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

Task 8.1: National report from the pilot tests of

Case application 9, Improvement of Lighting Systems (tertiary sector) and Case application 17, Energy Performance Contracting

Performed under the

Swedish Investment Support for Energy Efficiency Improvements and Conversion to Renewable Energy Sources in Public Non-residential Buildings

Final draft

Authors:

Christian Stenqvist and Katie Lindgren, Lund University

on behalf of the Swedish Energy Agency

coordinated by

Wuppertal Institute for Climate, Environment and Energy

supported by

Intelligent Energy Europe

April 30, 2009

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

Task 8.1: National report from the pilot test of Case application 9, Improvement of Lighting Systems (Tertiary sector) and Case application 17, Energy Performance Contracting

Performed under the
Swedish Investment Support for Energy Efficiency Improvements and Conversion to Renewable Energy Sources in Public Non-residential Buildings

Authors;
Christian Stenqvist and Katie Lindgren, Lund University
on behalf of the Swedish Energy Agency

Contents

2 Executive summary

The report presents the pilot tests of the two EMEEES bottom-up evaluation methodologies: Case application 9, Improvements of Lighting Systems (Tertiary sector) and Case application 17, Energy Performance Contracting (EPC).

The proposed methods were tested under the Swedish (EEI) facilitating measure (a public policy programme): *Investment support for energy efficiency and conversion to renewable energy sources in public non-residential buildings* (hereafter referred to as OFFROT).

OFFROT was operating between 2005 and 2008, by granting investment subsidies for a number of end-use (EEI) actions for energy efficiency improvement and conversion to renewable energy sources in public non-residential buildings. Improvements of lighting systems were among eligible actions, and in total 960 applications were received (and granted funding). Although EPC was neither an explicit requirement nor a criterion for OFFROT funding, some projects that received funding did utilize the EPC concept for implementing the actions. The actual number of OFFROT projects that used EPC is not known.

While the OFFROT application form asked for the expected energy savings from planned projects (i.e. the ex-ante savings), the responsible agencies are now (during 2009) beginning to evaluate the energy savings from these projects (i.e. doing the ex-post evaluation). Total ex-ante estimated savings from OFFROT are 472 GWh/year. Lighting improvements are estimated to result in electricity savings of 23.7 GWh/year. The ex-ante savings from EPC projects completed under OFFROT are unknown. It is too early to determine how the ex-ante and ex-post energy savings results will compare.

To perform the pilot tests on the OFFROT program, a summarised version of each EMEEES Case application was presented to some key stakeholders including public authorities, government representatives and energy service companies. After, and throughout, the presentation the interviewees were asked to provide feedback regarding both general concerns and any technical issues for applying these methods to OFFROT projects. Also, a sub-set of OFFROT lighting projects applicants were contacted and asked to answer a questionnaire concerning data availability and methodologies applied for calculating energy savings.

Although the calculations and data requirements for each method are relatively straightforward, the pilot test outcomes identified some complexities in gathering this data. The main issues identified by respondents regarding the ongoing OFFROT evaluations included quality of data reported, especially given the amount of information requested and range of motivation among individuals in voluntarily reporting evaluation results. Moreover, respondents noted that there is often a mismatch in purpose: energy savings is but one of the broader set of priorities for the public agencies and authorities that administered the OFFROT program. These same issues and concerns apply with the proposed methods. Suggestions on how each of the two EMEEES methods can be improved are given in the final sections of chapter 5 and 6.

3 Introduction

This report is the result from pilot testing the listed bottom-up evaluation methodologies.

Table 1: The tested EMEEES bottom-up case applications

EMEEES bottom-up case application	Sector	Ch.
Case application 9, Improvements of Lighting Systems	Tertiary	5
Case application 17, Energy Performance Contracting	Industry, tertiary and residential (multi-dwelling buildings)	6

Case application 9 on Improvements of Lighting Systems in the tertiary sector, describes how (EEI) facilitating measures targeting implementation of energy-efficient luminaries, light sources, ballasts and control strategies, will result in energy efficiency improvements. Calculation methodologies and procedures for data collection are proposed for the purpose of measurement and verification of energy savings.

Case application 17 on Energy Performance Contracting describes the EPC concept as an (EEI) facilitating measure based on a contractual arrangement between the customer and the provider of one, or several, end-use (EEI) actions. Investments in the actions are paid for in relation to a contractually agreed level of energy efficiency improvement (ESD article 3). Calculation methodologies and procedures for data collection are proposed for the purpose of measurement and verification of energy savings.

For testing the selected methods, it has been decided to apply the proposed methodologies to an existing (EEI) facilitating measure, namely the Swedish *Investment Support for Energy Efficiency and Conversion to Renewable Energy Sources in Public Non-residential Buildings* (hereafter referred to as OFFROT). As the name suggests, OFFROT is a financial instrument granting investment subsidies for end-use (EEI) actions and fuel conversions in buildings and premises that are managed by public sector organisations and/or used for public services. OFFROT appears to be a beneficial real case (EEI) facilitating measure for pilot testing as it is granting investment support for a number of end-use (EEI) actions, most of which match with bottom-up methods developed under WP4 of the EMEEES project. Though the decision to test the selected methods was not taken by the authors of this report, some reasoning on the rationale for the selected case applications is:

Concerning Case application 9, the choice is easy to justify. Installation of electricity-efficient lighting systems is a designated action under the OFFROT scheme. Actions related to lighting systems have also proven to be rather common.

Regarding Case application 17, there is nothing stated about EPC in the OFFROT regulations (SFS 2005:205 or BFS 2005:6). Nevertheless, the program administration is promoting the set up of EPC projects for implementing the end-use (EEI) actions eligible for support. In OFFROT information material directed to potential applicants, collaboration with an Energy Service Company (ESCO) is argued to be a viable option for public property managers which lack internal resources to implement actions on their

own (STEM 2005). Considering this promotion for EPC under OFFROT and the fact that the current Swedish EPC market is constituted of in principle public non-residential buildings, it is reasonable to assume that there are many EPC projects under the OFFROT scheme. With an ESCO market on the upswing, the testing activity of EPC did aim at raising awareness among policy evaluators and other stakeholders about aspects on monitoring and evaluation of EPC.

The general approach for performing the pilot tests has been to expose a summarised version of each Case application for a number of stakeholders, i.e. public authorities and energy service companies (ESCOs) (all of which are listed in the list of references). The Case application summaries have been outlined as presentations which the authors have walked through together with the respondents. The focus has been on the calculation steps and their related levels for data collection. Comments and criticism have been gathered regarding both general concerns and in-depth details.

4 Description of the (EEI) facilitating measure considered for the pilot test

Title of the EEI measure	*Investment support for energy efficiency improvements and conversions to renewable energy sources in public non-residential buildings (the authors' translation from Swedish title). The program is commonly referred to as OFFROT.*
Category	*OFFROT is a financial instrument that is offered to building owners within the public sector. The economic incentive is an investment subsidy covering up to 30 percent of the costs for implementation of end-use (EEI) actions and/or actions for conversion to renewable energy sources. (the subsidy is 70 percent for installation of photovoltaic systems)*
Regional application	*Without restrictions OFFROT has been operating in the whole of Sweden.*
Sector(s) addressed	*OFFROT is targeting energy efficiency in the tertiary sector and more specifically in public non-residential buildings managed by public sector organisations and/or used for public services.*
Target group	*In Sweden, the final energy consumption addressed by the ESD has been estimated to be 359 TWh/year as an average during the base period 2001-2005. The sector building and services consumed 151 TWh, or 42 percent (SOU 2008:25).* *According to data from Statistics Sweden (2002) the total area of public non-residential buildings was 62.7 million m^2. This is about 43 percent of the total non-residential building stock of 144 million m^2. The 2002 final energy consumption for public non-residential buildings was 21 TWh. 11 TWh was electricity and the remaining 10 TWh heat that can be divided as follows: district heating 6.5 TWh, oil 1.5 TWh, electricity incl. heat pump 1.5 TWh, bio-energy incl. peat 0.3 TWh, gas 0.3 TWh. (Näringsdepartementet, 2004).* *Hence, based on these final energy consumption figures, the energy consumption of the OFFROT target group is 21 TWh which corresponds to 5.8 percent of the Swedish energy consumption addressed by the ESD.*

End-use (EEI) action targeted	*According to OFFROT regulations (SFS 2005:205), investment support can be granted to the following categories of actions:* *1. The carrying out of an energy audit* *2. Converting heating system by replacing electricity or fossil fuels with renewable energy sources, heat pump, or district heating* *3. Connecting to district cooling or installation of system for free cooling* *4. Installation of electricity-efficient lighting system* *5. Installation of electricity-efficient ventilation system* *6. Installation of equipment for effective control, measurement, monitoring, regulation and operation of motors or heating systems* *7. Energy efficiency improvements of the building envelope or to the building's heat recovery system* *8. Installation of photovoltaic system* *Case application 9 on Efficient Lighting Systems will focus only on end-use (EEI) actions of category (4).* *Case application 17 on Energy Performance Contracting does not target a specific category of end-use (EEI) actions. EPC projects may very well include actions from categories (1) – (7). Energy auditing (1) will always be an integrated part of an EPC project.*

