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

Assessment of existing evaluation practice and experience

Deliverable D1 – Final Version

Authors

Lars J. Nilsson, Lund University on behalf of the Swedish Energy Agency
Carlos Lopes, workpackage coordinator, Swedish Energy Agency
Paula Fonseca and Mark Araújo, University of Coimbra
Nicola Labanca, Politecnico di Milano

Special contribution and review

Stefan Thomas, Wuppertal Institute

18 April 2008

coordinated by
Wuppertal Institute for Climate, Environment and Energy

supported by
Intelligent Energy Europe

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)	DE
Agence de l'Environnement et de la Maitrise de l'Energie (ADEME)	FR
SenterNovem	NL
Energy research Centre of the Netherlands (ECN)	NL
Enerdata sas	FR
Fraunhofer-Institut für System- und Innovationsforschung (FhG-ISI)	DE
SRC International A/S (SRCI)	DK
Politecnico di Milano, Dipartimento di Energetica, eERG	IT
AGH University of Science and Technology (AGH-UST)	PL
Österreichische Energieagentur – Austrian Energy Agency (A.E.A.)	AT
Ekodoma	LV
Istituto di Studi per l'Integrazione dei Sistemi (ISIS)	IT
Swedish Energy Agency (STEM)	SE
Association pour la Recherche et le Développement des Méthodes et Processus Industriels (ARMINES)	FR
Electricité de France (EdF)	FR
Enova SF	NO
Motiva Oy	FI
Department for Environment, Food and Rural Affairs (DEFRA)	UK
ISR – University of Coimbra (ISR-UC)	PT
DONG Energy (DONG)	DK
Centre for Renewable Energy Sources (CRES)	EL

Contact

Dr. Stefan Thomas, Dr. Ralf Schüle
Wuppertal Institute
for Climate, Environment and Energy
Döppersberg 19
42103 Wuppertal, Germany

Tel.: +49 (0)202-2492-110
Fax.: +49 (0)202-2492-250
Email: info@evaluate-energy-savings.eu
URL: www.evaluate-energy-savings.eu
www.wupperinst.org

Briefing on existing evaluation practice and experience

Lars J. Nilsson, Lund University on behalf of the Swedish Energy Agency
Carlos Lopes, workpackage coordinator, Swedish Energy Agency
Paula Fonseca and Mark Araújo, University of Coimbra
Nicola Labanca, Politecnico di Milano

Special contribution and review: Stefan Thomas, Wuppertal Institute

Contents

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 energy 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 end-use action 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 or action. 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

Sector	EEI measure[4]	Country	Main type of measure	Bottom-up evaluation method used: Direct measurement	Bottom-up evaluation method used: Bills & sales data analysis	Bottom-up evaluation method used: Enhanced eng. Estimate	Bottom-up evaluation method used: Mixed deemed and ex-post	Bottom-up evaluation method used: Deemed estimate	Bottom-up evaluation method used: Bottom-up modelling	Top-down evaluation method used: Equipment diffusion	Top-down evaluation method used: End-use/sector indicators	Top-down evaluation method used: 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	X	X				
	Elsparefonden	DK	F		X		X	X				
	Applicance labelling	NL	I/F		X				X	X		
	Energy+ – Europe	EU	I				X	X		X		
	KfW buildings programme	DE	F			X	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		X				
	Energy Audit Program	FI	I/F			X	X					
	Industrial EE Network	NO	I/F			X	X	X				
Transport	ACEA	EU	R							X	X	
	Ecodriving	NL	I				X	X	X			
	Congestion charging Stockholm	SE	F/R	X	X	X	X		X	X	X	
	Car sharing[5]	DE	S					X	X			
General	Energy taxes[6]	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			

[4] The EEI measure refered to in the table are described in Annexe A

[5] 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.

[6] A new method will be available by mid-february 2008 at www.sou.gov.se/energieffektiv

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 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 [7]

	EEI measure[8]	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								
	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	SE	F/R	X	X			X		X	
	Car sharing [9]	DE	I				X	X			
General	Energy taxes[10]	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					

7 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.

8 The EEI measures refered to in the table are described in Annexe A

9 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.

10 A new method will be available by mid-february 2008 at www.sou.gov.se/energieffektiv

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.

Experiences from evaluation: the British Energy Efficiency Commitments (EEC) [11]

The Energy Efficiency Commitment programme (EEC) is a three-year programme that started in 2002 and which forms an important part of the Government's Climate Change Programme and Fuel Poverty Strategy in Great Britain. It follows on from the Energy Efficiency Standards of Performance (EESoP) that ran from 1994 until 2002. A second period of EEC is on-going between 2005 and 2008. The EEC is a non-tradable certificate-based framework mechanism. Encouraging the least-cost solution for obliged parties, the EEC gives the option to suppliers to trade on a bilateral basis their obligation of energy savings with other suppliers. Ofgem (Office

11 Sources: Eoin Lees Energy, "Evaluation of the Energy Efficiency Commitments 2002-2005", February 2006; Forfori, F. "Evaluation of the British Energy Efficiency Commitment," AID-EE project, www.aid-ee.org

of Gas and Electricity Markets) is the institution in charge of administering the EEC including the approval of energy savings, monitoring, evaluating and reporting to Defra (Department for Environment, Food and Rural Affairs), which also sets the target. Ofgem determines the obligation for each electricity or gas supplier.

Target. The EEC sets mandatory targets for the promotion of higher energy efficiency in the residential sector. The target is 62 TWh (fuel standardised lifetime discounted energy) over the three-year period. For the following period, the overall saving target will be increased to 130 TWh. There is also a strong social objective, through which an attempt is made to assist low-income households to reduce the impact of energy on disposable income and to increase comfort. As a consequence, half of the target has to be achieved in the priority group of consumers, which includes the so called fuel poors. A secondary objective is to accelerate the penetration of energy efficient technologies and services onto the market.

The EEC programme left freedom to suppliers about the ways to comply with obligations. An illustrative list of measures was created, with the possibility for suppliers to include additional measures subject to the approval of the authority. An ex-post evaluation of the programme, realised by an independent consultant, showed that the illustrative list of measures was, in terms of types of measures, close to that of the actually carried out. Of the total savings, 56% come from insulation measures, 25% from lighting, 11% from the promotion of A-rated appliances, and the remaining from improvements in the heating systems.

Results. Energy suppliers exceeded their legal target requirements in EEC1, and, furthermore, have delivered at a cost at 20% less than anticipated by Defra. The cost to the nation of saving a delivered unit of electricity or gas was respectively c.a. five and three times less than the prices to consumers. The market for household appliances and lighting has transformed, while the growth of condensing boiler sales and associated installation experience during the course of EEC1 gave the Government confidence to legislate through the Building Regulations to bring about market transformation in residential boilers.

Evaluation method. A mix of methods has been used to monitor and evaluate the savings in the programme. This includes deemed estimates complemented by an ex-post evaluation. Also, diffusion indicators have been used for evaluating the market transformation effects.

As for the deemed estimates Ofgem follows a three-step procedure: (1) an annual unitary energy saving (kWh/a) is attributed to the end-use actions based upon information collected from recognised sources; (2) a relevant multiplier is applied to the annual energy saving attributed to the action to reflect the fuel type (3) the annual fuel-standardised energy saving is applied over the stated lifetime of the action and the resultant figure (kWh) is discounted by 6% annually.

An ex-post evaluation was commissioned to an independent consultant. This evaluation focused particularly on four types of outcomes. The first one was target related, including the comparison between the predicted illustrative mix and the action actually implemented. The second focused on financial and social related issues, including the impact on the priority group. The third focused on the market transformation effect towards more efficient products and services, i.e. lasting effect after the direct effect of the programme, and it included the variation in prices for energy efficiency solutions and a qualitative assessment of innovation. The last one addressed other issues such as the networking benefits created by the EEC.

Correction factors. The target was increased in order to take into account a predicted effect of free riders, and suppliers were required to demonstrate clearly this additional component. The ex-post evaluation showed that the global free-rider effect was ca. 21%, which is less than anticipated by DEFRA. Also a correction of 30% is made for compensating for the increased comfort in insulation measures.

Conclusion. Given the British experience in evaluation acquired in the energy efficiency commitments, and the potential of this kind of policy instruments, this experience should play a leading role in the development of evaluation methods in similar schemes at EU level.

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.

Experience from evaluations: The industrial energy audits in Finland[12]

Energy audit programmes are well suited for getting relatively high quality data that can verify savings from the audits and from other facilitating measures. They are the most prominent example of an enhanced engineering estimate method. Audits are a central part of energy efficiency programs in industry. Finland has one of the first and long standing experiences through the Energy Audit Programme (EAP) that was launched in 1992 and has been a full fledged programme since 1994. The basic element has been a 40-50% subsidy on energy audits that companies voluntarily decide to do. Industry is one of the sectors targeted. Motiva, a government agency is responsible for operating the EAP. Motiva´s legal status as a state owned company gives it considerable independence and freedom in the management and implementation of programmes.

In addition to offering subsidies for energy audits, Motiva is also developing auditing tools and guidelines, organises training and authorises auditors, monitors and controls quality, etc. The auditors are typically engineers working for consulting companies. Audit reports are submitted to Motiva and data on energy use, potentials, measures, costs and profitability of measures are gathered and stored in a database. The identified average potential savings in industry are typically of the order of 10-24% and 3-7% for heat and electricity respectively. It should be noted, however, that most of the identified measures have payback times of 0-3 years, indicating that potentials would be bigger if a broader range of measures, with longer pay-back times, were included.

EAP is generally considered a success, not least since it reaches the majority of industrial energy use and that about 60% of the identified measures are actually implemented. Several success factors have been identified: a flexible planning approach, clear objectives, active promotion, training and guidelines, competent implementing agency with a clear mandate, long-standing political support, etc. There was also an element of luck in the sense that industry was interested in cutting costs and that qualified engineers were available as auditors due to the overall macroeconomic situation in the early 1990s. Although the interest started to diminish after a few years, the start of a voluntary agreement (VA) scheme in 1998 restored the motivation of industry to participate. The EAP and the VA are tightly interlinked and since 2000 there is also an ESCO programme aimed at increasing implementation rates.

12 Sources: Khan J. 2006 "Evaluation of the Energy Audit Programme in Finland," AID-EE project, www-aid-ee.org; Motiva, 2006 "Annual Review 2006," Motiva, Finland; www.motiva.fi

Evaluation method. Verifying the actual savings made has not been a strong priority in the EAP. However, follow-up questionnaires have been used to check implementation rates. In these studies, a representative selection of the companies was included. The companies have a three-year obligation to submit information, if requested by Motiva or the Ministry of Trade and Industry, on the measures identified in the energy audit report. Based on these surveys, the implementation rate has been calculated to 60%. The implemented savings in absolute terms have apparently been calculated based on this number and the aggregate number of potential savings, as stored in the database.

