirements. Double counting is only taken into account when several instruments target the same end-use or in a few cases to assess the interaction between two efficiency improvements in two end-uses (e.g. lighting and air conditioning). For example, the UK EEC interplays with other programs (e.g., Warm Front Warm Deal and the Scottish Executive Central Heating Programs). The most detailed evaluation methods concerning gross-to-net energy savings are the ones used by the UK EEC, Elsparefonden, and the Dutch EPS building code and the labelling program.

5.2 Tertiary sector

The tertiary sector is a relatively heterogeneous sector with different needs for energy and energy services mainly in buildings.

About 10-12 of the evaluation case studies include the tertiary sector. The evaluation methodology used under each case study has been analysed. However, it is difficult to draw any firm conclusions concerning good practice due to the specificity and particular legal and framework conditions of each case study. The California EE Portfolio and the U.S. Federal Energy Management Program (FEMP) target, among other types of measures, education and training in the tertiary sector. The informational and educational component is generally strong in this sector. It is present, for example, in the Dutch EPS through campaigns, guidebooks, demonstration programmes and subsidies for demonstration projects. FEMP and the Dutch EPS also include regulatory components. Architects, design engineers and consultants, installers of energy systems and building contractors and inspectors are among the main targets of standards and other regulations. Financial incentives (e.g., grants, subsidies, and fiscal incentives) are used in several cases including Oregon's Building Efficiency Program, FEMP and the California EE Portfolio. Procurement guidelines and regulation which stipulates energy efficient equipment is sometimes used in the public sector.

Buildings in the tertiary sector are often large enough to warrant energy audits and the use of building energy models for assessing and calculating the effects of different options. For quantification and verification of energy savings, the most commonly used methods include enhanced engineering estimates through energy audits, mixed deemed and ex-post, and deemed estimates. In white certificates schemes, energy savings are often calculated according to predetermined formulas and factors (see below). Baselines are usually calculated based on ex-ante estimates, surveys and audit results data. A common method is considering a reference situation (EPS building code) or estimating continued effects of past programs (FEMP) where the latter requires accurate annual progress reports. Surveys and inspections have been used to assess the implementation of the Dutch EPS. Oregon's Building Efficiency Program developed a complex statistical approach to estimate the realization rate, based on the engineering reviews and site visits. Because one of the sources of uncertainty is the lack of verified measures energy savings, recommendations for ex-post analysis and detailed monitoring systems are constant in the different programmes, stating that this would reduce uncertainty.

Free-riders and multiplier effects are the most commonly considered gross-to-net correction factors but they are usually dealt with in qualitative terms or based on assumptions. In some cases such as the Oregon program there are defined factors to adjust for free-rider and multiplier effects according to different end-uses. Double counting is also an important aspect in the tertiary sector since building energy efficiency is often influenced by many different programs, building codes, etc. Again, most evaluations take a qualitative approach. For example, the FEMP interplays with other programmes (e.g., with tax benefits, ASHRAE standards, and utility DSM programs), and so does EPS (with various subsidies and fiscal incentives). Hence, quantification of the net impact with gross-to-net correction for individual programs appears as a necessary but difficult task in the tertiary sector.

5.3 Industrial sector

The case studies include five to six cases, for which the main target is the industrial sector. Furthermore, the French and Italian white certificates, the RUE obligation in Flanders, and the California EE Portfolio also include some energy saving options in the industrial sector. The industrial sector is more complex and even less coherent than the residential and tertiary sectors. Opportunities for, and barriers to, energy efficiency vary widely. In energy intensive industries, costs for process energy use account for a large share of total production costs, and energy efficiency has improved also during long periods of falling real energy prices. In contrast, energy use in light manufacturing may be dominated by non-process energy uses such as lighting, compressed air, and ventilation. The conditions are different but in all cases there are potentials for energy savings that remain untapped because necessary investments are not considered profitable, or because profitable investments are not made for various reasons.

The EEI measures are dominated by various types of supporting measures such as voluntary agreements, and free or subsidized energy audits. In the case of White Certificates and similar, the eligible options are almost exclusively in the areas of high efficiency motors, variable speed drives, lighting, compressed air systems, etc. More process specific options are much harder to “standardise” in these schemes.

Quantification of energy savings is made in the evaluations, but verification with rigor does not seem to have been a high priority in the cases included here. Evaluations show that energy savings are high enough to motivate the EEI measure. For the most part, energy savings are determined based on what energy auditors, industry companies, or project developers report to the respective agency. Evaluations are based on enhanced engineering estimates, mixed deemed and ex-post, as well as deemed estimates. Some energy savings are reported ex-post but it is not clear how rigorously the energy savings were determined, i.e., whether based on estimates or measurements. The lifetime of energy savings is generally not considered in the evaluations. Quantitative energy savings targets may not have been formulated at all, and when formulated, the target is typically to generate an amount of first year savings.