Effectiveness	*OFFROT was based on a two step application procedure. In the first step the building owner applied for support to the county administrative board. An electronic form was submitted, in which the planned actions were stated and the expected energy savings were given together with some other details (i.e. installation costs and working hours for implementation). The county board then gave a preliminary approval for investment support. The building owner went ahead to implement the actions and three months after implementation a second application, complemented with documentation that proved the installations, was submitted. The county board then gave an approval whereupon the support was rewarded.* *The National Board of Housing, Building and Planning is the administrating agent that collects and compiles the data that have been reported to the county boards. The reporting and documentation procedures provide trust in that the actions have actually been undertaken and that the costs claimed are accurate. Supervision can be issued and upon non-compliance the funding can be retrieved. (SFS 2005:205).* *By offering a 30 percent investment support OFFROT has been an attractive benefit for many building owners, and between 2005 and 2008 more or less all of the earmarked 2 billion SEK[1] had been granted (Näringsdepartementet, 2009).* *Energy efficiency improvement is only one of several OFFROT objectives. Primarily the program aims to (Näringsdepartementet, 2009):* *i) Boost national economy by creating employment in the construction sector* *ii) Increase energy efficiency* *iii) Increase the use of renewable energy sources* *Some secondary objectives are:* *iv) Decrease the use of electricity for heating purposes* *v) Introduce photovoltaic systems*
If available: **expected annual energy savings in 2016 and 2010**	*The expected total gross annual energy savings can be based on the savings estimates stated in the granted application forms. This data is prepared and reported by the applicants.*

[1] 100 SEK is equivalent to about 9 Euro as of January-March 2009

	OFFROT total energy savings *The estimated energy savings from granted actions are: 472 GWh per year, of which about 75 percent are heat savings and the remaining 25 percent electricity savings. All actions have been implemented between 2005 and 2009, meaning that those implemented in 2005 through 2007 will give rise to early energy savings, if these are allowed to count towards the ESD energy savings targets (i.e. stemming from end-use actions initiated between 1995 and (beginning of) 2008).* *Only if actions are persistent in achieving energy savings at initial performance (i.e. like first year annual savings) during a energy saving lifetime greater than between 8 and 11 years, the expected total gross energy savings due to OFFROT will be 472 GWh in 2016 (and 2010). Energy savings are expressed in terms of final energy use. There is no information available regarding the choice of conversion factors. Presumably, a factor of 1.0 has been applied for all energy carriers.* ***Lighting action energy savings*** *The estimated energy savings from granted actions are: 23.7 GWh electricity per year.* *Only if actions are persistent in achieving energy savings at initial performance (i.e. like first year annual savings) during a energy saving lifetime greater than between 8 and 11 years, the expected total gross energy savings from lighting actions due to OFFROT will be 23.7 GWh in 2016 (and 2010). Lighting actions have default lifetimes of 10 or 12 years (based on CWA 27) meaning that all savings will be accountable in 2010, and most of them in 2016, given that early energy savings are allowed. Energy savings are expressed in terms of final energy use. There is no information available regarding the choice of conversion factors. Most likely a factor of 1.0 has been applied.* ***EPC energy savings*** *There is no evidential support for making estimates.*

	NEEAP estimates *In the Swedish National Energy Efficiency Action Plan (NEEAP) there are higher expectations about the OFFROT energy savings. The NEEAP suggests savings of 0.6 TWh (0.8 TWh in terms of primary energy) by 2010 and 2016 (SOU 2008:25, p. 176). The conversion factor for electricity is 2.5.*
Status of implementation and exact timeframe	*OFFROT was enforced on May 15 2005. Initially, the program was scheduled to be concluded in December 2006. Later on the program was extended so that the final date for submitting applications became December 31 2008. In conclusion, all end-use (EEI) actions under the OFFROT scheme have been implemented between 2005 and early 2009.* *Hence, OFFROT does contain early energy savings from end-use actions initiated between 1995 and 2008. For these a contribution to the target of 2016 can only be counted if the energy saving lifetime is greater than between 8 and 11 years depending on the year of implementation (2005 -2008).* *OFFROT is now concluded and the National Board of Housing, Building and Planning have begun the ex-post evaluation that is planned to be finished during 2009 (Boverket, 2009).*

5 Test 1 – Case application 9, Improvements of Lighting Systems

5.1 Testing activity description

While the OFFROT program, as explained in Chapter 4, provided investment support for several categories of end-use (EEI) actions, this test of Case application 9 on Improvement of Lighting Systems (hereafter referred to as the EMEEES method) will focus on the lighting actions. These actions were all taken during the program years between 2005 and early 2009.

OFFROT regulations describe a lighting system as consisting of luminaries including lamps and ballasts, together with other installation materials that are needed for connection and overall system function (BFS 2005:6). This general description is by and large compatible with the definitions made in the EMEEES method of lighting equipment and related efficiency improvement actions. Apart from the components lamps, ballasts and luminaires, the method addresses the control apparatus as an essential component of any lighting system. The control apparatus would likely fall into the category “other installation materials” in the OFFROT regulations.

Energy savings from lighting projects can be estimated through the OFFROT application process, since the applicants have reported the calculated electricity savings from their installations. From the 960 lighting applications, the total ex-ante electricity savings are 23.7 GWh. No instructions have been given to the applicants on how to calculate the electricity savings. Therefore, there is little understanding of the evaluation methodologies used by the individual applicants. The aggregated ex-post evaluation, for which the National Board of Housing, Building and Planning is responsible, is currently (during 2009) being conducted. It is currently unknown how the ex-ante and ex-post energy savings results will compare.

The aim of this testing activity has been to assess the usability of the suggested EMEEES method, and whether it can be applied for evaluating the OFFROT lighting actions. Focus has been on testing the suggested calculation formulas and the related requirements made on data gathering. A number of stakeholders involved in the OFFROT process have been identified as appropriate for answering to this. The stakeholders include public authorities (the Swedish Energy Agency, the National Board of Housing, Building and Planning), government representatives (the Ministry of Enterprise, Energy and Communications), property managers in their role as OFFROT applicants, and energy service companies (ESCO’s) whose customers have received OFFROT funding. The stakeholders have been introduced to a summarised version of the proposed EMEEES method. They have been asked to put forward their comments on the applicability of the method; both their general concerns and their specific concerns about applying the method for evaluating the OFFROT actions.

Among OFFROT applicants a sub-set of lighting projects applicants were contacted; the property managers were asked to answer a questionnaire concerning data availability and methodologies applied for calculating energy savings. The response rate turned out to be low (only 3 out for 16 responded), which makes it difficult to make generalised conclusions. However, those that did respond provided comprehensive answers which gave an understanding of the situation for these specific applicants.

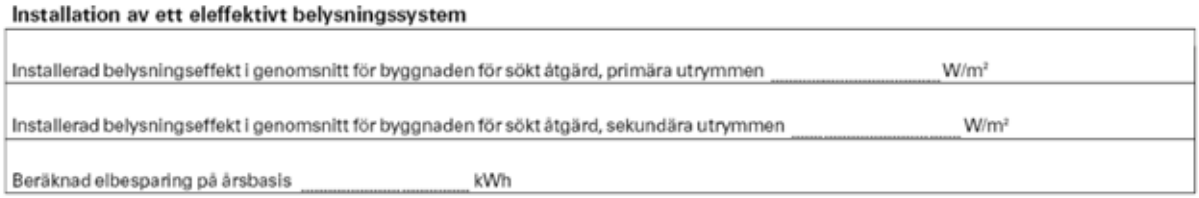
In conclusion, the above mentioned stakeholders have been involved in the test though a variety of ways (i.e. meetings, telephone interviews, questionnaires, e-mail contact). The authors have then compiled the received comments, and examples of such are given throughout this report.

5.2 Main data sources used for the pilot test

To perform the test we first reviewed the available (i.e. easily accessible) OFFROT data provided by the National Board of Housing, Building and Planning. Given how the OFFROT program was structured (i.e.: lighting system improvements were a specific measure eligible for funding), it was easy to sort the data to study the sub-set of lighting projects. The purpose of breaking out the OFFROT lighting data was to assess its compatibility with the data requirements made by the EMEEES method.

The available OFFROT data corresponds to what has been reported in the application forms. Figure 1 illustrates a snapshot of the section dedicated to lighting actions. The information, with an energy relevance, that the applicants are requested to fill out are:

- Installed average power for lighting in primary spaces [W/m^2]
- Installed average power for lighting in secondary spaces [W/m^2]
- Calculated annual electricity savings [kWh]



Installation av ett eleffektivt belysningssystem

Installerad belysningseffekt i genomsnitt för byggnaden för sökt åtgärd, primära utrymmen _____	W/m²
Installerad belysningseffekt i genomsnitt för byggnaden för sökt åtgärd, sekundära utrymmen _____	W/m²
Beräknad elbesparing på årsbasis _____	kWh

Figure 1: Section dedicated to lighting improvements in the OFFROT application form (Boverket, 2005b)

Of the three requested figures the calculated annual electricity savings is relevant for this testing activity. Ideally this reported figure is the final result based on engineering calculations performed by the applicants or a contracted energy consultant. If so, the reported result will correspond to something like the unitary gross annual energy savings at a level 3 evaluation as proposed by the EMEEES method. On the other hand, the reported figure may just as well be the applicant's "guesstimate". In fact, the OFFROT administration provides no instructions for how to calculate electricity savings.