Savings that result from programs that involve energy audits and audit reports are in principle relatively simple to verify. In the case of EAP there are three sources of uncertainty: (i) savings are based on data from auditors and companies introducing a risk of bias, (i) absolute savings are calculated based on implementation rate and aggregate potential savings identified in audits, (iii) and there are no ex-post measurement and verification of savings from individual measures. Although it has not been a strong priority in the Finnish EAP, the level of precision can be increased at relatively low cost, for example, by somewhat more detailed data gathering and sample direct measurements to check for differences between real savings and engineering estimates. The basic structures for increasing the precision and quality of data on savings are already in place.

Correction factors. For gross-to-net correction factors, the most important one is probably free-rider effects. It is very difficult to determine to what extent energy audits would have been made in the absence of the EAP and whether measures would have been implemented. Typically, low pay-back times (0-3 years) reported could suggest that the share of free-riders is high. On the other hand, it is well known that very profitable saving opportunities are foregone in the absence of programmes or management systems that can identify these opportunities. Motiva has estimated that free-rider measures account for 10-15% of the reported savings. Motiva has also observed that there are spill-over effects but conclude that these are very difficult or impossible to quantify. It is not possible to attribute savings specifically to the EAP, the VA, and other programmes, respectively. However, seen and monitored in the source database as a package of EEI promotion measures, there is no real problem of double counting. Under the voluntary agreements, companies have to report each year the measures implemented and wether these had been proposed in the energy audit. Finally, direct rebound effect is rarely a problem worth considering in industry.

Conclusion. Schemes that target industry and include energy audits are well suited for the purpose of verifying savings under the ESD. A balance can be struck between the quality of data on savings and the costs associated with getting the data. Doing the gross-to-net correction is more difficult and it is likely that some common rules-of-thumb or guidelines must be developed for this purpose. A first and perhaps sufficient step would be to require that correction factors and how they were estimated are reported.

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, investments in transport infrastructure and thus improved access induces more demand and 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.

Experiences from evaluation: The Dutch Ecodrive Programme[13]

The Dutch Ecodrive programme ‘Het Nieuwe Rijden’ is an instrument with the objective of stimulating more energy-efficient purchase- and driving behaviour. The Ecodrive programme is one of the instruments mentioned in the National Climate Change Action Plan (Ministry of Environmental Affairs, 1999). It targets car users and fleet owners, which participate on a voluntary basis. The Ecodrive programme started in 1998 and is supposed to end in 2010.

The programme consists of 5 different modules: 1) Stimulating Ecodrive driving style of (professional) drivers; 2) integrating Ecodrive principles in driving school curriculum; 3) training new drivers with ecodriving; 4) stimulating in-car devices by favouring the introduction of tax exemptions for the purchase of such devices, 5) facilitating optimal tyre pressures. The

[13] All information herewith reported have been taken from the analysis report produced in framework of the AID-EE project: “Evaluation of the Dutch Ecodrive programme” (authors: Robert van den Hoed, Mirjam Harmelink, Suzanne Joosen) available at www.aid-ee.org

Ecodrive programme interacts with two policies related: the Energy label set up in 2001 to provide consumers with information on energy use and CO2 emissions of passenger cars, and the national tax exemption scheme for the purchase of fuel-saving in-car devices. The Ecodrive programme is executed by SenterNovem (Dutch agency for energy and the environment) on behalf of the Dutch Ministry of Transport and in cooperation with the Ministry of Environment. The programme cooperates with approximately 20 consumer and retail organisations, mainly in the transport and car business. These organisations have signed a voluntary agreement thereby endorsing the Ecodrive programme.

Targets. The programme has set targets to reduce an amount of 0,8 Mton of CO2 emissions by 2010 annually. Apart from the targets related to CO2 emission reduction, in its communication the programme emphasises additional advantages of ecodriving such as economic gains, comfort and safety..

Evaluation method. SenterNovem is the subject in charge of programme evaluation that is accomplished on an annual basis. Such evaluation is mainly performed through surveys. In case of subsidised activities, participation in subsidized projects requires applicants to report on their activities and monitor improvements in fuel usage. Typically fleet owners or large organizations are involved in projects where consultants with knowledge of mobility and subsidy schemes coordinate the project and assist in monitoring and reporting. Margins in the net impact of the ecodrive programme (i.e. net impact estimated minimum and maximum value) have been assessed for three ‘policy-modules’: (i) in-car devices, (ii) existing drivers / communication, (iii) new drivers / driving school curricula.

Correction factors. Net impact low and high limit result from specific assumptions on maximum and minimum percentage amount of (i) free-riders and CO2 emission reductions in case of in-car device purchase; (ii) familiarity with Ecodrive principles and driving behaviour changes as a result of communication campaign in case of existing drivers; (iii) reach in personal transport and reach in goods transport in case of new drivers. The biggest uncertainties of such assessment relate to the persistence levels of emission reductions over time and potential negative influences of social desirable answers in the survey.

The underlying assumptions for calculating the impact of the programme have a significant influence on the assessment of the programme’s success: the lower and higher limits of the bandwidth differ with a factor 2.3. More research is required to confirm the assumptions. Although this type of (behavioural) research is complex and expensive, the current assumptions do not enable to make thorough estimations of the programme’s net impact. Moreover, sensitivity analysis of the influence of oil prices on the adoption of ecodriving has not been taken into account.

Conclusions. The evaluation of the Dutch ecodrive programme indicates that subsidized activities for non-professional existing drivers and for in-car devices provide a limited contribution to the emission reduction. In general, training in ecodriving proves by far more effective on professional drivers (notably bus and truck drivers). Programme effects on fuel consumption are mostly estimated in training situations or experiments and not by using people behaviour during their daily life as a reference. There is a need for the development of useful measuring principles concerning driver behaviour in relation to fuel consumption. This would help to develop more effective training courses and technical aids for the trainers. Measuring accelerations can help in correcting the drivers’ behaviour during training.

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.

White Certificate Schemes[14]

White certificates have up to now been used in combination with an energy saving obligation scheme. Energy companies (usually retail energy suppliers or distributors) are obliged to reach a certain amount of energy saving. Target compliance requires submission of a number of certificates commensurate with the energy saving target. Certificates can be created from projects that result in energy savings beyond business as usual, by target market actors or by Energy Service Companies (ESCOs). The market actor receives certificates for savings achieved, which can be used for their own target compliance or can be sold to (other) obliged parties. The evaluation of possible interactions of white certificate schemes with other certificate and permit systems (like green certificates and the EU-ETS) as well as with other energy policy instruments in place in the countries where white certificates are implemented is crucial to assure scheme effectiveness and efficiency as well as to avoid energy saving double-counting, white certificate market distortions and possible windfall profits by market actors involved.

Evaluation method. Concerning the energy saving evaluation methods developed under such schemes, effects like double counting, multiplier effect, free-riders and rebound effects are typically not taken into account in such methods (free-riders and rebound effects were estimated under the EEC implemented in Great Britain). Baselines are typically set based on the average energy consumption of the equivalent solutions available on the national markets. Whereas energy efficient solutions massively sold on the market are addressed (e.g. CFLs, low flow water taps, etc.), a rather frequent update of the reference baselines is needed in order to perform accurate estimates of the energy saving delivered by such solutions.

What makes white certificate schemes particularly interesting for the EMEEES project is that the existence of an energy saving measurement and verification protocol to be applied by an independent body over each energy efficiency measure implemented under such schemes represents a fundamental pre-requisite for their functioning. Therefore the plenty of already existing evaluation methods related to the energy efficient technologies addressed under such schemes may constitute a valuable starting point for the methodologies to be developed within the project. Nevertheless, evaluation approaches adopted under the various existing systems are quite different as may be argued from the overview of the two major white certificate schemes in place in the EU provided in the table below.

[14] All information reported hereunder have been taken from the analysis reports produced in the framework of the EuroWhiteCert project available at www.eurowhitecert.org

Table 3. White certificates schemes in Italy and France

Country	Italy	France
Starting date of the scheme	January 2005	July 2006
Energy saving target	At the end of the first five years of the scheme (2005-2009), annual primary energy savings should be equal to 5.8 millions toe (life time cumulated and not discounted), equivalent to approximately 45 TWh.	54 TWh of final energy for the first three years (2006-2009, cumulated over the lifetime of the actions and 4% discounted.
Obligated parties	Electricity and gas grid distribution companies	Energy suppliers delivering electricity, gas, domestic fuel (not for transport), cooling and heating for stationary applications
Sectors covered	Projects can be realised in all energy end-use sectors (plus intermediate uses in the gas sector), but at least 50% of savings should be achieved via a reduction of electricity and gas end-uses.	All, including transport, that are not already covered by the EU ETS
Eligible participating parties	Only gas and electricity grid companies or ESCos can get certificates	Any economic actor can undertake energy saving actions and get certificates
Eligible measures	Open list with 14 categories.	Open list with 30 options for the household and commercial sector; 10 for the industrial sector and 5 for transportation.
Measurement and verification systems in place	AEEG, the Italian Regulatory Authority for Electricity and Gas, uses three evaluation approaches: Deemed estimates (where the energy saving is defined using an <u>ex-ante approach</u>) Mixed deemed and ex-post estimates (some on-field measurements, e.g. monitoring of installed equipment power) An energy monitoring plan (purely <u>ex-post approach</u>)	ADEME (French Agency for Environment and Energy Management) and ATEE (Association Technique Energie Environment) are in charge of defining standardised actions and setting related methodologies for calculation of the savings achieved. Deemed and mixed deemed and ex-post saving estimate approaches are adopted for standardised actions. Actions by eligible parties that are not standard are also permitted. Savings are validated by the French High Council for Energy.

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.

Annex A - Short description of evaluation case studies

Energy Efficiency Commitment, UK

The Energy Efficiency Commitment (EEC) is an obligation on gas and electricity suppliers that sets mandatory targets for the promotion of higher energy efficiency in the residential sector. EEC is a certificate-based framework mechanism that gives the option to suppliers to trade on a bilateral basis their obligation. It follows on from the Energy Efficiency Standards of Performance (EESoP) that ran from 1994 until 2002.

This report describes the evaluation of the period 2002-2005. The target was 62 TWh energy savings over the three-year period between. This target was exceeded, and was achieved at a cost at 20% less than anticipated. A mix of methods has been used to monitor and evaluate the savings in the programme. This includes **deemed estimates** for the unitary energy savings and used without correction factors for the energy suppliers' proof of target achievement through counting of participants/unitary actions, complemented by an **ex-post evaluation** mainly **on correction factors** and other issues of interest for the government. Also, **diffusion indicators** have been used for evaluating the **market transformation** effects. An ex-post evaluation was commissioned to an independent consultant to report on: the achievement of the target; the costs and the social benefits; the market transformation effect; other benefits such as the creation of networks. The target was increased in order to take into account a predicted effect of free riders, and suppliers were required to demonstrate clearly this additional component. The ex-post evaluation showed that the global free-rider effect was ca. 21%, which is less than anticipated. Also a correction of 30% was made for compensating for the increased comfort in insulation measures.

Pros: The approach shows the possibility of separating the proof of target attainment by the obliged energy companies from the assessment of the "real" impacts for policy-making purposes. The government also aims at making the deemed estimates for unitary annual energy savings consistent between the evaluation of different policies and measures.

Cons: A potential problem in very dynamic end-use technology markets could be that usually the deemed estimates are only updated every three years.

