

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

## EMEEES bottom-up case application 17: Energy Performance Contracting

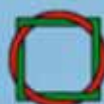
Jenny Gode and Rebecka Engström, IVL -  
Swedish Environmental Research Institute  
Carlos Lopes, Swedish Energy Agency



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evaluate  
energy savings<sup>EU</sup>

coordinated by



**Wuppertal Institute**  
for Climate, Environment  
and Energy

supported by

**Intelligent Energy**  Europe

## The Project in brief

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

## Consortium

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

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

## Contact

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

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

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Jenny Gode, IVL Swedish Environmental Research Institute  
Rebecka Engström, IVL Swedish Environmental Research Institute  
Carlos Lopes, Swedish Energy Agency

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## 1 Summary

### 1.1 Title of the method

Energy Performance Contracting

### 1.2 Type of EEI activities covered

End-use (EEI) action	
Sector	Industry, tertiary and residential (multi-dwelling buildings)
Energy end-use	Electricity, fuels (e.g. oil, natural gas, biomass, LPG), district heating, district cooling
Efficient solution	End-use actions are not restricted to certain applications. Typically, EPC projects will influence applications for: heating, cooling, ventilation, lighting, compressed air or other industrial fields of application. These end-use actions may involve investments or changes into: building automation systems, maintenance optimisation, heat recovery, heating and cooling systems, insulation of building envelope, specific industrial processes, education and training of staff or users.
(EEI) Facilitating measure	
Type(s) of EEI facilitating measures	Energy Performance Contracting

### 1.3 Detailed definition of EEI activities covered

The ESD article 3 (j) contains the following definition/description of Energy Performance Contracting (EPC):

*Energy Performance Contracting is a contractual arrangement between the beneficiary and the provider, normally an Energy Service Company (ESCO), of an energy efficiency improvement measure, where investments in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement.*

Hence, the set up of an EPC project means that the payment for the energy service is based (either wholly or in part) on the achievement of energy efficiency improvements and possibly other performance criteria. Typically, an EPC project can be divided into the three phases (SEA and EPA, 2007):

- 1. Project development:** the contracting ESCO makes an energy audit and analysis of the building or industrial facility. Data is compiled about end-use (EEI) actions, saving potentials, investment costs, and required efforts for educating staff etc.

2. **Project implementation:** The ESCO implements the agreed upon end-use (EEI) actions and educates the operating staff on the new systems and/or working practices.
3. **Project monitoring and evaluation:** The ESCO follow-up the implemented actions to verify that guaranteed savings are achieved according to contract.

The owner of the building or facility can engage more or less in each project phases in order to safeguard its interests. Section 1.2 ahead states that end-use (EEI) actions will relate to energy demand (electricity, fuels or heat) for heating, cooling, lighting, ventilation, compressed air or other fields of industrial applications. Without being exclusive end-use (EEI) actions may involve:

- implementation of building automation systems and maintenance optimisation (heating, cooling, ventilation, lighting etc.);
- heat recovery;
- investments or changes in heating, cooling, lighting and ventilation systems as well as compressed air or other industrial systems;
- insulation of building envelope;
- education and training of staff

## 1.4 General specifications

### 1.4.1 Eligibility of energy savings from EPC projects

In the ESD Annex IV it is explicitly stated that EPC is one, out of several requirements, that Member States should ensure that the public sector applies for it to play an exemplary role in undertaking energy efficiency improvements. In this method only end-use (EEI) actions resulting directly from EPC projects, being the (EEI) facilitating measure in question, should be taken into account.

There are unused energy saving potentials to be found in most buildings and/or facilities. While an energy audit can verify the potential and specify the actions, there may remain barriers, e.g. limited investment budget, for building owners to realise the savings. By sharing risks and benefits of the investment, the provider and the signatory customer facilitate that the saving potential is realised. Thus, EPC is a business model with the ability to overcome possible barriers to energy efficiency improvement. If the EPC provider is an ESCO with competence to analyse, implement and follow up energy efficiency projects and other maintenance cost reductions in buildings and industrial facilities, it is in position to make judgements about the financial risk related to a project. In the EPC project the provider is also accepting some degree of risk taking.

Within the European Committee for Standardization (CEN) there is an ongoing project aiming at developing standards on definitions and essential requirements for energy efficiency services, including EPC. The

definition/description in section 1.3 follows the ESD and should be harmonised with the CEN standard when finalised.

#### 1.4.2 Efforts for data collection

Level 1 calculation is not recommended and no EU default values have been presented in this report, see further explanation in section 3.4.1.

Level 2 calculation is a combination of level 3 calculation (to define national default values) and estimations based on identified EPC projects. The procedure suggested involves three steps; 1) national surveys of EPC projects and their achieved energy savings; 2) national default values calculated from averaging the survey results and; 3) extrapolation of energy savings to projects not covered in step 1. For details see section 3.4.2.