Looking at the data requirements made by the EMEEES method these are as follows for each level of evaluation.

Level 1:

If improvements to lamps, ballasts and control apparatus were undertaken as stand alone single actions, for level 1 calculation, data required to be reported by the participants are:

- The type of action (and no. of units for each type of action) according to the following categories:
  - Replacement of incandescent lamp to CFL (Ch. 2.5.1).
  - Replacement of electromagnetic to electronic ballast (Ch. 2.5.2).
  - Replacement of standard luminaire to higher efficiency alternative using electronic ballasts (Ch. 2.5.3). (also requires data on level 2 or 3)
  - Replacement of standard luminaire (incl. T8 lamps) to more efficient luminaire (incl. T5 lamps) (Ch. 2.5.4). (also requires data on level 2 or 3)
  - Introducing occupancy sensors (Ch. 2.5.5)

For other types of actions, various combined actions, or for a higher evaluation effort it is necessary to address level 2 or 3.

Level 2 and 3:

Both on the level 2 and level 3 the energy savings are determined through engineering calculations that requires the following data to be collected for the energy-efficient and for the replaced lighting system:

- The number and power of installed lamps
- The number and power of installed ballasts
- The hours of use of the lighting system
- The control apparatus type

What differentiates the two levels is their sources for data gathering. While national data is sometimes enough for level 2 calculations, level 3 rely on measure-specific data. Appendix II lists the main data to collect (according to the EMEEES method) for performing the BU calculations on each level 1, 2 and 3 respectively.

Clearly, there is discrepancy between the available (i.e. easy accessible) OFFROT data and the data requirements made by the EMEEES method. Already at level 1 the OFFROT evaluator would have to request the lighting applicants (representing 960 lighting projects) to submit additional information. Evaluation at level 2 or 3 involves increasing demands on reporting and thus additional work loads for applicants as well as evaluators. This extra work could, however, be avoided by requiring to use the straightforward EMEEES lighting system formula from the beginning for calculating the ex-ante energy savings and to provide the inputs and results along with the funding application. This would be a level 3 enhanced engineering method that is similar to engineering calculations made by consultants in any case.

5.3 Test of methodology application step by step

Given the data available (or rather, the lack thereof), it was not possible to conduct a quantitative method application test for each step envisaged by the method. However, in this section an attempt is made to walk through the four bottom-up calculation steps. For each step comments are given about the applicability of using the method for evaluating OFFROT lighting actions. To follow this discussion it is recommended that the reader is conversant with the method itself, which is available through the EMEEES website. A PDF of the case application can be found at:

http://www.evaluate-energy-savings.eu/emeees/downloads/EMEEES_Method_9_Lighting_final.pdf

Step 1: Unitary gross annual energy savings

Even on level 1, that is supposed to be least demanding, it is difficult to apply the EMEEES method to the current set up of OFFROT. The minimum requirement for calculating the electricity savings on level 1 is that the type and the number of each action is known. None of these seemingly simple facts have been collected through OFFROT reporting procedures. To obtain any energy and installation related information in addition to the reported “calculated electricity savings”, a follow-up is required where applicants are requested to answer to more detailed questions about their actions or even submit documentation that support their calculations. Based on answers from the survey of lighting applicants such a follow-up could be fruitful. The responding building managers did know what type of equipment had been replaced, what kind of actions had been implemented and the quantities of each. The respondents had also documented their actions and the related energy savings calculations. Since these are measure-specific data it demonstrates that applicants have performed their calculation (in terms of gross energy savings) similar to a level 3 evaluation as proposed by the EMEEES method. Admittedly, the respondents constitute only a small percentage of an already small sub-set of lighting applicants. Whether respondents are outliers or they represent a norm remains unknown.

Assuming the evaluator decides to do a follow-up in order to collect additional information, it does make sense to request data suiting a higher level of evaluation. From the respondents’ point of view higher level data, like the equipment’s power absorption and number of operating hours, seems to be just as available as level 1 data on type and number of actions. This provide evidence that requiring level 3 calculations from the outset would probably not cause a lot of extra effort for most participants in such programmes as OFFROT.

Step 2: Total gross annual energy savings

Assuming the set up of OFFROT would facilitate a proper evaluation on step 1 (regardless of the evaluation level), there should not be a problem of performing the second step of summing up the annual energy savings of all participants. The “elementary unit of action” which is one OFFROT lighting application is monitored through the direct accounting method of registering all applicants and their reported savings. Issues like missing data will bring some uncertainty into the final result, e.g.

about 3 percent of the applicants have failed to fill out the form concerning the calculated electricity savings.

The method argues that ex-post verification for a sample of participants should be done. Monitoring of implementation and of energy consumption could ensure that the end-use (EEI) actions are actually in place and operational, as specified initially. The National Board of Housing, Building and Planning is issued to control the compliance of the regulations (§ 14 SFS 2005:205), and the applicants are obliged to provide any data found necessary for enabling monitoring and verification (§ 15 SFS 2005:205).

Step 3: Total ESD annual energy savings

The method mentions free-rider coefficient (FR), multiplier ratio (MR) and double-counting coefficient (DC) as gross-to-net correction factors to account for. The possible occurrence of technical interactions (TI) is also mentioned though TI is not intended to be covered by a factor and calculated at the aggregated level. Quantifying the correction factors would require some in depth analysis. In the following, they are briefly addressed in relation to the OFFROT case:

- Free-rider coefficient (FR): The EMEEES method suggests level 1 default values for different types of end-use (EEI) actions. The underlying assumptions are transparent and the default values could provide useful for evaluators of lighting improvement projects. The problem of applying these to the reported gross annual energy savings of OFFROT is that the types of lighting actions are unknown. However, all the respondents of the survey could answer to this and thus a complete follow-up identifying the types of actions installed could, if combined with suggested default values, result in an estimate of the FR-effect. Another approach for estimating the effect would be a questionnaire with straightforward questions asking the applicants to what extent actions would have been implemented anyhow? To make an example from the survey, one respondent claimed that about 50 percent of the installed actions (in terms of annual electricity savings) would have been installed anyhow, partly because some equipment were more than 30 years old and needed to be replaced. An important remark made by the EMEEES method is that the coming EU wide phase out of incandescent lamps will require FR default values to be updated over the years.
- Multiplier energy savings (MR): For assessing the multiplier savings the EMEEES method makes reasonable suggestion about sales data analysis or surveys with non-participants or other stakeholders. OFFROT has given the target group clear economic incentives to identify and implement the eligible end-use (EEI) actions. Generous, but short-lived, subsidy schemes like OFFROT will naturally motivate large investments. Eventually, when programs are concluded additional actions/ investments may be postponed until another subsidy scheme is launched. Based on this principle, those identified but still not installed OFFROT actions with long pay back periods will probably not be implemented without a renewed financial support. This would imply that the multiplier effect is small. Multiplier savings are more likely to arise from clearly profitable actions (with pay back periods of less than two years). According to OFFROT regulations these are not eligible for funding but they could nevertheless be identified and implemented due to OFFROT driven activities.
- Double-counting coefficient (DC): Double-counting should primarily be avoided and

the EMEEES method suggests a few approaches for reducing the risk that DC occurs. Since OFFROT applications are registered by the County Boards in a centralised database for which the National Board of Housing, Building and Planning is responsible, each granted action becomes registered. These reporting procedures are necessary to ensure that a single action is not funded twice from overlapping facilitating measures, which is also prevented by the regulations (Boverket, 2009). General overlap with other measures cannot be ruled out (e.g. Swedish energy taxes), but there are no other policy instruments that like OFFROT are targeting lighting systems improvements in the public sector.

- Technical interactions (TI): Installing more efficient lighting equipment may reduce cooling or increase heating load of the HVAC system. Preferably, these types of system changing effects are covered in the reported gross annual savings of each end-use (EEI) action. With several types of end-use (EEI) actions eligible for OFFROT funding there can be many examples of TI between both new and old pieces of equipment. In the application form, the calculated energy/electricity savings are stated for each single end-use (EEI) action. To what extent applicants have compensated the isolated energy savings with possible TI is not known.

Step 4: Total ESD energy savings for year "i"

With reference to the CWA27 document on energy savings lifetimes the EMEEES method suggests 12 years for light sources and 10 years for control strategies. All OFFROT actions have been installed between 2005 and 2008. This means that most of the OFFROT lighting actions will be accountable for the overall target of 2016, if early energy savings are allowed by the European Commission and the ESD Committee. However, those that involve changes to control strategies and that have been installed during 2005 will not be accountable in any case. Lacking the information about the types of installed lighting actions, it is not possible to assess the impact of this restriction. A follow-up identifying the possible savings from control strategy actions (installed in 2005) and the other early energy savings is doable if evaluators wish to deduct these non eligible savings from the total ESD energy savings.

5.4 Methodology test on early actions and additionality issues

Early Action

The definition of early actions may include two possibilities (to be clarified by the European Commission and the ESD Committee):

- *early (EEI) facilitating measures*, and only those energy savings that result from end-use actions that are implemented during 2008-2016, as a result of these facilitating measures that still have a lasting effect during 2008-2016, are eligible

OR

- *early energy savings* from end-use actions initiated between 1995 and the beginning of 2008, with the end-use actions having a lasting effect in 2010 (for the intermediate target) or 2016 (for the overall target).