References and information sources

www.defra.gov.uk/environment/climatechange/uk/household/eec
www.ofgem.gov.uk/Sustainability/Environmnt/EnergyEff/Pages/EnergyEff.aspx
www.energysavingtrust.org.uk/uploads/documents/housingbuildings/eec2_CERT_bn.pdf
www.aid-ee.org/documents/004EEC-UnitedKingdom.PDF

FEMP – Federal Energy Management Program, USA

Since 1973, the US Department of Energy's (DOE) Federal Energy Management Program (FEMP) has been tasked to help federal agencies lead by example in reducing energy use, energy costs, and emissions in public sector facilities. To help agencies meet their goals, USDOE/FEMP coordinates federal energy policy guidance, provides technical assistance to agencies, supports third-party project financing, measures and reports on government performance in meeting goals, and presents annual awards to recognize federal accomplishments in energy and water management. The centralised role of the FEMP-Federal Energy Management Program in inter-agency policy coordination, technical support, and reporting has been crucial to the success of the federal effort. FEMP assists agencies with these projects by providing training, information, technical assistance, financing support, and guidance. Agencies measure their progress and report to FEMP. FEMP, in turn, reports federal progress to the President and the Congress and provides awards and recognition to agencies who demonstrate excellence. Federal agencies must meet specific targets for energy efficiency and water conservation in existing and new facilities, and for the use of renewable energy. Quantitative targets for energy efficiency from the Energy Policy Act (2005) include, among others: reduce energy use in buildings by 2% per year from 2006 through 2015; apply sustainable design principles in new construction and renovation, aiming at reducing energy use in new buildings by 30 percent. Executive orders on "greening the Government through energy management" requires federal agencies to reduce their GHG emissions by 30% by 2010 compared to 1990 (executive order from 1999), as well as purchasing products that minimise stand-by power.

There are both data limitations and conceptual difficulties for measuring the energy savings achieved. Estimates: between FY (Fiscal Year) 2000 and FY 2003, Federal agencies implemented 263 Energy Savings Performance Contracts (ESPC) projects with € 0,9 billion of private-sector investment. These projects led to 10.7 PJ of annual energy savings, worth between € 80,62 million and €128,16 million annually. **Enhanced engineering estimates, coupled to billing analysis** are both the basis for the ESPC and thus the easy and natural method used to calculate these savings. In 2004, USDOE/FEMP conducted 29 energy audits (i.e., **enhanced engineering estimates**) of major federal facilities, totaling 0.4 million m2. **Extrapolating** from past experience, these audits were expected to identify measures that – once implemented – would produce savings of 211 GJ, or about €1,38 million/year. Beyond the project level, it is often difficult to untangle causality and associate a given amount of energy savings with specific program activities, as indicated by the multiple interactions. Moreover, FEMP's program structure and cost categories have changed over time, making it difficult to track multiyear costs for certain program activities. There are similar problems in identifying federal agency expenditures by type of program, such as retrofit investments, O&M, training, upgrades of equipment or new construction.
The double-counting effect is considered for appliance standards and state/local building codes. The free-rider effect is determined for non-federal energy efficiency programmes, utility demand-side management and state market transformation programmes. Multiplier effect is considered, although the evaluation fails to address the broader market impact of federal policies and programs, despite the program theme of "leadership by example".

Pros: The use of enhanced engineering estimates enables relatively accurate estimates of energy savings. ESPC and energy audit programmes allow to collect experience on implementation rates.
Cons: It appears that the monitoring of actually implemented end-use actions and energy savings could be improved.

References and information sources
http://www.aid-ee.org/documents/000017FEMP-USAFINAL.pdf
http://www1.eere.energy.gov/femp/operations_maintenance/
http://www.calmac.org/

Building energy efficiency, Oregon, USA

The Energy Trust of Oregon, Inc. (Energy Trust) was incorporated as an Oregon nonprofit public benefit corporation in March 2001 to fulfill a mandate to invest "public purposes funding" for new energy conservation. It receives funding from a three-percent public purposes charge to the rates of the investor-owned electric utilities in the state: PacifiCorp and Portland General Electric (PGE). The programme design is market-driven and builds on existing market relationships, which is consistent with best practices among resource acquisition and market transformation efforts. The programme efficiency activities are divided into two groups: lighting and mechanical (including HVAC, motors, and projects that involve gas-fired equipment or measures).

Objectives of the evaluation are: (1) provide a process evaluation update for the program after two years of operation, (2) develop adjusted savings estimates for completed projects and the associated programme gross realisation rate, and (3) estimate the extent of free-ridership and *spillover* effects and the associated net realisation rate. The estimation of *adjusted savings* is based on conditions **observed in the field several months after** its installation. The adjusted savings numbers revise the estimates of project savings reported in the programme database, which were based on **engineering** and project planning (**deemed**) data. The *realisation rate* for the program is calculated as the ratio of total adjusted savings to total program-estimated savings. Software tools were also used to make rough estimates of achieved or to-be-achieved savings. Altogether, the methods applied are a **mix of deemed** values **and ex-post** analysis.

Pros: The use of ex-post surveys allows to address the gross-to-net correction factors
Cons:

References and information sources
http://www.dsireusa.org/library/includes/tabsrch.cfm?state=OR&type=Building&back=regeetab&Sector=S&CurrentPageID=7&EE=1&RE=1
http://www.bcap-energy.org/state_status.php?state_ab=OR
http://www.oregon.gov/ENERGY/CONS/Codes/cdpub.shtml
http://www.calmac.org/

EPS-Energy Performance Standard Building Code, The Netherlands

The energy performance standard introduced in 1995 in Netherlands aimed at an energy saving of 15% to 20% compared to the building practice valid under the building regulation until 1995. The energy performance standard applies to all residential and non-residential buildings. The introductory period of the Energy Performance Standard was embedded in the sustainable building policy that started in the mid-nineties. In the beginning it was not always clear to the stakeholders in the field what the government exactly meant with sustainable building. To overcome this issue, National Sustainable Building Packages were developed. It is intended that all parties within the building process are aware of the energy demand requirements; from the design phase until the actual realization of the building, therefore the target groups are architects, designer engineers, consultants, installers of energy systems, suppliers of energy efficient/saving techniques, building contractors, building inspectors.

Empiric data of actual energy consumption is only available for office buildings. These data show significant scattering. The analyses show that on average the energy performance standard results in a lower actual energy use.

Multiplier effect, direct rebound effect and double-counting effect (interaction with subsidy programmes and fiscal measures) have been considered in this method. Free-ridership effect is assumed not to be applicable for energy performance standards. The determination of an Energy Performance Coefficient - the deviation between energy performance according to the building permit and the actual energy performance of the building - indicates that the knowledge of the energy performance calculation is insufficient. In general, no sanctions are imposed on non-compliance with the standards. In the residential sector, the net impact in terms of primary energy savings was by end 2004 about 3 PJ (uncertainty ± 1.5 PJ).

Pros: The monitoring of the actual energy performance of the building enables to identify weaknesses in the implementation. Consideration of correction factors is a positive feature of the method.
Cons: Method is costly, especially in the residential sector, although the building energy certificate can contribute significantly.

References and information sources
http://www.ieadsm.org/Files/Tasks/Task%20XIV%20%20Market%20Mechanisms%20for%20White%20Certificates%2Trading/Workshop%204%20-%20October%202005%20-%20Groningen%20/Niermeijer-EE_NL.pdf
http://www.aid-ee.org/documents/002Buildingstandard-Netherlands.PDF

Building regulation in Carugate, Italy

As from November 2003 an innovative Building Regulation for Energy Efficiency (BREE) is in force in the Municipality of Carugate (Italy). Such regulation includes mandatory end-use energy saving actions and recommended actions addressing both new and retrofitted buildings. Mandatory actions include: more restrictive limitations on envelope thermal transmittance (U-value) with respect to the ones set by the Italian decree d.lgs. 192/2005; installation of solar thermal panels for domestic hot water (DHW) production; application of thermostatic valves to radiators or individual regulation systems; individual heating metering systems and gas-fired condensation boilers; low-energy electricity devices and high efficiency lamps; collection and storage system for gathering rain water.

Energy savings achieved in the period 2003-2005 for new buildings have been monitored ex-post by observing the decrease in the primary energy needs of such buildings with respect to the building stock primary energy needs in the period between 1999-2002 based on calculated consumption (i.e. enhanced engineering analysis). Achievable energy savings for new and existing buildings have been estimated also ex-ante by modeling the effects of the installation of a mix of mandatory and recommended end-use actions on a typical new and existing building (i.e, an enhanced engineering analysis of samples used to derive deemed estimates for the mass of cases). In this way per unit annual final energy savings around 43% have been estimated for new buildings. In case of existing buildings an annual renovation rate resulting in 30% of the 2005 building stock being renovated by 2010 has also been assumed and existing stock total annual final energy savings around 24% have been estimated for this year. Correction factors like free riders, rebound and spill over effects were **not** considered for such estimates.
No information about costs and administrative burden caused by the above evaluations are available.

Pros: The use of a comprehensive package of ex-ante and ex-post assessments is a positive feature of this case.
Cons: Correction factors were not addressed, and no information on evaluation costs is available.

Reference and information sources:
www.aid-ee.org/documents/000007BuildingregulationonEEinCarugatemunicipality-Italy.pdf

Elsparefonden (Electricity Saving Trust), Denmark

The Electricity Saving Trust (Elsparefonden) was established in 1996 for the purpose of furthering electricity savings in residential and public buildings in agreement with socio-economic and environmental considerations. It should also promote competition and use innovative EEI improvement measures to increase cost-efficiency. Elsparefonden has had an annual budget of about 10 million EUR financed through a small levy on electricity.

The overall target is that the activities of Elsparefonden should result in 750-800 GWh savings in 2007 and the evaluation (dated 2004) reports that these are likely to be exceeded, estimated to reach about 1000 GWh. The EEI improvement measures are mainly campaigns with information, marketing and efforts to reduce prices and/or, stimulate demand through subsidies, agreements with suppliers etc. The bulk of the savings accrue from promoting fuel switching (away from electric resistance heating), efficient appliances, and CFLs. The purpose of the 2004 evaluation was to make a broad assessment of Elsparefonden, in which savings and cost efficiency was one component. The evaluation was partly based on earlier evaluations of individual campaigns. The evaluations relied on baselines combined with sales data for CFLs and appliances, and participant rates with ex-post estimates and deemed savings for fuel-switching from electric space heating. For some of the activities multiplier and free-rider effects are considered in the context of market transformation. In the case of fuel switching a direct rebound effect (increased indoor temperature) was estimated to reduce the savings by 15%.

Pros: Each individual campaign is evaluated.
Cons: The budget for the evaluations is limited, since the campaign costs are also usually quite low (ca. 25,000 Euros per campaign, equivalent to ca. 2 to 5 % of its costs).