Level 3 calculation offers the highest accuracy and happens when Step 1 of the procedure in Level 2 covers 100% of EPC projects in the MS. For this purpose, knowledge about past and present EPC projects and data on energy savings for each EPC project per energy carrier are needed, and recommended also by type of end-use action, e.g. by establishing national EPC associations, voluntary agreements and/or reporting data bases (see section 3.4.3). Data collection at level 3 may be done either ex-post, through direct measurement or billing analysis with normalisation, or ex-ante by enhanced engineering estimates.

#### 1.5 Formula for unitary gross annual energy savings

For this method, the unit used in the formula for unitary gross annual energy savings is one EPC project. The formula for calculation of unitary gross annual energy savings (equation S1) separates between savings in each relevant energy carrier  $i$ .

$$\text{Unitary gross annual energy savings} = \text{Energy savings of one EPC project} = \sum_{i=1}^n C_i * S_i * \eta_i$$

(equation S1)

Where:

$C_i$  = Initial annual consumption of energy carrier  $i$  (electricity, fuels, district heating, district cooling), MWh/a, normalised

$S_i$  = Savings of energy carrier  $i$  (electricity, fuels, district heating, district cooling), %

$\eta_i$  = Conversion factor of energy carrier  $i$  (electricity, fuels, district heating, district cooling). Member States can use their national conversion factors or conversion factors listed in annex II of the ESD.

The annual consumption figures may be based on average consumption during a period of three to five years before the launch of the EPC project. If there is no such record, when estimating annual consumption one will have to normalise for factors that directly influence consumption levels, e.g., major changes in production. Energy savings should preferably be divided into savings of electricity, fuels, district heating and district cooling, and aggregated savings should be avoided.

### 1.6 Indicative default value for unitary gross annual energy savings

EU wide default values are not recommended for EPC.

### 1.7 Formula for total ESD annual energy savings

Total gross annual energy savings are calculated as the sum of unitary gross annual energy savings due to EPC projects at all possible calculation levels. If all correction factors are included, the formula for the total ESD (net) annual energy savings will read as equation S2 (as presented in section 5).

$$TGESD = \sum_{j=1}^m \sum_{i=1}^n C_{j,i} * S_{j,i} * \eta_i + \left( \sum_{k=1}^p \sum_{i=1}^n C_{k,i} * DV_i * \eta_i \right) * \alpha - DC - TI + M - FR$$

(equation S2)

Where the first summation is over EPC projects evaluated at level 3 and the second summation is over EPC projects evaluated at level 2 but no project savings will be counted twice, and:

TGESD = Total ESD annual energy savings, MWh/a

$i$  = energy carrier (electricity, fuel, district heating or district cooling)

$j$  = EPC project for which savings are reported individually (level 3)

$m$  = number of projects for which savings are reported individually (level 3)

$k$  = EPC project identified with estimated data (possibly reported data for initial annual energy consumption)

$C_{j/k,i}$  = initial annual energy consumption of energy carrier  $i$  in EPC project  $j$  (or  $k$ ), MWh/a, normalised

$p$  = number of projects identified, with estimated data

$S_{j,i}$  = annual energy savings of energy carrier  $i$  in EPC project  $j$  (level 3), %

$DV_i$  = national default value for energy saving of energy carrier  $i$ , %

$\eta_i$  = national conversion factor for energy carrier  $i$

$\alpha$  = “quality factor”  $\leq 1$ , a factor that could be used by Member States to penalize EPC projects that have not fully reported energy savings.  $\alpha = 1$  means that all energy savings are accounted for.

DC = double counting

TI = technical interaction

M = multiplier effect

FR = Free-rider effect

According to Annex II of the ESD, Member States can use national conversion factors or conversion factors listed in the Annex.

## 1.8 Indicative default value for energy savings lifetime

Energy saving lifetimes of EPC projects have to be evaluated from case to case as explained further in section 6.

## 1.9 Main data to collect

Data needed in calculation for <u>EU</u> values (level 1)	Corresponding data sources
Data 1	n.a.

Data to be collected <u>national values</u> (level 2)	Corresponding data sources
Data 1 Reported data	Data gathered according to level 3 (see level 3 below)
Data 2 National default values for energy savings per energy carrier or total	Estimated from level 3 data for a sample of EPC projects
Data 3 Conversion factors	According to Annex II of the ESD, Member states can use national conversion factors or conversion factors listed in the Annex.