Since OFFROT has been operating between 2005 and the end of 2008, the second option would need to be allowed for all energy savings it generated before the 1st of January 2008. All end-use (EEI) actions have been initiated between 1995 and 2009 and more specifically between 2005 and 2009. Consequently, Sweden may include in its ESD savings the energy savings from OFFROT actions in 2008 in any case, and before 2008 if early energy savings are allowed, and if all of these have a lasting effect in 2016 (or 2010 for the intermediate target). This means that the following condition should be fulfilled:

$$\text{Energy saving lifetime} \geq 8 \text{ years} + (2008 - \text{year of installation})$$

The EMEEES method proposes default values for energy saving lifetimes as presented in table 2.

Table 2: The method's suggestion for EU savings lifetime harmonised values.

Category	End-use EEI action	EU Savings Lifetime harmonised values	First year for eligibility, if early energy savings are allowed
Light source	New/renovated office lighting *(Commercial /Public sector)*	12 years	2004
Control strategies	Motion detection light controls *(Commercial /Public sector)*	10 years	2006

Thus, if determining the saving lifetimes to be 10 or 12 years (depending on category of action) all actions will have a lasting effect in 2010, while a large (but unknown) share will have a lasting effect in 2016. Those actions installed during 2005 that involve changes in control strategies will not be accountable. Lacking information about the category of installed OFFROT lighting actions it is not possible to assess the impact of this restriction. A follow-up that identifies the possible savings from control strategy actions (installed in 2005) and other early energy savings is doable given that evaluators wishes to deduct these non-eligible savings from the total ESD energy savings. Another option than choosing the suggested default lifetimes would be to determine specific energy saving lifetimes of the OFFROT actions, which would then have to be verified by the MS. The EMEEES method discusses the persistence of energy savings as a function of measure retention and technical degradation. Acknowledging the skills and resources required for conducting such analysis it is more likely that MS will apply harmonised default saving lifetimes given these values have a legal status.

Additionality

The level 1 default values proposed by the EMEEES method correspond to each of the two baselines: (inefficient) stock baseline or inefficient market baseline. Although OFFROT participants most likely used the energy consumption of existing systems as

the baseline in their calculation of ex-ante energy savings, it would be appropriate, for a level 1 evaluation, to use the (inefficient) stock baseline for the old equipment/system if the aim were to calculate all energy savings, or to use the inefficient market baseline if the aim were to calculate additional energy savings, and in both cases use the efficient market benchmark that is also provided by the method for the new installations. When possible, the EMEEES method suggests default values for the different categories of actions that can be evaluated at level 1. However, the question is whether level 1 calculations are useful for OFFROT at all, or whether the participants' calculation of ex-ante energy savings can be accepted as a level 3 approach. In that case, for practical reasons, the baseline will be the individual before situation.

Also on the level 2 and 3, the baseline can be the individual situation before implementing the improvement. The OFFROT applicants have not been instructed how to treat baseline issues. It can be assumed that, for most applicants, the baseline is an estimated or calculated annual electricity use (installed power multiplied with the annual operating hours) of the old lighting system. This has been confirmed by respondents of the survey. A level 2 evaluation could rely on national data on lighting electricity consumption. In Sweden, an ongoing project for improving statistics on energy consumption in premises will likely provide adequate figures for establishing a national stock baseline (STEM 2007a). For level 3, the EMEEES method suggests end-use metering campaigns as a valid data source for deciding the measure specific electricity consumption. None of the respondents stated that they had metered the lighting specific electricity consumption.

In the previous section (step 3 of Ch 5.3), the influence of correction factors was discussed as well as the efforts to determine these in order to estimate the additional savings from OFFROT. Eliminating the free-rider effect or not constitutes the difference between additional and all energy savings in the area of correction factors. Partly based on EU market shares of energy efficient lighting equipment, the EMEEES method suggests free-rider values for level 1. These are applicable given that the type of action is defined and known to the evaluator. This condition would require additional data gathering for the OFFROT evaluator. A level 2 assessment of the free-rider effect could involve an analysis of the national market shares of energy-efficient lighting equipment. A survey/questionnaire to determine free-riders would be an option. The EMEEES method does not enter deeply into these issues but refers to the "State-wide Market Assessment and Evaluation Non-Residential New Construction Program Area Building Efficiency Assessment Quarterly Report, 2001" (http://www.calmac.org).

5.5 Method comparison and interactions with already existing evaluation methods

By compiling the information on expected energy savings from the application forms, a preliminary estimate of the OFFROT energy savings has been made (Boverket, 2009). Based on reported data from the 960 applicants, lighting system improvements will give annual electricity savings of 23.7 GWh (i.e.: ex-ante savings). Made apparent in previous sections of this report, there is little understanding on how the reported expected electricity savings comply with the evaluation procedures of the EMEEES method.

Respondents claim that engineering calculations form the basis for the expected savings. Yet, diversity can be assumed in how input data has been chosen. It is not known for example, how the figures used for absorbed power of ballasts or reduced operation hours due to occupancy sensors will compare with the conservative level 1 default values. All respondents stated they had based their calculations on their building's specific annual operating hours. If instead, the suggested baseline of 2500 hours per year had been applied on the same actions the calculated energy savings had become between -30 and +40 percent different. Clearly, there is a large uncertainty in using a general default value for operating hours.

There exists no explicit evaluation method for how to calculate the energy savings from OFFROT. In 2005 however, a plan for monitoring and evaluation was drawn up by the National Board of Housing, Building and Planning in consultation with the Energy Agency (Boverket, 2005a). The plan states that monitoring and the subsequent evaluation will be concerned about:

- Number of applications, requested funding, total administrative costs, and granted funding
- Impact on employment, i.e. working hours for implementing eligible actions
- The share of the cost for the actions financed by the OFFROT support
- The total calculated energy savings

Seemingly, and as mentioned in the table of chapter 4, OFFROT has multiple goals. Moreover, for the National Board of Housing, Building and Planning (i.e. the designated agency for the built environment), energy efficiency is only one out of several matters to consider (Boverket, 2009).

The plan expresses confidence in that a quantification of total energy savings as well as energy savings per category of action (for the eight eligible actions) is feasible. The application forms (containing the reported figures) are referred to as appropriate data sources. An assessment could, as the plan states, be accompanied with figures on measured energy consumption before and after the implementation of the actions. But, there is no real discussion about the accuracy of the reported data. Regarding additionality issues, none of the mentioned gross-to-net correction factors are mentioned in the plan. The plan does admit that apart from OFFROT there may be other driving forces behind the resulting energy savings (Boverket, 2005a). However, no ambitions are made to distinguishing the additional savings.

OFFROT was concluded in 2008 and the National Board of Housing, Building and Planning have just started the ex-post evaluation. As the evaluation is budgeted it is not likely that there will be any major changes to its original focus or level of ambition. Moreover, the evaluation is very much dependent on the monitoring practices until now. Additional data gathering would be demanding. Acknowledging that OFFROT involves different types of end-use (EEI) actions it is questionable, considering the skills and resources it requires, to perform thorough ex-post evaluations for each category of action. If only a few types of actions were to be evaluated according to any of the proposed EMEEES BU methodologies, it would probably not be lighting improvement actions since the estimated energy saving is only five percent of total OFFROT

savings.

The choice of energy savings lifetimes is of course important for deciding the ESD target achievement. The lifetime values suggested by the EMEEES method (based on CWA 27) will probably be useful for evaluators given these values obtain legal status.

5.6 Evaluation of costs related to method application

Initially, it should be stated that the following discussion is based on aggregated cost and estimated energy savings of the entire OFFROT program. A specific discussion on lighting actions would require a break out of costs which is not available.

Stakeholders had general concerns about the costs associated with doing high quality evaluation work, including national surveys and follow-up questionnaires, interviews etc. Regarding the ambitions of the EMEEES project to develop an EU harmonisation of evaluation methodologies there were concerns about the different situations in which Member States are, and their ability to comply with the monitoring and evaluation practices expressed in the methods. Sweden has a relatively well-established organisation of appointed agencies provided with skills and resources. Even so, for the OFFROT lighting projects, the least demanding level 1 evaluation would not be possible without additional efforts in terms of data gathering. This could, however, be avoided if the ex-ante estimates by the participants were allowed as level 3 figures.

The OFFROT monitoring and evaluation plan, from 2005, includes figures on budgeted and estimated costs (see table 3). The figures represent the shared budget and cost estimates of the National Board of Housing, Building and Planning and the Energy Agency. Estimated cost varies with the efforts put into monitoring and evaluation. In the basic scenario, the aim is to understand and assess the result of the program. The impact and effectiveness should be presented and communicated to decision makers (i.e. politicians and civil servants) on regional and national level. The total cost is estimated to be 14 MSEK (equalling about 1.3 million Euros). (Boverket, 2005a)

Several suggestions are made on certain policy aspects that could be of interest to evaluate further. One is to closely examine 10 to 15 projects from each category of end-use (EEI) action, and to evaluate aspects like technical, energy-related, economical, levers for implementation, quality improvements etc. Combining this with other suggestions for focused evaluation on specific end-use (EEI) actions, the total cost is estimated to increase by 50 percent, reaching 21 MSEK (equalling about 1.9 million Euro). (Boverket, 2005a)

Table 3: Estimated costs for monitoring and evaluation of OFFROT (Boverket, 2005a)

Year	Cost for basic monitoring and evaluation (kSEK*)	Cost for a thorough monitoring and evaluation (kSEK*)
2005	5 500	5 500
2006	5 500	6 600
2007	3 000	8 550
2008		
2009		500
Total	14 000	21 150

* 1000 SEK = ~90 Euro

According to the basic scenario, 11 MSEK were budgeted for monitoring activities during the 2005 to 2006 period (Boverket, 2005a). For the period between 2007 and 2009 costs will mainly be devoted to evaluation activities, i.e. 3 MSEK in the basic scenario. Considering the relationship between monitoring and evaluation, it can be assumed that the current ex-post evaluation will be based on the monitoring data from the application forms. This will resemble a basic scenario and thus the estimated government cost for monitoring and evaluation is 14 MSEK.