References and information sources
Ramboell, 2004, “Evaluering av Elsparefonden” (Evaluation of the Electricity Savings Trust), Copenhagen, Denmark (in Danish, also available in English 2007).
www.elsparefonden.dk has this and other evaluations but not all evaluations are posted on the web-site.
Personal communication from Peter Karbo, former co-manager of Elsparefonden, quoted in: Thomas, Stefan, 2004, “Aktivitäten der Energiewirtschaft zur Förderung der Energieeffizienz auf der Nachfrageseite in liberalisierten Strom- und Gasmärkten europäischer Staaten: Kriteriengestützter Vergleich der politischen Rahmenbedingungen (in German)

Applicance labelling, The Netherlands
The EU energy labels for appliances were first introduced in the Netherlands in 1995 for refrigerators, freezers and their combinations. Since that date several other "large" energy consuming appliances were added to the list; washing machines and electric tumble dryers in 1996, washing and drying combinations in 1998, dishwashers in 1999, lighting in 2001. In 2003 also ovens and air-conditioners where added to the list, transposing the EU directives on the subject. From the beginning the energy label in the Netherlands had a strong relation with the MAP (Environmental Action Plan from 1991 to 2000) and the EPR (Energy Premium Regulation from 2000 to 2003). Only a MAP or EPR subsidy could be received when the appliance had an "A" label. The Dutch association of suppliers of domestic appliances (VLEHAN) is providing the labels. A producer should apply for a label at the VLEHAN. Control and verification is carried out by the Economische Controle Dienst (ECD). From 1995 to 2002, awareness campaigns were broadcasted on television, and publications were organised in newspapers and magazines within the framework of both MAP as EPR. Within the framework of the Dutch Climate policy and the national Kyoto target, both labeling as fiscal incentives are expected to lead to a CO2 emission reduction of 0.3 Mton in 2010. Monitoring of the results was done by EnergieNed. The results showed that since the introduction of the energy label in 1996, the familiarity increased from 27% to 64% in 2000. The total net savings due to MAP and EPR are based upon the total amount of appliances sold with a MAP and EPR subsidy times a standard energy saving per appliance, times the free rider effect for MAP and for EPR. The free rider effect per appliance is based on the figures presented in the study "Evaluation of climate policy in the built environment" (Ecofys, 2004). Multiplier effect, the free ridership effect (for MAP and EPR) and double-counting effect (the energy label has a relation with the EPR and MAP) have been considered in this method. Market share of label A and better between 1997 and 2003 for washing machines, dishwashers, refrigerators and freezers grew considerably, based on **sales data** combined with **diffusion indicators.** Pros: Combination of bottom-up modelling and diffusion indicators. Cons: Method for evaluation of correction factors not clear. High cost of market analysis. <u>References and information sources</u> http://www.aid-ee.org/documents/001Labelling-Netherlands.PDF Ecofys, 2004, "Evaluation of climate policy in the built environment" Personal communication with Hans-Paul Siderius, SenterNovem, referring to VLEHAN, belastingdienst and GfK (Oktober, 2005)
Energy+, Europe
Energy+ was a co-operative procurement process developed by energy agencies and research institutes that started in 1998 to increase the market for super-efficient cold appliances and contribute to long term market transformation. It was set up as a SAVE project in two phases (1999-2001 and 2002-2004) funded by the European Commission. The idea was to simultaneously make high efficiency units available on a larger scale and stimulate market demand. Energy+ did not set explicit total energy savings targets but specifications included low Energy Efficiency Index (EEI) at the appliance unit level. The evaluation of Energy+ was conducted as one of the case studies in the AID-EE project for the purpose of exploring success and fail factors using a policy theory approach. Due to the absence of explicit savings targets in Energy+ there was also a lack of monitoring information that could be used for verifying the savings. The evaluation of savings is also complicated by the simultaneous revision of energy labels (adding A+ and A++) and the existence of national programmes. Savings estimates in the evaluation are rough and based on extrapolated sales data and **deemed** unitary energy **savings**. Double counting and multiplier effects are treated mainly through the use of motivated assumptions and illustrative calculations. Free-rider and rebound effects are not considered. Pros: Market transformation effects were monitored through the number and share of Energy+ models available on the market. Cons: No monitoring of sales data and correction factors was possible, due to budget constraints in

theproject (co-funded by the EU programme SAVE).

References and information sources:

Labanca N., 2006, "Evaluation of the Energy+ process" Report under AID-EE, contract no. EIE-203-14. (can be downloaded from www.aid-ee.org)

KfW buildings programme, Germany

In 1996 the German government launched an incentive programme for building modernisation as part of the National Climate Protection Plan 2000. Since then the program has been changed and restructured several times. The program provides favourable loans for implementing energy saving measures for households, building associations and public entities who modernise their buildings and apartments according to the highest energy standards. Among the various kfW incentive programmes for energy savings particularly relevant are the so called KfW-CO2 Reduction Program and the KfW CO2 Building Rehabilitation Programme in the period 1996-2004. Originally created to support individual renovation measures in existing buildings such as improvement of the heating features, the first program was used as of 1998 to support also measures in new buildings (such as construction and initial purchase of KfW energy-saving houses 60, 40 and passive houses) and for financing the introduction of renewable energy sources (RES) in new and existing buildings. The second programme, established in January 2001, provides favourable loans for the retrofitting of buildings built before 1979, as well as demolition of empty residential rental buildings in Eastern Germany and East Berlin. In 2003 a partial debt relief was first introduced. A precondition for receiving a debt relief is that predefined packages of actions leading to a pre-estimated annual reduction of 40kg CO2 per m2 of living space are installed (if the houseowner does not implement a whole package, a proof is needed that the 40 kg CO2 per m2 are achieved. If he/she achieves a reduction worth less than 40 kg CO2/m2 a support is provided but lowered accordingly and reductions have to be certified by an authorised energy consultant). The height of the debt relief was originally set at 20% (2003), and later decreased to 15%.

It may be assumed that programme evaluation is a mix of **ex-post** (in case of individual packages of measures, based on **enhanced engineering analysis**) and ex-ante **deemed estimate** (in case of proposed packages of actions whose annual CO2 abatement power has been estimated in 40 kg CO2/m2) bottom-up approaches. KfW provides statistics on amount of loans provided every year both in terms of accepted applications and the volume of the provided loans. Jülich Research centre monitors and analyses the realised energy savings and related CO2 emissions reduced in the households who applied the programmes' measures. The total energy savings (gross impact) in the period 1996-2004 account for 39.5 PJ (of final energy) and has been estimated from totally achieved CO2 emission reductions (corresponding to about 2.9 million tons of CO2 emission) by using conversion factors and the weighted average of the main energy sources used for heating in Germany. Based on previous studies on energy savings in the built environment that were performed in the Netherlands the share of the free-riders on energy savings in the built environment in Germany has been assumed as ranging from 30% to 50%. Such range for free-riders implies a net energy savings range from 32 to 23 PJ attributable to the programmes considered. An average household saved 26-36 GJ of energy per year through the two KfW programs mentioned. The programmes led to an average energy saving of 308-431 MJ per m2 per year.
Information about costs and administrative burden of the above estimates are not available. However it may be assumed that programme participants not implementing a whole package of actions and hence having to certify reductions achieved potentially represent a greater source of costs and administrative burden than programme participants implementing the whole packages with 40 kg CO2/m2 of emission reductions attributed ex-ante.

Pros: A combination of a pragmatic approach with deemed savings for pre-defined packages, and flexibility through allowing enhanced engineering analysis for proof of energy savings from individual packages of end-use actions.

Cons: No own survey of real (implemented) energy savings and for estimating correction factors was carried out.

Reference and information sources:

www.aid-ee.org/documents/000003KfWbuildingprogramme-Germany.pdf
IER.1998 Evaluation and comparisons of Utitily's van Government DSM programmes for the promotion of condensing boilers. IER, Stuttgart, October 1998.

Helles NRW, Germany

Helles NRW, or "Bright NRW" was a CFL program in North Rhine-Westphalia (NRW) that took place from November 1996 to March 1997. The target was to increase the use of CFLs by 1 million. Participating utilities could develop their own programme design. Four types of programmes were used: free give-aways, conditional free give-aways, rebate vouchers, advertisment campaigns. The objectives of Helles NRW were to reduce energy demand and carbon emissions, encourage household energy efficiency and increase awareness in general, and demonstrate least cost planning (LCP) in order to spread this practice among utilities.

Helles NRW was evaluated by the Wuppertal Institute. Based on the number of give-aways, redeemed vouchers, and **ex-post** surveys that quantified the multiplier effects (determining additional purchases by participants and non-participants), and an extrapolated sales trend estimate to account for free-riders, the total increase was calculated to 1.4 millon CFLs. This number of units was multiplied with a **deemed estimate** for unitary annual energy savings and operating hours, based on surveys for other programmes. The evaluation also included cost-benefit analyses.

Pros: The evaluation is a good example of how a straight forward facilitating measure, which is limited in time and space, and that targets a specific end-use, can be evaluated with respect to realised savings. It also addressed market transformation (multiplier) effects and other correction factors, through a survey including non-participants.
Cons: The second proposed approach based on sales data was not possible to implement due to lack of such data.

<u>References and information sources:</u>
Thomas S., Dudda C., Hennicke P., 1997, "Evaluation of the joint DSM action "Bright North Rhine-Westphalia" for efficient residential lighting," Wuppertal Institute, Germany, paper for the EEDAL 1997 conference. (based on a more detailed Wuppertal Institute report: Evaluation der "Aktion Helles NRW" (in German))

Technology Procurement, Sweden

The Swedish Energy Agency, and its preceding organisation, has carried out 55 technology procurements in the area of energy between 1990 and 2005 to promote and accelerate technology development and diffusion. Different performance and diffusion targets have been set in different procurements and there have been several evaluations undertaken along the way. Realised savings can be quantified through constructing a baseline and calculating **deemed** unitary annual energy **savings**. However, the baseline as well as the attribution of savings to the procurement can be questioned due to the long term character of market transformation effects.

The evaluation at hand selected 10 procurements (heat pumps, energy monitoring systems, heat meters, tap fittings, heat recovery systems, cold applicances (2), chiller cabinets, occupancy sensors, electric motors, copiers). Number of units sold relative to the baseline and savings per unit is the basic methodological approach used. Free-rider, multiplier, and rebound effects are discussed but not quantified. It should be noted that it is a relatively small evaluation in terms of resources. Alas, although the basic approach is sound the evaluation includes rather brave assumptions concerning baselines and level of savings to be attributed to the procurement. For example, ground source heat pump sales are attributed to the procurement and does not consider the effects of various programmes before and after the procurement (thus introducing a double counting risk).

Pros: A pragmatic approach.
Cons: Quantification of correction factors was not possible.

<u>References and information sources:</u>
Solpros, 2006, "Reporting of the quantitative effects of reduced use of primary energy from ten technology procurements," Solpros AY, Helsinki (report to the Swedish Energy Agency,

unpublished)

Free energy audits, Denmark

The free of charge energy audit program under the Danish Energy Authority started about 1992 and is still ongoing. The target group is enterprises with an annual electricity consumption >20 MWh and the audits are delivered through an obligation on electricity network companies. The program does not have a savings target but since 2002 there is a requirement that 10% of the enterprises in the service area or about 10% of their electricity consumption should be offered an energy audit each year.