<b>Data to be collected <u>measure-specific</u> (or participants-specific) (level 3)</b>	<b>Corresponding data sources</b>
Data 1 Identified past and present EPC projects	National EPC associations, voluntary agreements and/or national reporting data bases
Data 2 Initial consumption per energy carrier before EPC implementation (electricity, fuels, district heating, district cooling)	Existing data and/or data collected by establishing national EPC associations, voluntary agreements and/or national reporting data bases
Data 3 Final consumption per energy carrier after EPC implementation (electricity, fuels, district heating, district cooling)	Existing data and/or data collected by establishing national EPC associations, voluntary agreements and/or national reporting data bases. Ex-post (direct measurements or billing analysis with normalisation) or enhanced engineering estimates (guaranteed savings from EPC providers).
Data 4 Savings per energy carrier (electricity, fuels, district heating, district cooling)	Gained from data 1-3 above
Data 5 Conversion factors	According to Annex II of the ESD, Member States can use national conversion factors or conversion factors listed in the Annex.

A further collection of data for division of savings data by type of end use or end-use action is not necessary but recommended at least for a sample of projects. This will enable gaining knowledge about which types of end-use actions are usually included in EPC projects, and in which end use areas which part of the potential is being realised by EPC. Policymakers can then, if desired, try to provide guidance and incentives to EPC markets and/or install additional measures to tap potential not sufficiently realised by EPC so far.

Data by end use or end-use action would also be helpful for estimating average lifetimes, and potentially for avoiding double-counting.

## 2 Introduction

### 2.1 Twenty bottom-up case applications of methods

Within EMEEES, task 4.1 provided methodological materials in the internal working paper “Definition of the process to develop harmonised bottom-up evaluation methods”, version 20 April 2007; an update has been published as an Appendix to the report on Bottom-up methods at [www.evaluate-energy-savings.eu](http://www.evaluate-energy-savings.eu). Based on this draft report, concrete bottom-up case applications were developed by EMEEES partners within task 4.2, and reference values were to be specified within task 4.3.

This report deals with case application 17 “Energy performance contracting” developed by the Swedish Energy Agency.

Eleven project partners have developed concrete bottom-up case applications for a specific type of technology or energy efficiency improvement measure or end-use action. All gave comments and input to the methods developed by the other organisations.

The 20 case applications developed are presented in the table below:

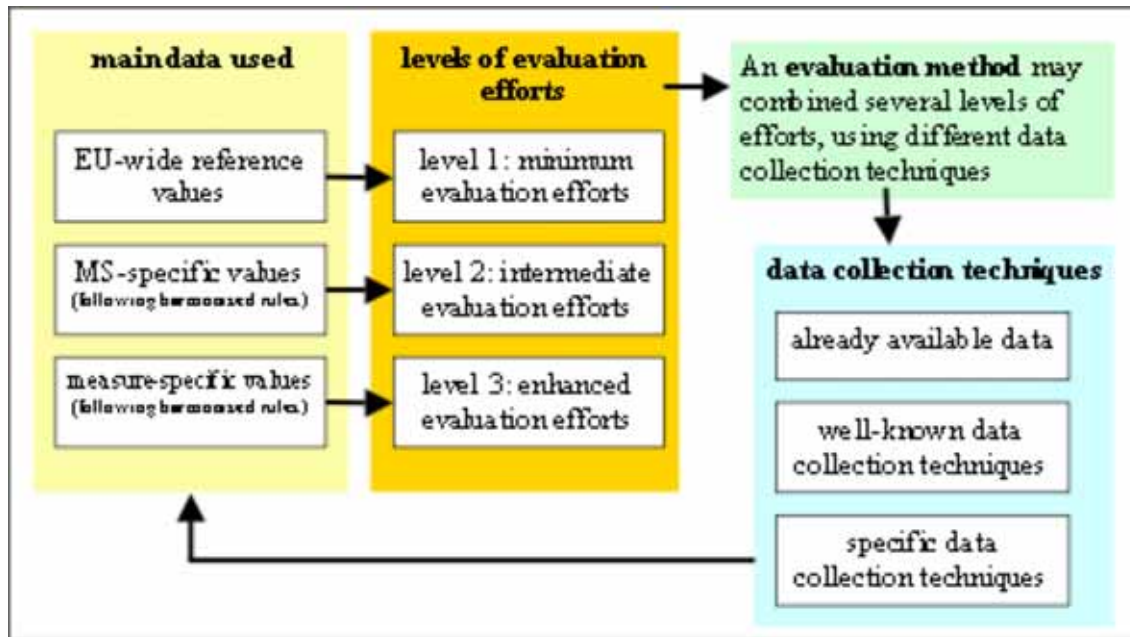
Nº	End-use or end-use action, technology, or facilitating measure	Sector	Responsible organisation
1	Building regulations for new residential buildings	Residential	SenterNovem
2	Improvement of the building envelope of residential buildings	Residential	AEA
3	Biomass boilers	Residential	AGH-UST
4	Residential condensing boilers in space heating	Residential	Armines
5	Energy efficient cold appliances and washing machines	Residential	ADEME
6	Domestic Hot Water – Solar water heaters	Residential	AGH-UST
7	Domestic Hot Water - Heat Pumps	Residential	AGH-UST
8	Non residential space heating improvement in case of heating distribution by a water loop	Tertiary	eERG
9	Improvement of lighting systems	Tertiary (industry)	eERG
10	Improvement of central air conditioning	Tertiary	Armines