Based on the ex-ante estimated gross annual energy savings of 472 GWh the cost of monitoring and evaluation activities per saved kWh becomes 0.03 SEK/kWh (equal to 2.7 Euro/MWh). While the OFFROT investment subsidy of 2 billion SEK is truly dominating, costs for monitoring and evaluation and other administrative expenditures (e.g. at the County Boards and Tax Authority) will make small contributions to the total government cost. Hence, monitoring and evaluation costs will make up roughly 0.7 percent of the total government cost for OFFROT. But, since OFFROT has multiple goals, monitoring and evaluation will not relate only to the energy savings achieved. Costs that are specific to monitoring and evaluation of energy savings are likely to be well below 0.7 percent of total government cost.

There is no straightforward approach for quantifying the costs of applying the EMEEES method to OFFROT. It will depend on circumstances like: If the EMEEES method is applied instead or in addition to an existing methodology? Should EMEEES methodologies (if possible) be used for each eligible end-use (EEI) action? At what level of evaluation effort should the EMEEES methods be applied?

A “guesstimate” is that applying the EMEEES methods at this late stage (and for all possible eligible end-use (EEI) actions) may increase cost in the same range as the more thorough monitoring and evaluation alternative of the plan (i.e. with some 50 percent). If it had been planned from the beginning that EMEEES methods were to be applied, the application form could have been outlined in accordance. In such case, since additional ex-post data gathering would be avoided, it is viable that monitoring and evaluation costs could be kept well below one percent of the total government cost.

Though an application form rich on detailed data would provide transparency and be possible to review, it would add administrative burden to both program administrators, operating agents and end-users to perform this work. Reported aggregated data, obliged to be based on engineering calculations with accurate input data, should be equally reliable. The figures reported by the survey respondents were in fact based on engineering calculations. As many end-users hire energy consultants for their energy efficiency improvement projects, energy savings calculations are typically a part of the project documentation. An option for strengthening confidence in the OFFROT figures would be to require applicants to submit this documentation.

This would then be equivalent to a level 3 calculation method. If required from the beginning, this variant of the EMEEES method would probably not be more costly than the Swedish monitoring method. However, if additionality of energy savings was to be proven by application of the free-rider correction and baselines for specific end-use actions, and if also the aim was to specify lifetimes for specific end-use actions, then surveys of a sample of participants and projects would be needed. These could easily cost 200.000 to 300.000 Euros or more. Still, this would be feasible within the range of the planned extended evaluation cost.

5.7 Target group perspective

The key stakeholders involved in the pilot test were:

- Public authorities (the National Board of Housing, Building and Planning, and the Swedish Energy Agency) >> Interview, Email communication
- Government representative (the Ministry of Enterprise, Energy and Communication) >> Interview
- Energy service companies (having customers that received OFFROT funding) >> Interviews
- OFFROT applicants/end-users (property managers/building owners) >> Survey

Apart from the OFFROT applicants, all stakeholders were involved through interviews. The interviews were conducted in person or by phone and were taped and later reviewed and transcribed. When interviewing the ESCOs and the authorities we first presented a summarised version of the proposed EMEEES method. After a review of the calculation steps and the related levels for data collection, interviewees were asked to provide feedback regarding both general concerns and any technical issues for applying the method to OFFROT projects. The discussion questions were as follows:

- From your experience, what aspects of the proposed methods would you expect to work well?
- What challenges would you anticipate in applying these methods?
- How difficult would it be to apply the proposed lighting method and EPC method to recent projects you have completed? Why?
- What recommendations would you have for revising the proposed methods? (e.g.: Is anything missing? What should remain unchanged versus be changed and or

deleted?)

Summarised comments from some stakeholders follow below.

The National Board of Housing, Building and Planning

One difficulty of using the EMEEES method for estimating the savings from OFFROT lighting actions is the contrast between the method's requirements on detailed data gathering and the currently available aggregated data. It can be argued that it should be required for the applicants to report more detailed data (e.g. number of lamps, installed power, operating hours etc.). This would be feasible for an (EEI) facilitating measure dedicated to only lighting energy efficiency improvement. With OFFROT however, lighting is only one out of many eligible end-use (EEI) actions. If all actions were to be reported in the same down-to-detail manner, the application process and form could become an unwieldy procedure. It is uncertain whether this would improve data quality. Already as it is, the five pages long application form is considered to be demanding, and there are some problems with incomplete forms. It deserves to be mentioned that the main purpose of the application form is to foster a smooth administration and payment of the investment support. Secondly, it should gather data to enable a program evaluation. For this reason, there are restrictions to the level of detail/disaggregation of the information for applicants to fill in. The application form should be seen as one, but not the only source of information. In the ex-post evaluation it is possible that applicants will be requested for additional information.

Swedish Energy Agency

The plan for monitoring and evaluation was drawn up by the National Board of Housing, Building and Planning in consultation with the Swedish Energy Agency (STEM) (Boverket, 2005a). Commissioned by the government, the responsibility (and budget) for conducting the evaluation is shared between the two authorities (Näringsdepartementet, 2004). During the OFFROT planning and formulation phase, STEM argued for the application form to request energy related data on a more detailed level. Though the precise arguments are unknown, the motivation was to enable bottom-up calculations of the resulting energy savings (STEM, 2006).

The Ministry of Enterprise, Energy and Communication

This interview focused mainly on the background to and the implementation of OFFROT. The approach of presenting a summarised version of the EMEEES method was not used in this case.

When evaluating OFFROT, it is important to understand that it has multiple goals. More than energy efficiency improvement and conversion to renewable energy, employment in the construction sector is an important aspect. The program is planned to make contributions to the national energy savings target under the ESD. OFFROT is also a program in which the public sector plays an exemplary role, as stressed in the Directive (2006/32/EC Article 5).

It is difficult to address additionality issues. Regarding double-counting, the risk is reduced by the fact that it is forbidden for the same action to receive double subsidies, although this does not take away occasions with partly overlapping programs. OFFROT has probably influenced investment decisions in the municipal boards (that have economic responsibility for public buildings like hospitals and schools etc.). These effects, however, are difficult to evaluate.

Energy Service Companies

ESCOs had no objections against the calculation formula presented by the EMEEES method (Ch. 3.1), which they regarded to be standard formulas for calculating electricity savings from lighting projects. Some concerns were raised about the required data gathering. There were doubts that end-users would be capable of reporting all the parameters correctly. If practices for reporting would require ESCOs to put efforts into compiling and presenting information any different, it could imply additional time and resources spent. In some way they would need to be compensated for that.

OFFROT applicants

Data provided by the National Board of Housing, Building and Planning shows that about 250 end-users submitted in total 960 lighting applications. Thus, as an average each end-user submitted and received investment support for four applications. To assess the reported figures, and understand if they are well-founded, a sub-set of 16 end-users were selected. The questionnaire included four questions that captured themes like: How the actions had been identified? The types of actions installed? How energy savings had been quantified? Whether the EMEEES method could be useful for calculating energy savings? The response rate turned out to be very low; only three (out of 16) end-users answered.

Actions have been identified in different ways, sometimes internally but it is common that energy consultants have been hired for identifying and/or implementing lighting actions. In some cases consultants have presented engineering calculations to estimate the electricity use before and after the planned actions. The calculations use as input data: estimated operating hours, rated power of the lamps, default value for the power absorbed by the ballast, default value for reduced operation due to automatic control (e.g. occupancy sensor). Consequently, this describes a measure-specific assessment according to level 3 of the EMEEES method. On the whole, responding end-users feel confident in their reported energy savings estimates and don't really see a need for an extensive methodology on how to calculate energy savings. One respondent claims that the calculation formula of the EMEEES method is manageable and that data about lighting equipment power absorption is available. The most important uncertainty factor is argued to be the estimation of annual operating hours.

With regards to the free-rider effect, one respondent admits that a large share of the actions had been taken anyhow. In order to receive the OFFROT subsidy, some previously known actions have been implemented earlier than planned. This is, therefore, only a partial free-rider effect; as there are savings due to the advanced implementation.

5.8 Specific conclusions

Based on the pilot test outcomes some conclusions can be made related to the following themes:

Accuracy and reliability of level 1 default values

The EMEEES method makes a transparent and easy-to-follow reasoning when suggesting the level 1 default values.