The evaluation which is summarised in an ECEEE conference paper consists of 3 parts (one based on reported audit results, an econometric study, and ten in-depth case studies). The econometric study using **billing analysis including a control group** did not show statistically significant results. A reason may be that both participants and non-participants were also influenced by a number of other policies and programmes, e.g., financial incentives, and voluntary agreements. The ten case studies were not aimed at quantifying savings and were not a representative sample. Audit reports with information on recommended and implemented measures (i.e., **enhanced engineering analyses**) have been gathered in a database over time and this constitutes the basis for calculating the electricity savings in the evaluation. However, the database is not complete. Correction factors were not considered. The results of audits in 2002 were approximately 122 GWh implemented first year savings. The cumulative first year savings at the time of the evaluation were 688 GWh.

Pros: The evaluation demonstrates the value and importance of gathering audit and implementation results in a database.

Cons: The database does not contain information on correction factors and potential double-counting with other policies and programmes (the later is addressed by the monitoring of the Finnish energy audit programme, cf. below).

<u>References and information sources:</u>

Dyhr-Mikkelsen K., Bach P., 2005, ”Evaluation of Free-of-Charge Energy Audits,” ECEEE Summer Study 2005 (this paper contains reference to the summary evaluation report, but there are also three underlying reports in Danish published by AKF Forlaget in October 2004)

Investment Deduction Scheme, The Netherlands

The EIA – Investment Deduction Scheme is part of a broader context of energy efficiency policy in the Netherlands and is one of the instruments implemented to meet Kyoto targets. It was initiated by the Ministry of Economic Affairs in 1997. SenterNovem and the Dutch tax authority (Belastingdienst) are responsible for implementation of this measure. The scheme offers Dutch companies tax relief on investments in energy efficient technologies and renewable energy technologies. Up to 44% of the investment costs may be offset against taxable profits, provided that the equipment appears on an Energy List (‘Energielijst’) or meets specific energy savings criteria (e.g. in euro/GJ saved).

Although energy saving techniques are not monitored, the net impact of the EIA in the service sector and light industry is determined, based on *average* energy saving factors (i.e., **deemed** savings). The free-rider effect is determined per technique in order to calculate the net impact of EIA (without free-riders). Evaluation reports provide a lower and an upper percentage for free-riders based on an **ex-post** survey. The lower percentage represents the part of free-riders that certainly did not experience the attention value of the EIA. These are the so-called ‘real’ free-riders. The upper boundary gives the share of free-riders that could possibly experience attention value of EIA. An average free-rider percentages was used in the calculations and does not take into account that free-rider percentages most likely have decreased in past years. With the available data it was not possible to determine which part of the energy savings is directly caused by the EIA without interference with other policies like Long Term Agreements. The data on free riders percentages are from the year 2000 and are not defined for all selected technologies in the light industry. The actual energy savings per technique are not monitored. The energy savings and CO_2 reductions reported by SenterNovem are established by applying ex-ante energy saving figures for techniques that are responsible for the bulk of reported investments. For the remainder a generic energy saving number is applied. Cost efficiency figures for society, government and end-users were surrounded by large uncertainties.

Pros: The criteria for eligibility of specific equipment allow to define the baseline and the deemed savings; survey for free-rider factor.
Cons: Lack of monitoring of actual energy savings, no database to exclude double-counting, no survey of non-participants and supply chain to better evaluate free-rider and multiplier effects

References and information sources
http://www.aid-ee.org/documents/010EIA-Netherlands.PDF

Voluntary Agreement in Industry, Denmark

The Danish scheme on voluntary agreements (VA) on energy efficiency in industry was launched in 1990 as part of a green tax package and when the Parliament adopted a national energy plan, Energy 2000. This plan called for reducing CO2 emissions by 20% between 1988 and 2005. No quantitative target was set for the VA scheme alone, but the VA and the subsidy scheme together were expected to jointly reduce the Danish CO2 emissions by 1.8% (1.1 million tonnes CO2) for 1996-2005. The VA should at the same time ensure that the competitiveness of Danish industry is not weakened by the increased green tax. The VA scheme has resulted in energy savings, mainly as a result of the obligation to implement an EMS-Energy Management Scheme, which puts energy efficiency on the company agenda.

Compliance to the VA is monitored by the Danish Energy Agency (DEA). Since 1998 a database compiling the questionnaires filled in by individual companies was to be used. However, due to the deficient quality of the information received, the evaluation was based on interviews, special investigations, and indirectly through the accredited organisations which certify the EMS. Consequently, there is currently no data available to determine the net impact and effectiveness with certainty. The initial expectations on effectiveness are assumed to have been achieved according to the DEA. Also, the early estimates of the net impact are assumed to be reasonably correct. DEA planned to work from 2006 in the database in order to secure the quality of the data..

This method considered the double-counting effect, the multiplier effect and free-rider effect (34% in 1999). Many companies appreciate that the EMS was designed on the basis of the structure and terminology of the environmental management system. Such co-ordination facilitates the implementation of the EMS. The cost efficiency is better for the collective VAs than the individual VAs. The signing of a collective agreement generally requires the industry branch organisation to be active and the individual companies to be willing to co-operate. An evaluation by the Ministry of Finance (1999) showed that the administrative costs for public authorities and companies were unsatisfactorily high, and decided to impose minimum thresholds for paying out the tax rebate in order to limit the administrative costs and to ensure reasonable cost efficiency. In the revised scheme the collective agreements are exempted from this minimum level and may therefore be economically motivated even for rather small companies. Flexibility and use of sanctions has lead to few cases of non-compliance. Administrative cost for the implementing authority can be reduced over time as a result of learn-by-doing, continuous adjustments (eg. removal of energy audit) and increased systematisation of the administration.

Pros: Learning process decreases evaluation costs by implementing alternative solutions such as collective agreements with industry organisations instead of individual agreements.
Cons: Difficulty in getting information from individual companies. High evaluation costs for agreements with inidividual companies.

References and information sources
http://www.aid-ee.org/documents/011Danishvoluntaryagreements.PDF

Programme for Energy Efficiency Imprement in industry, Sweden

The Swedish programme for EEI in industry (PFE) is a five year “long-term agreement” launched in January 2005 with the overall target of delivering electricity savings that are at least as big as the savings that would result from the EU mandated minimum electricity tax of 0.5 EUR/MWh. Energy intensive companies can participate in the program and in return get exempt from the minimum tax. During the first two years the companies have done energy audits and reported planned actions to be implemented 2007-2009 to the Swedish Energy Agency. They should also in the first two years implement a standardised energy management system, as well as routines for planning and purchasing high-consumption electrical equipment based on life-cycle cost assessments.

The program has not been fully evaluated yet but the first results have been reported and a survey of experiences (not including efforts to verify savings) was completed in 2007. The participating companies account for 31.5 TWh electricity consumption of which 29.4 is taxed at 0.5 EUR/MWh. The total annual electricity savings based on actions that the companies have reported and thereby committed to implement amount to 765 GWh (2.6%). The methods used vary from ex-ante engineering estimates produced in energy audits, to detailed ex-post direct measurements. However, the expectation is that companies have identified electricity saving options, as well as savings in heat and fuel, that are not reported. It is also expected that the energy management system will result in savings from changes in the operation of equipment and processes. The first reporting has not attempted to address the issue of free-ridership but most of the reported actions have pay-back times below 2 years. Multiplier effects are expected but have not been quantified.

Pros: Reporting and monitoring system of end-use actions and energy savings. Reporting requirements are part of the programme regulation.
Cons: No evaluation of correction factors yet. Reporting requirements can be more detailed.

<u>References and information sources:</u>

Ottosson C., Petersson K., 2007, "First results from the Swedish LTA programme for energy efficiency in industry," ECEEE Summer Study 2007.
Demoskop, 2007, "Utvärdering av PFE" (Evaluation of PFE), report to the Swedish Energy Agency (this and other material can be downloaded from www.energimyndigheten.se)

Energy Audit Program, Finland

The Energy Audit Programme (EAP) was launched in 1992. The central part of the programme is subsidies (40-50 %) to companies and organizations who decide to carry out energy audits of their buildings or processes. From the energy audits, saving potentials and saving measures are identified. The companies and organisations then decide whether to carry out saving measures or not. The EAP also includes many other elements to support the carrying out of energy audits: development of energy audit models, development of auditor's tools, training and authorisation of auditors, monitoring and quality control. The EAP is closely connected to the Voluntary Agreement (VA) in Finland scheme which started in 1997. The companies who join the VA scheme have committed themselves to carry out energy audits. The EAP has also been linked to a programme with the aim to support Energy Service Companies (ESCOs) in order to increase implementation of energy saving measures.

For this method, the results of energy audits are tracked in a database of each end-use action proposed and its potential energy savings, by type of end use. The unitary energy savings are thus based on the energy audits, i.e., **enhanced engineering estimates**. Furthermore, the implementation of the proposed end-use actions is monitored for each company or organization that received an energy audit. In addition, the end-use actions reported by the same companies and organizations if they participate in the voluntary agreement programme, are stored in the same database. The double-counting effect is thus considered based on the joint database of energy audits and voluntary agreements (for cost efficiency), as well as the free-rider effect (probably does not exceed 15% of the energy savings), but in this case multiplier effect are impossible to quantify. The costs of target organisations have been EUR 22.7 million (average of 1.7 million €/year) or 55 % of total costs. The level of subsidies for carrying out an energy audit has been between 40-50 % of the auditing costs, depending on the sector and the year. Cumulative savings during the period 1992-2004 were about 29 PJ (70% Industry).

Pros: Very comprehensive monitoring of end-use actions across different facilitating measures targeting the same sectors and final consumers, allowing to avoid double-counting; tracking of actually implemented energy savings; quality energy audits provide credible energy savings data.

Cons: No in-depth analysis of free-rider and multiplier effects yet.

References and information sources

http://www.aid-ee.org/documents/012EnergyAuditProgramme-Finland.PDF

http://www.motiva.fi/en/publications/orderpublications/energyefficiencyagreementsinfinland19972005.html

Industrial energy efficiency network, Norway

The industry was given the target of reducing energy consumption – or converting to renewable energy - by 9 PJ by 2010. For the purpose an industrial energy efficiency network was created. The analysis carried out covers the period 1996-2004 when a great number of the industrial energy efficiency network members got technical and economic support for improving the energy performance through increased knowledge and awareness of the savings potential. The support and benefits to companies in the industrial network is still in force but the focus concerning activities has now changed. It was assumed that energy auditing could give a reduction in energy consumption by at least 5% without any major investments. The direct cost for the work involved was refunded by maximum 90% of the typical cost around EUR 3750. An additional 50% of max EUR 12500 could be granted to necessary hardware and software for establishing an efficient energy monitoring system if the existing system was considered inadequate. Based on the initial energy analysis it was possible to get a financial support covering up to 50% of the consultancy and other costs, limited to EUR 25000.

The last projects of this kind were approved in 2004 giving an estimated result of approximately 6 PJ cumulative energy savings through advice and implementation of energy management systems. The savings were estimated based on **deemed savings and ex-post savings** estimates reported by auditors and participating companies, including softer estimates of the savings resulting from the use of energy management systems. As for the correction factors, only free-rider effect has been considered.

Pros:

Cons: As for the correction factors, only free-rider effect has been considered. Reporting by individual companies to be improved.