N°	End-use or end-use action, technology, or facilitating measure	Sector	Responsible organisation
11	Office equipment	Tertiary	Fraunhofer
12	Energy-efficient motors	Industry	ISR-UC
13	Variable speed drives	Industry	ISR-UC
14	Vehicle energy efficiency	Transport	Wuppertal Institute
15	Modal shifts in passenger transport	Transport	Wuppertal Institute
16	Ecodriving	Transport	SenterNovem
17	Energy performance contracting	Tertiary and industry end-uses	STEM
18	Energy audits	Tertiary and industry end-uses	Motiva
19	Voluntary agreements – billing analysis method	Tertiary and industry end-uses	SenterNovem
20	Voluntary agreements with individual companies – engineering method	Tertiary and industry end-uses	STEM

## 2.2 Three levels of harmonisation

In order to be as practicable as possible and to stimulate continued improvement, the harmonised reporting on bottom-up evaluation is structured on three levels (cf. figure 1).

Figure 1: Three levels of harmonisation



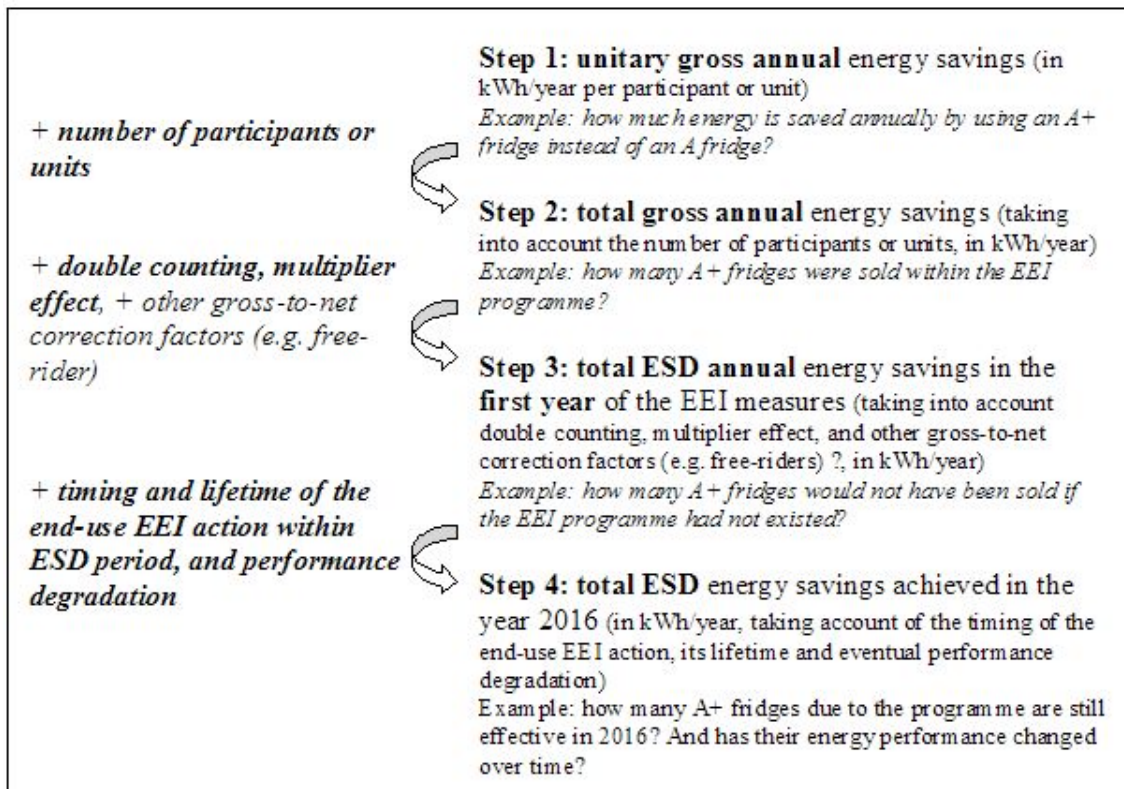
As a consequence, the EMEES case applications for bottom-up evaluation methods present:

- EU wide reference values, if applicable;
- Guidelines how Member States can use country-specific values following harmonised rules;
- Guidelines how measure- or action-specific (national) values can be developed, following harmonised rules.