Gross-to-net correction of energy savings is considered in several of the cases. The most common correction is to consider the free-rider effect but it is mainly done in qualitative terms. In the case of Norway, the free-rider effect was estimated, based on interpreting answers in a questionnaire, to be between 10% and 50%. In the case of Finland, it was estimated by the energy auditors that about 10-15% of the energy savings options would have been implemented also without the audit. Consideration of double-counting and multiplier effects is typically included in even more qualitative terms. These effects are typically discussed and considered but not quantified since it is beyond the scope, or not considered possible, to put a number on them. Direct rebound effects are not considered in the cases here, perhaps because this type of rebound is not really a valid concern in the context of industrial energy efficiency.

In industry, it is generally difficult to establish if EEI investments would have, or even should have, been made without the EEI measure. Required rates of return may vary with business cycles, as well as plans for expanding or moving production. Non-energy benefits may be an important motivation for investments made, and changes in production may complicate ex-post evaluations. A specific difficulty is the existence of information asymmetry which makes it difficult to assess not only the direct quantification of energy savings but also the gross-to-net correction of savings.

5.4 Transport sector

The transport sector is in one sense the most difficult from the perspective of evaluating energy savings. By regular definitions of the transport sector, its energy use consists of liquid fuels use in various transport modes and some electricity. On the one hand, fuel savings from improvements in vehicle fuel efficiency are relatively easy to calculate by looking at specific fuel consumption multiplied by distances driven. On the other hand, transport is a derived demand, i.e., investments in transport infrastructure and thus improved access generates more traffic. Hence, changes in transport systems can have a range of short and long term effects. For example, improved public transport may result in increased transport demand, which overshadows fuel savings that result from modal shifts. Transport demand is also determined by spatial planning and infrastructure investments in road, rail, etc. There are also measures such as road and congestion charges for which effects may be measured but not without significant effort due to various effects on traffic flows and choice of transport modes.

In this study the transport sector is represented only through four case studies: the agreement with car manufacturers to reduce the specific fuel consumption of new cars (ACEA), the eco-driving scheme in Netherlands, the Stockholm congestion charging trial, and an analysis of the development and potentials of “car sharing” schemes in Germany. Reducing local environmental effects (local pollution, noise, etc), dependence on oil, or congestion are important motivations for these EEI measures. In the case of Stockholm, energy savings are a less important ancillary benefit to the main objective of reducing congestion.

In principle, energy savings from the ACEA agreement can be estimated from baseline car sales and information on distances driven. In reality, lack of data means that the exact energy savings cannot be determined. Estimates are based on test cycle emissions and not real conditions. For car-sharing and eco-driving, the calculated energy savings rely on even more assumptions that are more or less substantiated. The congestion charging trial included changes in access to parking and public transport and the whole package of measures was extensively evaluated using several methods. Road and congestion charges typically generate new flows of traffic outside of charging areas which may be difficult to monitor.

Gross-to-net corrections are carefully covered in the evaluation of the Stockholm congestion trial and considered but only dealt with qualitatively in the other cases, for example concerning rebound effects from fuel efficiency. In the context of the ESD, quantification of energy savings in the transport sector from some types of EEI measures may present particular challenges. Effects of infrastructure investments, traffic planning and public transport measures are difficult to quantify and typically case-specific, complicating the formulation of harmonised methods with default values for what the effects may be. The effects of eco-driving and car-sharing may also vary depending on design as well as geographical and cultural context.

5.5 General EEI measures and EEI mechanisms

In this category of general measures (i.e., cross-sectoral and horizontal measures according to ESD nomenclature) and EEI mechanisms (i.e., instruments facilitating the implementation of EEI measures) we include taxes, cross-cutting schemes such as the California EE portfolio (see above), and white certificates. Determining the effect of taxes is typically done using econometric modelling and is not discussed further. The cross-cutting EEI measures provide a framework for energy service companies and other market actors to provide energy efficiency to a range of energy end-users in different sectors. Hence, there is not one method to evaluate the effects and consequently the evaluations typically employ a range of evaluation methods as indicated in Table 1. In this section we focus on the emerging white certificates schemes. These are an EEI mechanism triggering a whole variety of different EEI measures, which can both be EEI programmes and energy services.

A particular feature of white certificate schemes is that they work based on defined energy savings per type of measure. These schemes have not been used long enough to evaluate and verify energy savings but nevertheless should be discussed here. It is interesting to note in the case of white certificates that the energy savings resulting from options such as variable speed drives and improved compressed air system are predetermined according to technical sheets, with only one or two parameters (such as installed power) monitored on each site. In reality, such savings may vary widely from case to case. This need not be a problem if the predetermined level is reasonable and verified through random measured samples. Real energy savings from investments in such options are actually likely to generate greater savings than the predetermined levels, depending on how levels are defined and assuming that the most profitable options are implemented. It may, however, be a problem in terms of generating high levels of free-riders.

In the case of white certificates in Italy and France there are long lists of eligible options with technical sheets specifying how energy savings are calculated. As noted above, in industry the eligible options are almost exclusively in areas that can be standardized in these schemes. However, in the Italian case the project developer can also apply for certificates for energy savings options that are not in the predetermined list of options. A potential problem with lists of eligible options is that other options or innovative solutions are not implemented.