References and information sources

http://www.aid-ee.org/documents/013IndustrialEnergyEfficiencyNetwork-Norway.PDF

ACEA – Voluntary agreement between ACEA and European Commission, EU

In 1998, a voluntary agreement has been concluded between the European Commission and the European Automobile Manufacturers Association (ACEA – Association des Constructeurs Européens d'Automobiles) dealing with CO_2 emissions from passenger cars. Such agreement envisaged a progressive approach consisting in the introduction of cars emitting less than 120g CO_2/km by 2000, in an interim target of 165-170g CO_2/km for the average of 2003 EU new car sales (9-11% reduction compared to 1995) and in a final target of 140g CO_2/km for the average of 2008 EU new passenger car sales (25% reduction compared to 1995).

EU member states are required to provide data on CO_2 emissions of passenger cars for the annual monitoring. ACEA and the Commission decided to monitor the progress on a commonly basis with data gathered independently. Within the ACEA Agreement one of the characteristics is that the target is a common one and has to be achieved by collective responsibility. All data provided is given on a commonly basis for the average European car fleet and not for individual car manufactures. The European Commission having negotiated similar voluntary agreements with the Japanese automotive industry (JAMA) and the Korean vehicle manufacturer's association (KAMA), the policy instrument affects almost every passenger car in Europe.

The results have been evaluated ex ante by the Commission (staff working paper SEC/1998/1047). The calculations were based on a reference scenario (baseline) of 380 Mt CO_2 emissions from passenger cars in 1990 and 536 Mt in 2010 with an annual growth in passenger car mileage of 2%. Furthermore a linear reduction in average new passenger car CO_2 emission was assumed as well as an average vehicle lifetime of 12 years. This assessment concluded 85 Mt CO_2 emission savings due to the ACEA agreement. However, it is not clear what kind of data of CO_2 emissions from passenger cars was used and the baseline trend was defined without assuming potential energy savings and CO_2 emission reduction from new passenger cars without an Agreement. Altogether, the method uses a **specific energy consumption indicator** that is used in a **top-down** fashion to measure the energy savings and CO_2 emission reductions.

Finally, it may be worth mentioning that reducing CO_2 emissions from new cars may have considerable rebound effects. Indeed empirical studies show that by improving the fuel efficiency of cars the total fuel costs for motoring are reduced and an increased driving is encouraged (Kågeson estimates the rebound effect could be as high as 25%). No information about costs and administrative burden related to the above mentioned evaluations are available.

Pros: Example of a top-down indicator-based method using a well-defined indicator.
Cons: The baseline trend was defined without assuming potential energy savings and CO_2 emission reduction from new passenger cars without an Agreement.

<u>Reference and information sources:</u>
http://www.aid-ee.org/documents/000016ACEA-EuropeFINAL.pdf
Umweltbundesamt (UBA), 2004: Quantifizierung der Effekte der Ökologischen Steuerreform auf Umwelt, Beschäftigung und Innovation. Background Paper of the German Federal Environmental Protection Agency. Internet: http://www.umweltdaten.de/uba-info-presse/hintergrund/oekosteuer.pdf (10.02.2006)
Per Kågeson (2005): Reducing CO2 Emissions from New Cars. A progress report on the car industry's voluntary agreement and an assessment of potential policy instruments

Ecodriving Programme, The Netherlands

The Dutch Ecodrive programme 'Het Nieuwe Rijden' is one of the instruments mentioned in the National Climate Change Action Plan (Ministry of Environmental Affairs, 1999) to reduce CO2 emissions in the Netherlands. It was put in place in 1999 on the basis of earlier experiences and its current phase 3 will run until 2010. Ecodrive is focused on creating the necessary conditions and organisational structures that facilitate more energy-efficient purchase and driving behaviour of car users, professional drivers and fleet owners, which participate on a voluntary basis. A large range of activities is covered in order to achieve more efficient driving behavior (e.g. stimulating ecodriving of professional drivers, integrating ecodrive principles in driving school curriculum, training new drivers with ecodriving, stimulating the use of in-car devices, facilitating optimal tyre pressures, stimulating purchase of more efficient vehicles). Approximately half of the budget (corresponding to 15 million € for the period 2006-2010) is focused on setting up communication campaigns; the remaining half is spread over subsidized projects, contracted projects, and overall project execution costs. In case of in-car devices a tax exemption scheme and various subsidized activities are implemented to stimulate their purchasing.

CO2 emission reduction due to the Ecodrive programme has been estimated largely based on data that SenterNovem has collected through annual telephone surveys and elaborated in its annual reports (2000; 2001; 2002; 2003; 2004; 2005). The method can therefore be called a **mix of deemed** unitary energy **savings estimates** per driver **and ex-post data**. The margins in the net impact (low-high values) on CO2 emission have been estimated including higher and lower values regarding several key assumptions on the three 'policy-modules': (i) in-car devices, (ii) existing drivers / communication, (iii) new drivers / driving school curricula. These assumptions relate to free riders, familiarity with Ecodrive principles, behaviour change, persistence levels etc. Based on such assumptions it has been estimated that CO2 emission reductions due to in-car devices have continuously increased from 2000 to 2004 up to 16-42 kton in 2004. CO2 emission reduction as a result of targeting existing drivers has increased from 8-39kton in 2000 to 34-86kton in 2004, whereas the integration of Ecodrive in the drive school curriculum has led to a reduction of CO2 emissions of 47-94 kton in 2004.

A sensitivity analysis of the influence of oil prices on the adoption of ecodriving (although necessary) has not been included in the above estimates and more research would be needed to confirm all the assumptions mentioned above. Costs and administrative burden due to the instrument net impact evaluation may be assumed as relatively high and mostly deriving from the telephone surveys performed in the period 1999-2004.

Pros: Annual surveys may allow adjusting programme implementation and evaluation approach.
Cons: Uncertainties in the evaluation are rather high due to the several assumptions needed. Evaluation costs may also represent a problem.

References and information sources
http://www.aid-ee.org/documents/000015Ecodriving-Netherlands.pdf

Congestion charging Stockholm, Sweden

The Stockholm congestion charging trial ran between August 2005 and July 2006. After a period of evaluation and political processes, congestion charges were introduced permanently in August 2007. The trial was very carefully evaluated. The primary objectives of the trial were to reduce congestion, increase accessibility and improve the environment. The main parts of the trial were congestion charges to enter the center of Stockholm, increased public transport and expanded park-and-ride facilities. One of the secondary objectives was to decrease traffic in and out of the city by 10-15% during rush hours.

The trial was very carefully evaluated including travel surveys, traffic monitoring, and evaluations of a variety of effects. It used a **mix of methods** including **direct measurement, billing analysis, mixed enhanced engineering analyses, deemed and ex-post data, bottom-up modelling**, as well as **top-down indicators on diffusion of transport modes, and energy consumption**. The reduction of traffic over 24 hours was 22%, thus exceeding the target. Vehicle kilometers driven within the charging zone dropped by about 15%, as did fuel consumption and resulting emissions. The evaluation was careful to include consideration of correction factors but the complexity of the traffic system obviously makes it difficult to separate cause-effect relationships and all correction factors are not easily applicable. The fact that inner-city residents used their cars more due to less congestion can be considered a rebound effect that was captured in the evaluation. However, should the fact that public transport passengers got more and better options be considered a free-rider effect?

Pros: Comprehensive mix of methods
Cons: Probably high cost of comprehensive evaluation

References and information sources
Stockholmsförsöket, 2006, “Facts and results from the Stockholm trials,” City of Stockholm (this and many other reports can be downloaded from www.stockholmsforsoket.se)

Car sharing, Germany

The aim of the research project “The future of Carsharing in Germany” was to make an empirical evaluation on the conditions, chances and relevant climate impact (main indicator CO_2) for a mid-term market diffusion (in 2020) of carsharing in German cities with more than 100.000 inhabitants. The research project identified a system dualism for the development of carsharing service providers in Germany in a mid-term perspective: Civil society organisations and commercial providers will co-exist and both forms of organisation will become more and more professionalized.

In the scope of the project, two analyses were being conducted on the basis of a survey of 500 private carsharing customers and 1,500 representative non-customers. The interviewees were confronted with two service scenarios: While one only included few changes to the existing offering or service structure (moderately flexible), the second showed a very flexible “Call a car” system.

As a result of the first analysis, the annual CO_2-emissions reduction potential for these two scenarios in the year 2020 was estimated at 78.2 and 117.2 kg per person per year, which means 294 kWh respectively 441 kWh, depending on the underlying service structure and the user’s mobility behaviour. If the higher potential (6.4 million carsharing-users) was realised, 752 425 t CO_2 per year (2.84 TWh) would be reduced in Germany in 2020.

The second analysis aimed at quantifying the CO_2-reduction induced by the current private carsharing customers. According to this survey, the reduction in Germany is as high as 143 kg CO_2 per person and year (respectively 538 kWh). The baseline was set by investigating the individual mobility pattern of each person and the behavioural changes due to carsharing. Moreover, the baseline included the average fuel consumption of the customer’s private cars, which are less efficient than the service provider’s fleets. The value derived could be used as deemed unitary annual energy savings. The total gross annual savings can be derived by multiplying the total number of carsharers in Germany with the average unitary gross annual energy savings.

Within a sub-project on business mobility, experience was gained about the basic conditions of business mobility and the mobility demand of enterprises. However, due to the particular business mobility demand, the environmental effect of carsharing for businesses is neither positive nor negative. But as fiscal and regulatory policies have considerable influence on the enterprise decisions concerning the choice of means of transportation and the purchase of company cars, there is a potential to facilitating a more sustainable business mobility.

Pros: An estimate for unitary annual energy savings was developed.
Cons: Correction factors were not considered.

References and information sources

http://www.wupperinst.org/en/projects/proj/index.html?&projekt_id=9&bid=43&searchart=projekt_uebersicht
Bongardt, D.; Wilke, G. (2007): Verkehrs- und Ökobilanz. Arbeitspapier Zukunft des Carsharing. Wuppertal Institut

Energy taxes, Sweden

Energy taxation policy is aimed at improving the efficiency of energy use, encouraging the use of bioenergy, creating incentives for companies to reduce their environmental impact and creating favourable conditions for indigenous production of electricity. The energy taxes can be divided into an excise tax on energy and those intended to achieve environmental objectives, foremost the carbon dioxide tax. However, it is difficult to separate the effects from these taxes, as both the energy tax and the carbon dioxide tax have fiscal functions as well as steering effects. In order to encourage greening, the environmental taxes have been increasing since the year 2000, while taxes on labour have been lowered, keeping the fiscal revenue constant. The general carbon dioxide level has been altered from SEK 0,37/kg CO2 in 2000 to SEK 1,01/kg CO2 in 2008. Tax levels can be considered particulary high by international comparison; as an example, taxes amounted in 2006 to 57% of the final price for heating oil and to 44 % of the electricty price in the residential sector (including energy, CO2 and VAT taxes). In order to maintain the conditions for competitiveness, the tax on electricity consumption has been altered simultaneously. The energy tax was introduced in the 1950s and the carbon dioxide tax was introduced at the time of the great tax reform in 1991. The same year a VAT on energy products was introduced. Bioenergy is currently exempted from both the energy and the carbon dioxide tax. In addition, no tax is paid on diesel or fuel oils used in commercial maritime traffic or railbound traffic, nor on aviation petrol or aviation paraffin. The industrial sector pays only part of the taxes.