### 2.3 Four steps in the calculation process

The harmonised rules for bottom-up evaluation methods are organised around four steps in the calculation process (cf. figure 2). These steps are presented in detail in the report for WP 4.1.

Figure 2: Four steps in the calculation process



The reports on the concrete bottom-up case applications follow the format of these four steps and they each hold six chapters plus some annexes:

1. summary
2. introduction
3. step 1: unitary gross annual energy saving
4. step 2: total gross annual energy savings
5. step 3: total ESD annual energy savings
6. step 4: total ESD energy savings for year “i”

## 2.4 Pilot tests

Additional to the development of the 20 bottom-up case applications, some of these cases were tested in practice in Work Package 8.

Pilot tests of the following case applications were performed by EMEEES partners in Italy, France, Denmark, and Sweden:

EMEEES case application	Sector	Italy	France	Denmark	Sweden
Building envelope improvement	Residential		X		
Energy-efficient white goods	Residential	X			
Biomass boilers in the residential sector	Residential		X		
Condensing Boilers	Residential	X	X		
Improvement of lighting system	Tertiary (industry)				X
High efficiency electric motors	Industry	X			
Variable speed drives	Industry	X			
Energy audits	Tertiary and industry end uses			X	
Energy performance contracting	Tertiary and industry				X

The following EEI measures were evaluated ex-post using the above-mentioned EMEEES bottom-up case applications:

Country	Subject	Sector(s) addressed
France	Condensing boilers, building envelope improvements and compact fluorescent lamps under the French White Certificates.	Residential
Italy	Schemes under the Italian White Certificates system	Residential, tertiary, industry
Sweden	Energy Efficiency Investment Programme for Public Buildings (2005-2008)	Public non-residential buildings
Denmark	Energy audits performed in Denmark between 2006 and 2008	Industry, tertiary

As a result of the pilot tests, some of the case applications tested were updated to reflect the findings of the tests.

### 3 Step 1: Unitary gross annual energy savings

#### 3.1 Step 1.1: General formula and calculation model

For this method the unit is one EPC project. There is an ongoing CEN standardisation project, aiming at developing a standard for EPC services. The following definition/description follows the ESD and should be harmonised with the CEN standard when finalised:

*Energy Performance Contracting is a contractual arrangement between the beneficiary and the provider (normally an ESCO) of an energy efficiency improvement measure, where investments in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement.*

A unitary EPC project can, and commonly does, involve several end-use actions targeting savings in different energy carriers (i.e. electricity, fuels, district heating, district cooling) (SEA and EPA, 2007). With equation 3.1 the unitary gross annual energy savings of an EPC project are calculated, including savings in one or several energy carriers  $i$ .

$$\text{Unitary gross annual energy savings} = \text{Energy savings of one EPC project} = \sum_{i=1}^n C_i * S_i * \eta_i$$

(equation 3.1)

Where:

$C_i$  = Initial consumption of energy carrier  $i$  (electricity, fuels, district heating, district cooling), MWh/a, normalised

$S_i$  = Saving of energy carrier  $i$  (electricity, fuels, district heating, district cooling), %

$\eta_i$  = National conversion factor of energy carrier  $i$  (electricity, fuels, district heating, district cooling)

Savings should preferably be divided into savings of electricity, fuels, district heating and district cooling in line with equation 3.1 above, so that aggregated savings are avoided. Annex II of the ESD contains a conversion table for different fuels. Member States can also use national conversion factors when calculating primary energy savings.

Normalisation with respect to temperature, utilisation of building, opening hours, occupancy levels, plant throughput and level of production is presupposed as routine procedure by the providers of EPC services (see further explanation in section 3.3).

Other candidates for unit than one EPC project could have been, for example, square meters area affected by an EPC project, as far as the EPC project is implemented in a building, or end-use (EEI) actions. The former would offer an interesting key figure for estimating potentials of EPC in various building categories. However, the follow up of EPC projects' contribution to fulfil the ESD will be made on project level, either by using deemed/enhanced engineering estimates/measured data (level 3) and/or by applying national default values on known EPC projects with poor data knowledge (level 2). Using end-use actions as calculation unit would not be possible as EPC projects most often include several actions often technically interacting with each other, making it impossible (or at least difficult) to determine which end-use action contributed to which energy saving. Furthermore, the level of detail required for this kind of evaluation could imply unbearable costs. On the other hand, in order to avoid double-counting, e.g., between EPC and an energy audit programme that supported an energy audit, which identified some of the end-use actions later included in the EPC, such tracking of end-use actions may be necessary, at least for a sample of EPC projects.