Gross-to-net energy savings corrections are not considered - or are considered to have a negligible total effect - in the white certificates in Italy and France as well as in the RUE obligations in Flanders. The lifetime of measures is important in white certificates since it determines how many certificates a certain option generates. In the case of Italy, all options in industry have been assigned a lifetime of five years. In France life times considered for the industry sector are typically much longer (10-15 years) but a discount factor of 4% is applied to discount future energy savings. All of this indicates that it will not be possible to directly use the results for monitoring energy savings for the ESD without appropriate conversion and correction.

White certificates are interesting in the context of the ESD since they apply standardized energy savings to specified measures. Assuming that these standardized savings are reasonably correct, it simplifies monitoring and evaluation needs. Hence, it will be an important task to update and verify the formulas and factors used for calculating the energy savings, as well as their real application.

6 Analysis and discussion

The 26 case studies included here represent a cross-section of evaluation methods in sevaral types of EEI measures in the EU and in the USA. In most cases, each evaluation includes several different methods for quantifying energy savings. Our purpose here is to review the existing experiences, as well as draw and discuss some general conclusions that can guide the development of methods under the ESD. The overview has shown a considerable range of EEI measures and illustrated how in some cases it may be relatively easy to monitor and evaluate saving, e.g., in a campaign for energy-efficient appliances, combining “soft” and “hard” financial incentives. However, even in such cases it may be difficult to do accurate gross-to-net corrections for multiplier effects, free-riders, other policies, etc. One approach to handle such problems under the ESD may be to link the evaluation of energy savings more to the specific end-uses and sectors than to specific EEI measures.

It appears that evaluations from the USA are generally more ambitious, systematic and of higher quality. This is consistent with the long history of demand side management programs and decades of experience with this type of energy efficiency evaluations there. However, also in the USA cases there are concerns about the real level of energy savings and the lack of rigor in the evaluations. One conclusion to draw is that the ESD will have to live with certain levels of uncertainty. It may be better to have simple methods than exact methods – keeping in mind that the main objective is to improve energy efficiency and not necessarily to measure it 100% accurately.

Another issue is whether the methods need to be harmonised between Member States. There is an obvious risk that Member States will exaggerate energy savings in order to show compliance with the ESD targets. It is a relatively new situation that national energy agencies or other agents will have a strong incentive to show high energy savings from various EEI measures and will share this incentive with, for example, energy service companies on the white certificates market. The effect may be that resources are wasted and opportunities to generate real additional energy savings are foregone. The losers in this case will be consumers and tax payers at the national level.

Evaluations can be motivated by the need to legitimise a policy, to learn and improve, or to motivate the termination of a policy. In the case of the ESD, an important objective is to quantify and verify energy savings but in doing so the evaluations can also contribute to the continuous improvement of EEI measures. It is here that bottom-up methods have a distinct advantage due to the information they can yield on opportunities for improving the EEI measure and adjusting it to changing conditions. Detailed and strict planning is necessary in order to increase the quality and reduce costs of evaluation, monitoring and verification processes. This can include prescriptive protocols for evaluation, reporting and verification, containing clear definitions and spreadsheets helping the use of methods (e.g. life-cycle cost assessment) including default parameters and error estimates. It would also improve the feedback to facilitate improvement of the EEI measures. There are also important synergies with enforcement and compliance, for example if sampling is used for verifying the correct application of building codes.

A caveat worth mentioning is the risk that short term resource acquisition of energy savings may be favoured over EEI measures with a longer term target such as RTD, industrial innovation, and market transformation efforts. Although energy savings should accrue 2008-2016 under ESD there is also the stated European Council ambition for 20% energy savings in 2020. Hence, it is important that the longer term is not forgotten when working to comply with the ESD and, thus, methods for assessing EEI measures with longer term effects should also be developed.

7 Conclusions

This review of existing practices in evaluation covers **many different EEI measures and almost all end uses**. It has confirmed that **reasonably accurate quantifications of energy savings can be made**. It has also shown that there may be different **uncertainties** involved for different EEI measures and their interaction, as well as for different sectors and end-uses. These will have to be addressed in a very **pragmatic** way during the development of the **harmonised monitoring and evaluation system for the ESD**. Although the principal objective of the Energy Services Directive is to generate additional energy savings, it also requires that they are verified. Accurate quantification and verification of energy savings, including gross-to-net corrections, has not been a high priority in many past evaluations but the basic approaches and methods exist. The Directive offers an opportunity not only for improving methodologies for verifying energy savings but also for improving the overall quality of evaluations. Well planned, structured and systematic evaluations will also benefit the development and improvement of EEI measures in the longer term. It is important that the “verifiability” of energy savings does not influence the portfolio of EEI measures to be biased against options, which do not offer easily measurable energy savings. The need to accelerate the rate of energy efficiency improvement in the long term means that RD&D and technology procurement or market transformation efforts are also important, although it may be more challenging to measure the effects under this Directive.