The method here described aims at determining the effects of taxationon energy demand in Sweden. It was commissioned by the Government Independent Inquiry that is responsible for proposing the institutional organisation and the legislative changes needed for implementing the ESD in Sweden, as well as preparing the national energy efficiency action plan (NEEAP).

The impact of taxes depends upon the extend to which consumers respond to changes in energy prices, which are influenced by the tax. This impact is measured by the price-elasticity of energy demand. The effect on energy demand from taxation in the transport and the building sector has been evaluated using **econometric modelling**. The effect from taxes was calculated by using models to produce dynamic forecasts of energy use under two scenarios comparing the results. The first scenario considers the effects of the taxes introduced since 1991 including VAT and vehicle tax in addition to fuel taxes. The "no tax" case uses 1990 taxation levels and assumes that these have remained the same in nominal terms until 2016.

The evaluation concentrates primarily on the transport sector, due to its importance in the Swedish energy use and to the prevalence of taxation as an energy policy in the sector. The residential sector is also considered, although in less detailed due to limitation in data availability.

In the transport sector, fuel use in cars was estimated for petrol and diesel cars separately but also considering the long term relationship between the two. It showed that prices and taxation have encouraged substitution between the fuel types. It also appears that petrol demand is more price sensitive than dieasel demand. The estimate showed a price elasticity of -0,49 for the petrol price and -0,15 for the petrol tax. The price elasticity for diesel is lower, -0,32. and is insignificant for diesel tax. These own price elasticities are smaller than the interval of 0,6 to 0,8 found in the literature.

Within the residential sector, in multi-family houses there was a greater share of insignificant estimations. The only exception is the demand of district heating with respect to the price of heating oil, with a long run price-eleasticty of +0,52. It showed, however, that there is a slow adjustment to price increase, which is not surprising given the lifetime of residential heating systems. The estimates for single-family houses were more successful, showing that the own price elasticity for oil was very large (-2,40) and that there is a small cross-price effect for district heating in relation to the oil price. The electricity price had a small effect on electric heating demand. It showed that effect is greater for household electricity than for heating.

From the result, the energy saving in absolute terms due to taxes was calculated.. The final result indicates a saving of 9 TWh in 2016 resulting from taxation measures introduced since 1990 in the transport and the residential sector.

Pros: Good example of econometric analysis to calculate energy savings due to energy taxation. Dynamic models allow to calculate the effects over time.
Cons: The models require high quality data and for long periods. Price elasticities are more difficult to determine for the building and the industry sectors.

References and information sources

Dargay, Joyce; "Effects of Taxation on Energy Efficiency - Report to Energieffektiviseringutredningen", Institute for Transport Studies, University of Leeds. , Annexe 5 to "En energieffektivare Sverige", Delbetänkande av Energieffektiviseringutredningen, SOU 2008:25, Stockholm 2008, available at www.sou.gov.se/energieffektiv/

White certificates, Italy and France

White certificates have up to now been used in combination with an obligation scheme. Market actors (usually retail energy suppliers or distributors) are obliged to reach a certain amount of energy saving. Target compliance requires submission of a number of certificates commensurate with the energy saving target. Certificates can be created from projects that result in energy savings beyond business as usual, by target market actors or by Energy Service Companies (ESCOs). The market actor receives certificates for savings achieved, which can be used for their own target compliance or can be sold to (other) obliged parties. In Europe several countries have already implemented a white certificate scheme or are seriously considering doing so. Italy has started a scheme in January 2005; France a year later. Great Britain has combined its obligation system for energy savings with the possibility to trade obligations and savings (only among the obliged parties and through bilateral contracts). Denmark and the Netherlands are seriously considering introduction of a white certificate scheme in the near future. Flanders (Belgium) has implemented an energy saving obligation for energy grid companies without tradability of certificates.

Measurement and verification (M&V) is the key for an effective tradable certificate mechanism applied to the promotion of energy efficiency in end-use sectors. Various systems are in place; each with different levels of exactness and costs. These range from **simple deemed estimates** over **more complex deemed estimates** from engineering methods based on detailed calculations that are calibrated with onsite data to **end-use metering** where energy use is actively measured with specialised equipment and expertise. The more sophisticated the method, the higher the costs. There is no overall preferred method for all projects. Clearly extensive and complicated M&V can be way too costly for the small and medium-size projects. Parties have therefore developed ex-ante M&V protocols that pre-define saving factors **(deemed estimates)** for each type of project. Using these methods the costs of M&V – and therewith total certification costs – are significantly lowered.

The EuroWhiteCert project has estimated that ex post evaluations of individual complex projects cost typically (option C for IPMVP) 5 % of initial cost for initial audit + 1.5 % yearly. On 10 years that makes 20 % of investment. On the opposite, checking savings delivered based on ex ante estimates may cost a few hours, a negligible cost.

Pros: A very pragmatic approach to keep monitoring and evaluation costs low, as for the Energy Efficiency Commitment (EEC) in the UK (cf. first case study above).

Cons: Correction factors not explicitly treated, although some deemed estimates in Italy include a discount for free-rider effects. However, little transparency compared to the EEC. High deemed estimates in France for boilers due to use of stock data as baseline. Difficulty to include results of “soft” facilitating measures (like information campaigns).

<u>References and information sources</u>

Measurement and verification of energy efficiency projects; WP4.1 analysis report produced in the framework of the EuroWhiteCert project and available at www.eurowhitecert.org

RUE Obligations, Belgium

In order to encourage the efficient use of electricity in a liberalised market, the Flemish region of the Kingdom of Belgium has imposed RUE (Rational Use of Energy) public service obligations on its electricity distribution grid operators and electricity suppliers and has established mandatory energy saving targets to be annually achieved by such market actors. As of January 1st, 2003 in the calendar year *n* each grid manager has to realize an annual *primary* energy saving whose amount corresponds to a fraction ranging from 1% to 2.2% of the energy supplied during the year *n-2* and varies with the type of end users served (different saving targets have indeed to be achieved at so-called high voltage and low voltage end-users). Each action undertaken by the obliged actor must include a sensitizing and informing part (*indirect* action) and a stimulating part (*direct* action) whereby each energy end-use target group is financially supported to execute the action. Energy efficient solutions typically addressed in the *domestic* sector are low-flow shower heads, efficient lighting (CFLs), thermal insulation (roofs, windows) and condensing boilers / low-temperature boilers. As far as *non-domestic* sectors are concerned actions typically implemented relate to energy audits, retrofit of lighting systems, VSDs, thermal insulation (roofs), condensing boilers / air heaters.

Every year obliged electricity grid companies provide the Flemish regulatory authority of electricity and gas markets (ANRE) with the plan of indirect and direct actions to be implemented for the following year and ANRE approves the plan and the methodologies proposed to evaluate energy savings that will be achieved. The approved calculation methods are not made public. This fact makes difficult any assessment of the methods. In general, a pure ex-ante approach of **deemed estimates** (without on-field measurements) is typically preferred by obliged actors for the evaluation of the energy savings achieved. In case of rather **complex** actions (like VSD installation or energy audits) energy savings are **estimated** on the basis of pre-defined specific formulae depending on variables whose value is measured on-field (e.g. number of hours of VSDs use, etc.). Information on how the base line is set for the calculation of savings is not available either. Free rider, spill over, rebound and possible further dynamic side effects are not taken into account in the calculations.

Concerning costs due to M&V, the same conclusions mentioned for white certificate schemes apply to the RUE obligation in Flanders. Information on costs due to the administration of the system is not available. It may be, however, estimated that they are rather moderate, since the main body involved in system administration (ANRE) needed only around the equivalent of 1.5 full-time staff plus some expenditure for consultants.

Pros: Pragmatic approach based on deemed estimates.
Cons: Process of setting deemed estimates intransparent; no correction factors considered.

References and information sources
http://www.aid-ee.org/documents/020RUEobligations-Flanders-Belgium.PDF
Collys, A., 2005, *The Flanders (BE) regional utility obligations,* Presentation at the European Parliament, ANRE
Collys interview, 22 November 2005

Energy Efficiency Portfolio, California, USA

Two basic programme classifications are used in the EE portfolio: those that are designed to directly acquire energy resources (resource acquisition programmes), and those officially classified as "information-only" programmes. Information-only programmes are generally designed to help customers make energy-efficient product purchases, inform customers about energy-efficient options available in their home or business, or help channel customers into one or more of the resource acquisition programs. Most information-only and several of the resource acquisition programs also have educational components, however, the term "information-only" indicates that the California Public Utilities Commission(CPUC) did not require these programs to meet energy savings goals. All other programmes are expected to set and meet established energy savings, or resource acquisition, goals.

Only a slight majority of the energy savings (55 percent) was evaluated with sufficient rigor to provide impact estimates with a acceptable level of reliability. Only 23 percent of natural gas and 44 percent of demand savings were evaluated using reliable methods. Methods used **included survey information (i.e., mixed deemed and ex-post); engineering algorithm review; end-use metering; and billing analysis**. Across the portfolio of resource acquisition programmes, only twenty-one programme evaluations (42 percent) included an analysis of free-ridership instead of accepting the default net-to-gross ratio. Almost half (23 of 50) of the programme evaluations took free-ridership into consideration when reporting savings, covering 28 percent of kWh, 29 percent of demand and 45 percent of natural gas savings goals. Very few of the evaluations examined the different types of net-to-gross adjustments that typically act to increase savings estimates, i.e., spillovers and multiplier effect.

Pros: Mix of methods is used to evaluate results. Pragmatic approach of a default net-to-gross ratio.
Cons: Very few evaluations of multiplier effects.

References and information sources
http://www.tecmarket.net/publications.htm
http://www.calmac.org/

Annex B - Number of evaluation methods assessed

In this report, twenty three EEI measures have been selected as case studies to describe and analyse the existing practices in evaluation. Some of the case studies cover a range of end-uses and in a few cases various end-use sectors, which implies that a great variety of evaluation methods is employed. Table 3 below summarises the number of individual evaluation methods used per EEI measure analysed as case studies in the report. Table 4 to 7 lists the individual evaluation methods included in the EEI measure or "case studies" considered in the report, respectively for the Energy Efficiency Commitments in the Great Britain and Wales, White Certificates in Italy, White Certificates in France, and RUE obligations in Flanders.