### **3.2 Step 1.2: Baseline**

Average baselines for EPC projects cannot be formulated. Instead baselines have to be defined for each EPC project as the "energy consumption before the improvement action". The energy consumption after the EPC project is then compared to the "baseline". This is in line with the definition of energy savings in the ESD article 3(d), i.e. "an amount of saved energy determined by measuring and/or estimating consumption before and after implementation of one or more energy efficiency improvement measures, whilst ensuring normalisation for external conditions that affect energy consumption". In this way, all energy savings will be counted.

In cases, in which old equipment is being replaced in the EPC project that would otherwise have been replaced by the customer anyway, a second baseline would be needed to calculate the energy savings additional to those the customer would have achieved anyway: an average of a new equipment that is not particularly energy efficient would be the correct baseline. However, it would not be practical to require the providers or the customers of EPC services to do 'as if' calculations of such hypothetical equipment for each case. It is therefore not recommended to try collecting this information from market participants. A Member State wishing to know how much energy is being saved through the EPC business in addition to projections will have to fund research examining case studies of EPC projects to estimate the share of such additional energy savings.

Since the baseline will in any case be chosen as an individual baseline, it will automatically be dynamic.

Normalisation of baselines is assumed as standard routines by providers of EPC services, see further in section 3.3 below. The baselines are generally determined in co-operation between the EPC provider and the customer and are regulated in the EPC contract.

level 1	n.a.
level 2	guidelines: the baseline is defined as the energy consumption before the EPC project data required: consumption of electricity, fuels, heat and cold or other energy types before the EPC project
level 3	guidelines: the baseline is defined as the energy consumption before the EPC project data required: consumption of electricity, fuels, heat and cold or other energy types before the EPC project (the baseline is determined in an EPC project in co-operation between customer and provider, e.g. as part of the feasibility study)

### 3.3 Step 1.3: Requirements for normalisation factors

Normalisation is routine procedure by the EPC provider who has the capability to analyse and calculate energy utilisation before and after each EPC project taking the following into account:

- Temperature (heating and cooling degree days);
- Utilisation of building, opening hours, occupancy levels (number of visitors, change in utilisation influencing energy use etc.) and
- Plant throughput and level of production, e.g. an industry changing level of production influencing energy demand for heating and cooling, electricity, compressed air, etc.

### 3.4 Step 1.4 Specifying the calculation method and its three related levels

Calculation methods for the levels 2 and 3 are presented below. Priority should be given to level 3 calculations as these results will be most reliable and accurate. If level 3 calculations are not feasible, the level 2 approach should be used. Level 1 calculations for EPC are not recommended.

Preferably, the energy savings should be divided into savings of;

- electricity;
- fuels (e.g. natural gas, oil, biofuels, LPG);

- district heat and
- district cold

According to Annex II of the ESD, Member states can use national conversion factors or conversion factors listed in the Annex.

level 1	n.a.
level 2	<p>The following calculation procedure is suggested (mix of deemed and ex-post):</p> <p>Step 1. Savings are collected based on national surveys of reported data from individual EPC projects (see level 3 below)</p> <p>Step 2. National default values are calculated from data in step 1.</p> <p>Step 3. The default values from step 2 are used for calculations of savings based on estimated data and energy consumption data from identified EPC projects but not fully covered in the national survey in step 1</p>
level 3	<p>For level 3 calculations there are two options:</p> <p>Option 1. Ex-post (direct measurements and billing analysis) Follow-up of energy consumption by billing analysis and possibly direct measurements with normalisation is recommended as this will offer the highest accuracy.</p> <p>Option 2. Enhanced engineering estimates (guaranteed savings by EPC provider or direct measurement) As the EPC provider (normally an ESCO) offers guaranteed savings, there will be some margin to the actual potential savings. Using Option 2 will therefore in most cases lead to an underestimation of the savings.</p>

### 3.4.1 Level 1

Given the heterogeneity of EPC projects in different EU countries, level 1 calculations are not considered appropriate, i.e. default EU values for EPC are not recommended. The baselines as well as potential actions, energy savings and energy carriers will vary substantially between different MS and defining default values is therefore considered too inexact. Furthermore, EPC is by nature a facilitating measure with high potential of level 3 evaluation, since EPC projects are begun by a thorough evaluation of energy utilisation before and after the project and EPC providers also give guaranteed savings to their customers.