The SAVE II funded DEFU study “Market research on the use of energy efficient lighting in the commercial sector” is a frequently used data source. In addition to the uncertainty factors mentioned by the method (see Ch. 6.3) it is questionable if these statistics (published between 1999 and 2001) can be representative for the current and the near future EU situation. An up-to-date EU comprehensive audit of the installed stock and market baselines would generate accuracy and reliability on level 1.

Concerning operating hours, how this parameter is determined is of great importance for the final result. Based on the survey of lighting applicants it can be concluded that estimated operating hours differ a lot. Respondents stated operating hours varying from 1760 (for office rooms) to 3760 hours (for sports and activity centre). An EU default value of 2500 hours would introduce a large uncertainty.

Accuracy, usefulness and applicability of the indications provided for level 2 and 3 evaluation efforts

An ongoing survey on energy use in Swedish non-residential buildings will make available up-to-date and reliable statistics on lighting systems and related electricity use (as well as energy statistics for other end-uses) (STEM 2007a). This work will eventually facilitate a level 2 evaluation based on national data with high accuracy.

A measure-specific level 3 evaluation should be possible for OFFROT. If applicants had been obliged to support their reported figures with underlying engineering calculations, the aggregated gross annual energy savings from OFFROT would be more reliable. The fact that OFFROT involves a large number of eligible end-use (EEI) actions restricts the feasibility for extensive monitoring and evaluation practices.

Reliability and applicability of the gross-to net energy saving correction factors

The EMEEES method suggests free-rider factors for some types of lighting actions on level 1. The reasoning based on market share data is transparent.

It can be assumed that the OFFROT gross energy savings is influenced by correction factors. Among stakeholders, however, there seems to be a low interest in evaluating these effects.

Lifetimes

The proposed energy savings lifetimes did not raise debate among stakeholders. Considering that almost all of the OFFROT lighting actions can be made accountable for the ESD target of 2016, the proposed values are uncontroversial. Still, it is important that suggested lifetimes values will receive some kind of legal status in relation to ESD, and other future energy efficiency targets.

5.9 General conclusions

The pilot tests for lighting system improvements helped to identify the following general conclusions:

- **Transparency:** The method presents its main data sources and assumptions in a way that is satisfying.
- **Usability:** It is not obvious how the method should or could be used. In practice, different actors could benefit from specific sections of the methodology. The calculation of unitary gross annual energy savings (i.e. step 1) could perhaps be performed by each program participant? If so, each participant would need only a hands-on instruction for this specific calculation step. Apart from reviewing the reported unitary gross savings, the program administration would be in charge for performing the calculation steps 2 to 4. The method would be improved by including a discussion on how the different actors could be involved in the monitoring and evaluation activities.
- **Accuracy/uncertainty:** The method did good in pointing out that one of the main data sources (i.e. the DEFU study) does not provide a truly representative picture. Absence of comprehensive and reliable data illustrates one difficulty of applying EU wide default values. In this regard it is reasonable that the method applies a safety factor on all level 1 data. Operating hours is an important uncertainty factor. Accuracy should be increased by estimating operating hours based on building category (which ought to be known in most cases?), rather than applying one general EU default value.
- **Consistency:** It is not possible to make general judgments about the consistency between EMEEES default values and corresponding default values commonly used in Sweden (it is simply not known what default values are commonly used). One of the survey respondents could present engineering calculations where the default values used for the occupancy sensor and the ballast power absorption where in the proximity of those suggested by the EMEEES method. A comparison of EMEEES values with values possibly found in the Swedish (and European) standard “Energy performance of buildings - Energy requirements for lighting” (SS-EN 15193:2007) could perhaps provide insights on the issue of consistency.
- **Efficiency:** Time and costs imposed by using the EMEEES method is a significant concern. Since a cost estimate will rely on a number of assumptions it has not been possible to do a general cost comparison with the existing plan for monitoring and evaluation of OFFROT. It can be assumed, since additional data gathering would

be required, that using EMEEES methods would increase cost compared to the basic evaluation. If the existing plan had been drawn up based on the proposed EMEEES methodology there is a potential for cost-effective monitoring and evaluation. The fact that OFFROT includes several eligible end-use (EEI) actions complicates the picture. Should EMEEES methodologies be applied to all, or only a selection, of eligible actions? How would such a decision be justified?

It can be argued that OFFROT, by offering a generous incentive, is a rather expensive policy program from a government perspective. At the same time there are ex-ante judgments that expect significant energy savings. These are reasons for dedicating enough resources to enable a more thorough ex-post evaluation. The multiple policy goals, not only energy-efficiency, should then all be evaluated.

- **Coverage:** The EMEEES method does not cover all available energy-efficient lighting technologies. Light Emitting Diodes (LED's) is one example of a neglected technology. Since the available OFFROT data does not identify the types of installed lighting actions it is not known to what extent LED installations are relevant actions among OFFROT end-users.
- **Equity:** In terms of how the EMEEES method treats different lighting technologies, LED's are neglected. The seemingly contradictory statement is made that though LED's are available the technology is considered to be "Best Not yet Available Technology". Considering the higher initial cost of LED compared to other lighting systems, it might be a reasonable assumption that the main potential end-use actions to lamps are replacement with compact and improved linear fluorescent lamps. The potential for LED, however, can be expected to change over the near future. Consequently, by defining level 1 default values for LED equipment as an energy-efficient option to other lamps (e.g. incandescent lamps including halogen lamps, and some fluorescent types of lamps) the EMEEES method could be improved in terms of equity.
- **Adaptability:** There is a mismatch between the aggregated figures on energy savings that are reported in the OFFROT application forms and the detailed data requirements that are made by the EMEEES method. The EMEEES method would probably be best suited for an EEI facilitating measure that is really dedicated to lighting improvement action. In such case it would make sense to plan the monitoring and evaluation activities based on a single method. To better suit the OFFROT case the method should address the organizational aspects of conducting monitoring and evaluation. This would include a discussion about the key stakeholders involved in a program and how each of them could be suitable for performing one or another calculation step.
- **Impact:** In 2005 a plan was drawn up for the monitoring and evaluation of OFFROT. The program was concluded in 2008 and the administration is currently working on the ex-post evaluation. The main approach for monitoring has been to compile the data on energy savings that the end-users have reported in their application forms. Evaluation will primarily be based on this data material. A more thorough evaluation, for example according to the proposed EMEEES method, would require additional data gathering. This would impose additional costs and devotion of time for the agencies and program participants. The fact that lighting

action is only one out of several eligible end-use (EEI) actions makes the situation even harder. Given the mismatch between the EMEEES method and OFFROT program goals and set up, it is unlikely that the method will be used to evaluate the savings from OFFROT. This pilot test activity was the first time that the appointed evaluators were confronted with the EMEEES methodology. It is possible that awareness about the ESD target and the relevance of monitoring and verification has increased as a result of this testing activity along with other EMEEES dissemination activities.

5.10 Needs and potentials for improvement of the method tested

There can be made a few suggestions for improvement of the method:

It is not clear from studying the method how it ought to be applied in practice. The method should be improved by including a discussion on how different actors can be involved in the monitoring and evaluation activities, i.e. how the work can divided to facilitate efficient procedures.

Furthermore, it should state that level 1 values provided for the different components are mainly applicable for specific programmes targeting such components and monitoring data on numbers of installed components. In all other cases that use engineering calculations anyway, the EMEEES case application should recommend to shape and collect these and thus go to level 3.

Operating hours are an important uncertainty factor. Accuracy should be increased by estimating operating hours based on building category (which ought to be known in most cases), rather than applying one general EU default value.

The method does not cover LED's as an energy-efficient lighting technology. Improvements could be made by defining level 1 default values also for LED equipment.

6 Test 2 – Case application 17, Energy Performance Contracting

6.1 Testing activity description

The aim of the testing activity was to assess the usability of the suggested Case application 17 on Energy Performance Contracting for evaluating energy savings from the OFFROT program. From the outset, there was a mismatch between the method and the program being evaluated. Any EPC project is likely to include an energy audit, which was one of the 7 categories for end-use (EEI) actions in OFFROT. However, the OFFROT program did not track which recipients may have used EPC to complete their end-use (EEI) action.

Given the difficulties in isolating EPC projects within the overall OFFROT data, we used an interview format to identify general concerns as well as specific issues with applying the method. Key stakeholders for the pilot test included public authorities (Swedish Energy Agency, the National Board of Housing, Building and Planning), government representatives, several EPC providers whose customers had received OFFROT funding, and customers.

Interviews were conducted either in-person at the office of the stakeholder or by phone. Interviews were taped and later reviewed and transcribed. All interviews are cited in the reference list on page 17.

During the interview, we first presented a summarised version of the method. After we reviewed the calculation steps and related levels for data collection for each method, interviewees were asked to provide feedback regarding both general concerns and any technical issues for applying these methods to OFFROT projects.

6.2 Main data sources used for the pilot test

To perform the tests on the OFFROT program, we reviewed the existing data on OFFROT applicants from the National Board of Housing, Building and Planning. However, the specific data required for the method was not available. First, it was not possible to identify which OFFROT projects that used EPC. Anecdotally, EPC providers reported that some customers that completed recent EPC projects received OFFROT funding. But given how the OFFROT program was structured (i.e.: EPC projects were not categorized as a separate measure eligible for funding), it is not possible to isolate EPC projects within the OFFROT data.