Table 3. Number of assessed evaluation methods per EEI measure ("case studies")

Sector	Case study - EEI measures	Country	Number of evaluation case studies
Residential and tertiary	Energy Efficiency Commitment	UK	19
	FEMP	US	9
	Building EE, Oregon	US	6
	EPS Building Code	NL	2
	Building regulation in Carugate	IT	1
	Elsparefonden	DK	5
	Applicance labelling	NL	1
	Energy+ – Europe	EU	1
	KfW buildings programme	DE	1
	Helles NRW	DE	1
	Technology Procurement	SE	1
Industry	Free energy audits	DK	1
	Investment Deduction Scheme	NL	1
	Voluntary Agreement	DK	1
	Programme for EEI in industry	SE	1
	Energy Audit Program	FI	1
	Industrial EE Network	NO	1
Transport	ACEA	EU	1
	Ecodriving	NL	1
	Congestion charging Stockholm	SE	3
	Car sharing	DE	1
Cross cutting	Energy taxes	SE	7
	White certificates	IT	22
	White certificates	FR	87
	RUE Obligations	BE	46
	EE Portfolio, California	US	2
Total			**223**

Table 4. Assessed evaluation methods in the Energy Efficiency Commitment in Great Britain and Wales, UK

Insulation measures	1	Building shell	Loft insulation (top up and virgin)
	2	Building shell	DIY loft insulation
	3	Building shell	Cavity wall insulation
	4	Building Shell	Draught stripping
	5	Building shell	External and Internal solid wall insulation
	6	Heating System/hot water	Hot water tank insulation
	7	Heating System/hot water	High efficiency hot water cylinders
	8	Heating System/hot water	Radiator panels
	9	Building shell	Window glazing
Lighting measures	10	Lighting	Compact Fluorescent Lamps and luminaires
Heating Measures	11	Heating system/hot water	Installation of a condensing boiler, either with or without heating control upgrades
	12	Heating system/hot water	Heating controls
	13	Heating system/hot water	Solar water heating
	14	Heating system/hot water	Heat recovery ventilation
	15	Heating system/hot water	Ground source heat pumps
Energy Efficient Appliances	16	Electric appliances	Cold and wet appliances replacement
	17	Electric appliances	Cold and wet appliance incentive and trade in schemes
	18	Electric appliances	Fridge saver schemes
	19	Electric appliances	Jug Kettles

Table 5. Assessed evaluation methods in the White Certificates in Italy

	Target (energy use or technology involved)	Specific end-use
	Residential	
1	Lighting	Replacement of incandescent lamp with CFL
2	Heating system/hot water	Replacement of electric boilers with gas fired boilers
3	Heating system/hot water	Replacement of old boilers with "four stars" boilers
4	Heating system/hot water	Replacement of old boilers "open chamber" with "close chamber" boiler
5	Heating system/hot water	Replacement of single glazed windows with double glazed windows
6	Building shell	Insulation of walls and roof
7	Heating system/hot water	Installation of thermal solar collectors for the production of DHW
8	Electric appliances	Replacement electrical appliances (cold appliances, washing machines, refrigerators) with more efficient ones
9	Heating system/hot water	Installation of low-flow showers' water taps
10	Heating system/hot water	Installation of low-flow water taps
11	Heating system/hot water	Installation of heat pumps
	Industry	
12	Cross-cutting technologies	Installation of high efficiency electric motors
13	Pumping systems	Installation of frequency inverters (VSDs)
	Tertiary	
14	Heating system/hot water	Installation of low-flow showers' water taps
	Cross cutting	
15	Heating systems	District heating
16	Electric consumption	Installation of a PV system
17	Natural gas delivery	Energy recovery from decompression of natural gas
18	Lighting	Installation of light-flow regulators (public lighting)
19	Lighting	Replacement of mercury-vapour lamps with high pressure sodium-vapour lamps
20	Heating system/hot water/ventilation	Installation of high efficiency chillers
21	Building shell	Insulation of walls and roof
22	Heating system/hot water/ventilation	Small CHP

Table 6. Assessed evaluation methods in the White Certificates in France

	Target (Energy uses/technologies involved)	Specific end-use
	Residential	
1	Heating system/hot water	Installation of thermal solar collectors for the production of DHW
2	Building shell	Roof insulation
3	Heating system/hot water/ventilation	Installation of high efficiency chillers
4	Lighting	Replacement of incandescent lamp with CFL
5	Lighting	Replacement of incandescent lamp with CFL
6	Electric appliances	High efficiency (class A) washing machines
7	Electric appliances	High efficiency (class A) refrigerator and fridges
8	Building shell	Roof insulation
9	Building shell	Installation of high quality (low transmittance) windows
10	Heating system/hot water	Installation of condensation boilers for collective heating
11	Heating system/hot water	Installation of low temperature boilers for collective heating
12	Heating system/hot water	Installation of condensation boilers for individual heating
13	Heating system/hot water	Installation of low temperature boilers for individual heating
14	Heating system/hot water	Installation of a programmable timer for collective heating
15	Heating system/hot water	Installation of a programmable timer for individual heating
16	Heating system/hot water	Installation of a electric radiant panel or electric radiant type NFC
17	Heating system/hot water	Installation of a programmable timer for electric heating
18	Heating system/hot water/ventilation	Installation of an automatically driven fan for mechanical ventilation
19	Heating system/hot water/ventilation	Installation of an hydro-adjustable fan for mechanical ventilation
20	Building shell	Wall insulation
21	Building shell	Double wall insulation
22	Heating system/hot water	Adaptation of the size of the boiler for individual heating
23	Heating system/hot water	Adaptation of the size of the boiler for collective heating
24	Heating system/hot water	Installation of a modulating burner
25	Heating system/hot water	Smart systems for programmed switch on-off of collective heating systems

26	Heating system/hot water	Installation of efficent radiators (radiateur à chaleur douce)
27	Heating system/hot water	Heating system regulation on the base of the external temperature
28	Heating system/hot water	Insulation of heating system pipes
29	Heating system/hot water	DHW piping insulation
30	Heating system/hot water	Floor heating
31	Heating system/hot water	Installation of thermostatic control valves
32	Heating system/hot water	Individual billing in collective heating systems
33	Heating system/hot water	Installation of water-water type heat pumps
34	Heating system/hot water	Installation of air-water type heat pumps
35	Heating system/hot water	Installation of a double flow ventilation system
36	Heating system/hot water	Condensation type heat recovery
37	Heating system/hot water	Construction of buildings with energy performance higher than required
38	Heating system/hot water	Installation of air-air type heat pumps
39	Heating system/hot water	Electric floor heating
40	Heating system/hot water	Ceiling heating
41	Heating system/hot water	Installation of individual thermal solar collectors for the production of DHW
42	Heating system/hot water	Installation of collective thermal solar collectors for the production of DHW
43	Heating system/hot water	Biomass heating systems
44	Heating system/hot water	Wood fired heating systems
45	Heating system/hot water	Installation of a biomass fired boiler
46	Energy services	Improvement of the standard action linked with energy performance contracts
47	Energy services	Performance contracting
	Transport	
48	Goods transport	Intermodal transport units
49	Passenger transport	Course of energy-saving driving techniques
50	Passenger transport	Energy recovery from braking
51	Passenger transport	Course of energy-saving driving techniques for light veicles drivers
52	Passenger transport	Reduced consumption tyres
53	Passenger transport	Car sharing or subscription to public transportation systems by private company employees
54	Passenger transport	Substitution of company's old cars with more efficient new ones

55	Passenger transport	Electric buses
	Industry	
56	Cross-cutting technologies	Installation of high efficiency electric motors
57	Cross-cutting technologies	Installation of variable speed drive on electric motors
58	Heating system/hot water	Installation of economizer on boilers
59	Pressurized air	Optimization of pressurized air systems
60	Pressurized air	Reducion of leakage in pressurized air systems
61	Lighting	Timed lighting systems
62	Lighting	Lighting management systems using presence detection
63	Lighting	Installation of lighting systems with electronic ballast
64	Lighting	Dimmerable lighting systems
65	Lighting	Installation of high efficiency tube (T8)
66	Lighting	Installation of sodium or metal halide lamps
67	Cross-cutting technologies	Installation of a radiant drying oven
	Tertiary	
68	Heating system/hot water	Installation of efficient thermal solar collectors for the production of DHW
69	Heating system/hot water	Biomass heating systems
70	Energy services	Improvement of the standard action linked with energy performance contracts
71	Energy services	Performance contracting
72	Energy services	Cleaning pipes, balancing of heating distribution network
	Cross cutting	
73	Lighting	Replacement of mercury-vapours lamps with high pressure sodium-vapours lamps
74	Lighting	Voltage regulation in outdoor lighting
75	Lighting	Reduction of reactive power in outdoor lighting
76	Lighting	Power variation in outdoor lighting
77	Lighting	Replacement of mercury-vapour lamps with high pressure sodium-vapours lamps
78	Heating system/hot water	CHP
79	Heating system/hot water	Injection of insulating materials into the heating system pipes lodgement
80	Heating system/hot water	Refurbishment of an existing heat delivery point
81	Heating system/hot water	Replacement of a constant flow pump with variable flow one
82	Heating system/hot water	Use of renewable energy sources of energy in an

		existing system
83	Heating system/hot water	linking to a system feed by renewable sources
84	Energy services	Energy service: production of steam
85	Energy services	Energy service: production cold water
86	Energy services	Energy service: production hot water
87	Energy services	Cleaning pipes, balancing and optional treatment of heating distribution network

Table 7. Assessed evaluation methods in the RUE Obligations in Flanders, Belgium.

	Target (energy use or technology involved)	Specific end-use
	Residential	
1	Building shell	Wall insulation
2	Heating system/hot water	Pipes insulation
3	Energy services	Energy audit
4	Heating system/hot water	Domestic condensation boiler that uses natural gas
5	Electric appliances	Drying machine
6	Lighting	CFL
7	Electric appliances	High efficiency (class A) fridges and freezers
8	Building shell	Roof insulation
9	Heating system/hot water	Reflecting insulation behind the radiators
10	Heating system/hot water	High efficient boilers
11	Heating system/hot water	Thermal solar collectors
12	Heating system/hot water	Low-flow showers' water taps
13	Electric appliances	High efficiency (class A) washing machine
14	Building shell	Well insulated windows
15	Heating system/hot water	Thermostatic valves
16	Electric consumption	Installation of a PV system
17	Heating system/hot water	Heat pump
18	Heating system/hot water	Heat pump boiler
19	Electric appliances	High efficiency (class A) dish machines
	Industry	
20	Electric consumption	HR motors
21	Electric consumption	Frequency regulator
	Cross cutting	
22	Energy services	*Not defined*
23	Energy services	Energy audit in scholastic buildings
24	Heating system/hot water	Condensation techniques
25	Heating system/hot water	Condesation air heater
26	Heating system/hot water	Condensing warm air generator

27	Building shell	Roof insulation
28	Heating system/hot water	Energy accounting
29	Cross-cutting technologies	*Not defined*
30	Heating system/hot water	Close chamber air heater
31	Energy services	In depth energy audit
32	Energy services	Investment support
33	Heating system/hot water	Traditional warm air generator
34	Energy services	Energy losses evaluation
35	Heating system/hot water	*Information not available*
36	Heating system/hot water	Open air-heater
37	Lighting	Relighting
38	Energy services	Superficial audit
39	Lighting	High pressure sodium lamp SON-T 70 W
40	Lighting	Low pressure sodium lamp SOX-E 36 W
41	Building shell	Well insulated windows
42	Heating system/hot water	Thermostatic valves
43	Heating system/hot water	Heat pump
44	Heating system/hot water	Heat pump boiler
45	Heating system/hot water	Thermal solar collectors
	Residential	
46	Energy services	**Participation in building team**