### 3.4.2 Level 2

Level 2 calculation could be used in case a full level 3 calculation is not feasible, e.g., if it is impossible to get contractual information from all the ESCOs. Particularly for EPC projects targeting the same type of end-use action (e.g., heating or lighting), level 2 calculation could be relatively exact. Pure level 2 calculation is in fact not feasible as some element of level 3 calculation is needed to define national default values. The following multi-step-calculation-

procedure is suggested for level 2 calculations, including some elements of level 3 calculations:

#### *Step A. National surveys*

To define default values for level 2 calculation, we propose that national surveys are performed to evaluate energy savings of past EPC projects. This requires information on project level, which means evaluations at level 3. However, it is presented here as the aim is to define level 2 default values. For further details on level 3 calculations and data collection, see section 3.4.3. High coverage of EPC projects should be aimed for in the national surveys to enable definition of representative default values (a hypothetical full coverage would mean that no level 2 calculation would be needed). Also, it would be good to try and collect data distinguished by type of end-use action, to put the energy savings by type of end use from EPC projects in relation to the energy saving potential for each type of end use. Furthermore, collecting information about potential double-counting (has an end-use action been stimulated by other facilitating measures, e.g., an energy audit scheme?) will be important to estimate percentages and in this way avoid double-counting in the level 2 calculation (cf. chapter 5).

A Swedish national survey was carried out in 2007 (STEM, EPA, 2007). The results show overall energy savings in a range between 17 and 66 % (with an average of 22 %) for EPC projects in the tertiary sector. For the industrial sector the overall energy savings varied between 35 and 66 % (with an average of 55 %) energy savings in the industry. These are aggregated energy savings, but preferably, the energy savings should be divided into savings of electricity, fuels, district heating and district cooling. Note that some of the 25 EPC projects included in the Swedish national survey goes back as long as 1992 (the range of initiation of the EPC projects varies between 1992-2006). The data will neither be representative for EPC projects performed during the ESD target period, nor will they be representative for other EU member states. In fact, there are good reasons to believe that these “thresholds” in terms of percentage of energy savings for an ESCO to enter in an EPC will be lower in the future due to two main reasons. The first one is that the projects analysed come from a market in its infancy, and the margins will decrease as the market matures. Another possible reason is that the contract durations will likely increase when compared to the projects analysed, providing for financing measures with longer pay-back times.

*Step B. National default values*

From the data in step A, national default values are defined. The default values should be conservative (in the lowest range of energy savings achieved from the national surveys).

*Step C. Estimation of energy savings from EPC projects not covered in step A*

In step C the national default values from step B are used to estimate energy savings from known EPC projects that were not covered in the national survey (called level 2 EPC project). Except for default values there is a need for knowledge about EPC projects that were not fully covered in the national survey and about the initial energy consumption from those projects (or at least estimations).

Calculations at level 2 require the following data:

- Knowledge of past and present EPC projects
- Initial consumption of energy carriers (electricity, fuels, district heating and district cooling), normalised (e.g. for weather, occupancy, level of production)
- National default values of energy savings (percent) per energy carrier
- National conversion factors

Calculation formula for energy savings from one level 2 EPC project:

unitary gross annual energy savings for one level 2 EPC project (MWh/a) =

$$\sum_{i=1}^n C_i * DV_i * \eta_i$$

[N.B: calculation of default values requires some element of level 3 calculation]

(equation 3.2)

Where:

$C_i$  = Initial annual consumption of energy carrier  $i$ , MWh/a, normalised

$DV_i$  = National default value for savings of energy carrier  $i$ , %

$\eta_i$  = National conversion factor of energy carrier  $i$  (electricity, fuels, district heating, district cooling)

The savings should preferably be presented per energy carrier (electricity, fuels, district heating and district cooling), enabling calculation of primary energy savings by using national conversion factors (or conversion factors presented in Appendix II of the ESD). If a Member State has other reporting requirements in their energy efficiency action plans (EEAP)<sup>1</sup> (e.g. allowing aggregated reporting of energy savings) the calculations could be adjusted to fit these requirements.

### 3.4.3 Level 3

Level 3 calculation offers the highest accuracy and is recommended. This involves follow up of each individual EPC project. The data/information is needed to make level 3 calculations is knowledge about past and present EPC projects and data on energy savings for each EPC project per energy carrier. Procedures and routines for data collection and knowledge of EPC projects must be decided by the member states, but in section 4.2 the following three suggestions are presented;

- National EPC association
- Voluntary agreements
- National reporting data base

The following data/information is needed for level 3 calculations:

- Knowledge of past and present EPC projects
- Initial consumption of energy carriers (electricity, fuels, district heating and district cooling), normalised (e.g. for weather, occupancy, level of production)
- Final consumption (after the measure) of energy carriers (electricity, fuels, district heating and district cooling)
- Alternatively, directly savings of energy carriers (divided into electricity, fuels, district heating and district cooling)
- National conversion factors

There are at least two options for data collection at level 3. The first and most accurate option is ex-post data collection by direct measurements and/or billing analysis (ex-post). The second option is utilisation of the enhanced engineering estimates given by the EPC providers in the first phases of an EPC project. The estimates could e.g. be the guaranteed savings given by the EPC provider. However, basing the calculation of energy savings on guaranteed savings will in

<sup>1</sup> There is a requirement in the ESD for the MS to submit Energy Efficiency Action Plans (EEAP) to the EU Commission according to ESD Article 14.

many cases lead to an underestimation, since the EPC providers must have some marginal to the actual potential savings. These additional savings are usually under a profit-sharing mechanism between the ESCO and the client, which gives an incentive for the client for extra savings. In some cases of EPC project failures, it might lead to an overestimation.