A further issue in applying the method is that it does not align with how OFFROT applicants reported energy savings. The EMEEES method on EPC requires a breakout of energy savings by energy carrier in accordance with the ESD, at least between electricity and other final energies. In the OFFROT application form applicants were asked to report initial annual energy consumption on an aggregated level. Depending on the type of end-use (EEI) action, savings were reported as “energy savings” or “electricity savings”. For those reported as “energy savings” there is no available data about type of energy carriers (i.e. electricity, fuels, district heating or cooling).

6.3 Test of methodology application step by step

Given the data available (or rather, the lack thereof), we were unable to conduct a test for each step envisaged by the method itself. Instead, we used an interview format with EPC providers to solicit feedback on the method. The discussion questions were as follows:

- From your experience, what aspects of the proposed methods would you expect to work well?
- What challenges would you anticipate in applying these methods?
- How difficult would it be to apply the proposed lighting method and EPC method to recent projects you have completed? Why?
- What recommendations would you have for revising the proposed methods? (e.g.: Is anything missing? What should remain unchanged versus be changed and or deleted?)

6.4 Methodology test on early actions and additionality issues

OFFROT EPC projects would be eligible to contribute early action savings to the ESD targets for 2010 and 2016, if these early energy savings were allowed. The EPC projects may have a wide range of payback periods – typically ranging from 2 to 12 years in Sweden. If early energy savings are accepted, a contribution to the target in 2016 can only be counted if the energy saving lifetime is greater than 8 years plus the time between installation and 2008. The same holds for the intermediate target in 2010.

Because EPC projects may cover a broad range of end-use (EEI) actions, there is concern about double-counting with other end-use (EEI) facilitating measures, such as energy audits and voluntary agreements. However, if state-funded programs in Sweden report the energy savings, there is less concern about such an overlap for end-use (EEI) actions. According to program regulations in Sweden, applicants cannot receive state funding from two different subsidy schemes for the same actions. Typically, the program forms require the applicant to provide information and his/her signature that they are not receiving other funding. This information is then checked by the County Boards. Thus, this checking will help to eliminate double-counting in energy savings.

However, there still may be double-counting between energy savings from OFFROT and energy savings from EPC projects. Therefore, if Sweden collects data on energy savings from EPC projects from ESCOs, it needs to require the ESCOs to state whether these projects received OFFROT funding. And for future programmes like OFFROT, implementation in EPC should be tracked as well.

Interviewees confirmed that neither the multiplier nor free-rider effects could be followed up in the normal EPC procedure. While further interviews and questionnaires might be used to quantify the multiplier effect, interviewees were sceptical about the costs and relative quality of data for determining multiplier effects. Instead, the method suggests that the multiplier and free-rider effects for EPC project are likely to compensate each other.

6.5 Method comparison and interactions with already existing evaluation methods

The ex-ante savings from EPC projects completed through the OFFROT program are unknown. While a preliminary evaluation of OFFROT energy savings can be determined from the information in expected energy savings provided by program applications (i.e.: ex-ante 472 GWh), there was no specific questions in the applications to determine whether a project used EPC or not. Similarly, the Swedish Energy Agency provided an all-up analysis of the expected energy savings from the entire OFFROT program: 0.6 TWh (SOU 2008: 25, p. 176). But this analysis did not provide a breakout on EPC projects.

6.6 Evaluation of costs related to method application

Level 1 data is not applicable for the EPC method.

Level 2: There was significant concern about the costs for doing high quality evaluation work, such as national surveys and follow-up interviews to develop default values needed for level 2. In 2007, a Swedish national survey evaluated 25 EPC projects (14 in the Swedish public sector and 11 in the industrial sector) to investigate their contribution to reduced energy use (STEM, EPA, 2007).[2] According to the report authors, it was difficult to obtain data from many of the organizations due to lack of time, confidentiality concerns, institutional memory loss (e.g.: change in management within the organization). Of the 46 organizations contacted, only 25 provided data. They found that it was easier to obtain information regarding public facilities than industrial facilities, which may present further challenges in developing national default values across sectors.

There is no national reporting body that gathers data on EPC projects in Sweden. Currently, Sweden is one of the Member States that does not have an existing National Association of ESCOs. The European Union Joint Research Centre (EU JRC) has expressed interested in fostering an EU-level ESCO association. Meanwhile, the EU JRC has a voluntary database for ESCO activity, but the Sweden section has very limited information. In the future, an EU-level or national level ESCO association could play a role in gathering data at a country-level on EPC projects.

Level 3: Typically, the costs for monitoring and evaluation are 1 to 2 SEK/square meter (equalling about 0.1 – 0.2 Euro/m^2), according to an estimate from WSP, a consulting firm involved in many of the large energy efficiency projects in Sweden.

[2] There are two main problems that prevent us from applying the 2007 survey data to level 2 calculations in the EMEES method. First, the level of detail provided is not sufficient for using the method. Energy savings are aggregated: they are not expressed in terms of savings by electricity, fuels, district heating and district cooling. Second, this data for EPC projects does not match the ESD target period, even for early actions. The 25 EPC projects surveyed were initiated in a range of years (between 1992 and 2006).

6.7 Target group perspective

The key stakeholders for the pilot test were public authorities (Swedish Energy Agency, the National Board of Housing, Building and Planning), government representatives, EPC providers, and OFFROT applicants. The EPC providers interviewed had customers that received OFFROT funding. In addition, we also interviewed a consulting firm that has been involved in many public tendering for energy efficiency projects, including some that received OFFROT funding.

Stakeholders expressed concern about the administrative costs and burdens implied by the EPC method. Programs like OFFROT often have a broader context than just energy savings. For example, the OFFROT program had three main goals: stimulate the construction sector, increase energy efficiency, and promote greater use of renewable energy sources. Similarly, energy savings is but one of many priorities for the public authorities managing the program.

Another issue the stakeholders raised is whether providing aggregated data on energy savings was “good enough.” Though not all customers may have data at an energy carrier level, most do know the aggregated savings from the EPC projects. One might argue that the quality of these numbers should be quite high: EPC providers have expertise in establishing baselines for energy use and accounting for technical interactions when guaranteeing savings to customers. If greater detail is required for reporting, stakeholders asked who is responsible and “pays” for providing data? For example, EPC providers said they would expect to be compensated for their time if they were required to meet greater detail in reporting.

6.8 Specific conclusions

Based on the pilot test outcome, the EPC method being tested could not be easily adapted to the possible evaluation methodologies already existing in Sweden for OFFROT. There are two main issues in applying the method to OFFROT. First, the number of EPC projects in OFFROT is unknown. The OFFROT program was designed for specific policy objectives, not as an EPC-specific promotion. As such, the applicant data did not track usage of EPC as a vehicle for implementing end-use (EEI) actions. Anecdotally, we are aware that certain EPC projects have received OFFROT funding, but the exact numbers are unknown. Second, OFFROT recipients provided aggregated energy savings data, which does not have the level of detail required to apply the proposed method.

While the public agencies involved in OFFROT are now beginning program evaluation, it is beyond the scope and budget of the existing OFFROT evaluation process to apply the proposed method. Identifying EPC projects among the approximately 10 000 applicants would be time-consuming and not viewed as a good use of resources. This is no surprise when remembering that this method was devised for collecting EPC energy savings from ESCOs, not from a public policy program.

The gross-to-net energy saving correction factors could introduce a large amount of uncertainty into the evaluation. Here is a summary of findings:

- Double Counting: The major concern about double counting would likely be avoided due to program design: projects cannot receive funding from multiple sources for the same energy saving action. However, double-counting between OFFROT and EPC energy savings needs to be avoided (see suggestion above and below).
- Free-rider and multiplier effects: These two effects would be negligible for public sector projects (where a large share of EPC projects are done in Sweden) according to the EPC providers interviewed. EPC projects are typically sought when a lack of staff, expertise and/or motivation prevent these actions to be undertaken.
- Technical Interactions: A correction factor for technical interactions is not applicable. EPC projects may involve many end-use (EEI) actions that influence the consumption of the same energy carriers. However, the EPC provider will take account of these technical interactions in order to calculate overall energy savings from these actions and to guarantee savings to customers. This confirms the same argument that has been made in the EMEEES method.
- Additionality: Identifying additionality issues within baseline values would be problematic. Typically, the rationale for working with an EPC provider is that the end-use (EEI) actions would not be done otherwise (whether due to a lack of staff, expertise, money, time, or motivation).
- Lifetimes: there was some discussion about the lifetimes proposed for EPC projects (whether it was technical or economic lifetimes).

It's unclear how much should be generalized from this mismatch between the method and OFFROT. For example, one could argue that you could use bottom-up methods for each action in OFFROT to evaluate energy savings rather than trying to isolate which customers used EPC and applying the EPC method (though admittedly, this would not capture technical interactions). One could also go the other way round and apply this EPC method for collecting EPC energy savings from ESCOs. The only relation to programs such as OFFROT would be to avoid double-counting. This would need requiring the ESCOs to state, which EPC projects and/or energy savings were also supported by the public policy program. Furthermore, if there is interest in evaluating energy savings from EPC projects, future programs could design application forms and processes to track this data.

6.9 General conclusions

Going forward, it is theoretically possible to collect the necessary data for level 2 and 3 evaluation efforts regarding EPC projects. For example, EPC providers aggregate data from energy carriers to establish the initial baseline for energy use and for subsequent reports on savings achieved. While such data does exists, the major issue to resolve is how to and who should report this information.

The pilot test of the EPC method helped to identify the following general conclusions:

- **Transparency:** The assumptions and hypotheses made in the methodology are understandable. Depending on how reporting responsibility is determined, the attention devoted to disaggregating data to the energy carrier level may create some

additional complexity.

- **Usability:** While EPC providers have expertise in monitoring and verification, providing the data required by the EPC method would take additional time for them. The question becomes who will be required to report the data and what, if any compensation, the group would receive for their efforts.
- **Accuracy/uncertainty:** Given the wide range of project types and energy savings, the EMEEES method does not provide EU default values for EPC projects. Moreover, Sweden does not have estimated values for EPC projects that would match the ESD target period. Uncertainties should be identified and provided by either the EPC providers or building owners, as suggested by the method.
- **Consistency:** Because EPC projects themselves are not standard there is not an issue with consistency among default values.
- **Efficiency:** The time and costs implied by the application of the method being tested are a concern. Anyhow, these costs should be small since the ESCOs know what energy savings they invoice to their customers. The extra cost is for reporting. Still, the question is who pays for it.
- **Coverage:** The method would cover all the relevant energy efficient technologies and solutions in EPC projects.
- **Equity:** There was not specific concern that certain energy efficient technologies and solutions might be penalized with respect to others by the evaluation.
- **Adaptability:** To effectively implement the EPC method, the issues regarding reporting need to be addressed. Customers do not always look at energy savings in terms of breakout by energy carrier; they may only look at the aggregate savings. Thus, if customers were to be responsible for reporting, the proposed method would require a greater level of detail from them than they may commonly track. In absence of a national or EU ESCO association, EPC providers do not have a mechanism or incentive for reporting this information. This will need to be created.
- **Impact:** Given the mismatch between the EMEEES method and OFFROT program goals and set up, it is unlikely that the method will be used to evaluate the savings from OFFROT. It is unclear whether the method might be used for evaluating energy savings from future programs where EPC is a means for implementing end-use (EEI) actions and from the EPC business in general.

6.10 Needs and potentials for improvement of the method tested

Based on pilot test outcomes, additional work should be done to identify best practices for reporting the data at the level suggested by the method. For example, the EPC method might be tested in an EU Member State with a formal ESCO association.

Appendix I - Ex-Ante Energy Savings from OFFROT

Applications accepted until 2009-02-09 for conversion measures

The cost of the tables are the costs in the public area of the premises. The total cost of the whole building is not included in the system.

Total conversion to:	Number of cases *	Energy use for heat + water before in MWh **	Energy use for heat + water after in MWh **	Reduction in MWh	Decrease in %
District heating	1,000	280,601	260,286	20,315	7%
Biofuel boiler	931	412,808	400,004	12,804	3%
Solar	51	9,763	7,612	2,151	22%
Heat pump	1,062	128,020	43,594	84,426	66%
District heating & solar	1	1,138	1,110	28	2%
Biofuel & solar	15	1,731	1,562	169	10%
Heat pump & solar	36	3,711	1,304	2,407	65%
Total	**3,096**	**837,772**	**715,471**	**122,301**	**15%**

* Applications may consist of several other measures where the other was eligible. Thus, there may be overlap within the cases for several measures.
** Based on data contained in the application. Absent in some cases.
Source: Boverket 2009 [the National Board of Housing, Building and Planning]

Applications accepted until 2009-02-09 for energy efficiency improvement measures

Type of end-use (EEI) action	No. of cases	Labour cost [SEK]	Material cost [SEK]	Estimated energy savings [MWh] *	The share that reported savings
Heat recovery	889	348,612,448	558,234,562	104,181	95%
Efficient ventilation system	910	326,453,787	579,512,775	43,284	94%
Cooling system	74	23,994,390	57,176,815	9,991	92%
Efficient lighting system	960	132,305,519	275,767,640	23,720	97%
Control equipment	2,454	409,766,457	533,805,090	143,670	97%
EEI of climate shell	700	151,941,603	275,308,866	10,770	53% ***
Including windows **	406			14,702	100%
Energy auditing	1241	27,040,913			
Total	**7,634**	**1,420,115,117**	**2,279,805,747**	**350,327**	

* Application form data. Data on energy savings is sometimes missing, in particular for actions on the climate shell.
** Cost for EEI of the climate shell includes cost for windows, but savings from window actions are shown separately.
*** Low percentage because applicants have reported savings as coming from window actions.
Source: Boverket 2009 [the National Board of Housing, Building and Planning]

Appendix II – Main data to collect for EMEEES lighting method

Data needed in calculation for EU values (level 1)	Corresponding data sources
Stock and market ballast and lamp power	Default values given in this report
Average number of ballasts per luminaires	Default values given in this report
Luminaires per occupancy sensor and daylight sensors	Default values given in this report
Average annual operating hours	Default values given in this report
Number of luminaires installed or replaced	Level 3 (participant-specific) or maybe Level 2 input
Correction factors	Level 1 for free riders, Level 2 or 3 for multiplier effects and avoiding double-counting

Data to be collected national values (level 2)	Corresponding data sources
National Lighting electricity consumption	National databases
Implemented end-use actions with savings to derive national averages for: Stock and market ballast and lamp power; Average number of ballasts per luminaire; Average annual operating hours; Number of luminaires installed or replaced	Evaluation of pilot schemes; Existing MS Studies (e.g. EEC in UK, White Certificates in France and Italy)
Number of luminaires installed or replaced	Level 3 (participant-specific) or maybe monitoring/surveys for participants of pilot schemes
Correction factors	Analysis of national market shares of energy-efficient technologies or surveys for free riders and multiplier effects; database of participants and actions affected by different facilitating measures for avoiding double-counting

Data to be collected measure-specific (or participants-specific) (level 3)	Corresponding data sources
Specific Lighting electricity consumption	End-use Metering campaigns
Number of lighting operating hours	Detailed building audits
- Improvement of Lighting systems programme participants - Implemented measures with savings	Questionnaires/interviews → Monitoring database Source: CALifornia Measurement Advisory Council (CALMAC)
Lighting equipment power absorption	Manufacturer and product catalogues

References

BFS 2005:6. Boverkets föreskrifter och allmänna råd om stöd till investeringar i energieffektivisering och konvertering till förnybara energikällor i lokaler som används för offentlig verksamhet.

Boverket 2005a. Plan för uppföljning och utvärdering av stöd (SFS 2005:205) till investeringar i energieffektivisering och konvertering till förnybara energikällor i lokaler som används för offentlig verksamhet. Diarienummer 1399-2133/2005

Boverket 2005b. Ansökan om stöd till investeringar i energieffektivisering och konvertering till förnybara energikällor i lokaler som används för offentlig verksamhet. [the OFFROT application form].

Näringsdepartementet 2004. Investeringsstöd för vissa investeringar i ökad energieffektivitet och konvertering till förnybar energi i offentliga lokaler. N2004/2005/ESB.

SFS 2005:205. Förordning om stöd till investeringar i energieffektivisering och konvertering till förnybara energikällor i lokaler som används för offentlig verksamhet.

SOU 2008:25. Ett energieffektivare Sverige. Delbetänkande av Energieffektiviseringsutredningen.

STEM 2005. Effekt 2005-2007: om stödet för energieffektivisering i lokaler för offentlig verksamhet. A publication from the Swedish Energy Agency and the National Board of Housing, Building and Planning. ET 2005:28.

STEM 2006. Effektivare primärenergianvändning – En uppföljning av måluppfyllelse avseende EG-direktivet om effektivare slutanvändning av energi och om energitjänster mellan åren 1991 till 2004. A publication from the Swedish Energy Agency. ER 2006:32

STEM, EPA, 2007; J. Gode, A. Strömberg, U. Axelsson, E. Särnholm, Energy Performance Contracting – en modell för minskad energianvändning och miljöpåverkan, Report to Swedish Energy Agency (no ER 2007:35) and Swedish Environmental Protection Agency, 2007

STEM 2007a. Förbättrad energistatistik för lokaler – ”Stegvis STIL”. Rapport för år 1. Inventeringar av kontor och förvaltningsbyggnader. ER 2007:34

STEM 2007b Effektivare energianvändning: Beräkning av uppnådda effekter mellan året 1991 till 2005 och förväntade effekter av nyligen beslutade styrmedel för en effektivare energianvändning fram till 2016. ER 2007:21

Personal communication:

Näringsdepartementet 2009. [Ministry of Enterprise, Energy and Communications]. Meeting with Erik Thornström. 4th February 2009.

Boverket 2009. [the National Board of Housing, Building and Planning]. Meeting with Jonas Molinder, Anders Carlsson, Ann-Christin Kjellson and Hans-Olof Karlsson Hjorth. 9th February 2009.

STEM 2009. [The Swedish Energy Agency]. Email communication with Jörgen Sjödin and Arne Anderson. 28th January 2009.

Siemens AB 2009. Telephone interview with Stefan Källman. 16th February 2009.

TAC Energy Solutions 2009. Telephone interview with Peter Morelius. 12th February 2009.

WSP Environmental 2009. Meeting with Daniel Svensson. 22th March 2009.