The annual energy savings in MWh/a to be realised by one EPC project at level 3, using project specific data, is either calculated as follows:

unitary gross annual energy savings for one level 3 EPC project (MWh/a) =

$$\sum_{i=1}^n (C_{ii} - C_{fi}) * \eta_i$$

(equation 3.3a)

Where:

$C_{ii}$  = Initial annual consumption of energy carrier  $i$ , MWh/a, normalised

$C_{fi}$  = final annual consumption of energy carrier  $i$ , MWh/a, normalised

$\eta_i$  = National conversion factor of energy carrier  $i$  (electricity, fuels, district heating, district cooling)

Or, it can be calculated as follows:

unitary gross annual energy savings for one level 3 EPC project (MWh/a) =

$$\sum_{i=1}^n C_i * S_i * \eta_i$$

(equation 3.3b)

Where:

$C_i$  = Initial annual consumption of energy carrier  $i$ , MWh/a, normalised

$S_i$  = Savings of energy carrier  $i$ , %

$\eta_i$  = National conversion factor of energy carrier  $i$  (electricity, fuels, district heating, district cooling)

The savings should preferably be presented per energy carrier (electricity, fuels, district heating and district cooling) in line with the equation above, to enable calculation of primary energy savings by using national conversion factors (or conversion factors presented in the ESD). Member states may also base the reporting on requirements in their energy efficiency action plans.

### **3.4.4 Conversion factors**

Energy savings should preferably be presented per energy carrier (electricity, fuels, district heating and district cooling). Member states may use national conversion factors. Note that conversion factors may vary between different fuels.

### **3.4.5 Considering the direct rebound effect**

This section only applies for lighting, cars, and for measures related to the internal temperature of dwellings, unless there is clear evidence that it is relevant.

The direct rebound effect is not explicitly mentioned in the ESD. It is created by final energy consumers who increase the intensity of the use of energy-efficient equipment after an EEI measure, e.g., when the internal temperature of a building is increased after insulation. This reduces the energy savings achieved in comparison to the baseline of autonomous consumption changes. Consequently, including energy savings “eaten up” by the direct rebound effect in the total ESD annual energy savings would mean to include too high energy savings compared to the autonomous energy consumption changes. It has not yet been decided by the European Commission and the ESD committee, whether this effect shall be included in the total ESD annual energy savings or eliminated from them. In the latter case, the following requirements apply.

Direct rebound effects are unlikely to occur in the tertiary and industrial sectors as indoor climate is an important part of EPC projects. Conversely, a direct rebound effect on thermal comfort could happen in multi-dwelling residential buildings. However, possible rebound effects would be taken into account in ex-post savings reported in individual EPC projects.

### **3.4.6 From EMEEES tasks 4.2 to 4.3: defining values and requirements**

#### **3.4.6.1 Default values for energy consumption and/or related parameters**

We do not recommend using EU level default values for EPC projects.

#### **3.4.6.2 Requirements to define level 2 and level 3 values**

Level 2 is a combination of reported savings from individual EPC projects, and estimated savings from identified EPC projects.

Level 3 occurs when all savings result from reported savings from individual EPC projects. This level offers the highest accuracy.

## 4 Step 2: Total gross annual energy savings

### 4.1 Step 2.1: Formula for summing up the number of actions

For this method, the unit used in the formula for unitary gross annual energy savings is one EPC project. The energy savings achieved by one unit (one EPC project) will result from several end-use energy efficiency improvement actions. The actions will change the consumption of electricity, fuels, district heating and/or district cooling (energy carriers). The overall energy consumption will decrease, whereas the consumption of some individual energy carrier might increase.

Formula for total gross annual energy savings, TGES;

$$TGES = \sum_{j=1}^m \sum_{i=1}^n C_{j,i} * S_{j,i} * \eta_i + \left( \sum_{k=1}^p \sum_{i=1}^n C_{k,i} * DV_i * \eta_i \right) * \alpha$$

Where the first summation is over EPC projects evaluated at level 3 and the second summation is over EPC projects evaluated at level 2 but no project savings will be counted twice, and:

TGES = Total gross annual energy savings of EPC projects, MWh/a

$i$  = energy carrier (electricity, fuel, district heating or district cooling)

$j$  = EPC project for which savings are reported individually (level 3)

$m$  = number of projects for which savings are reported individually (level 3)

$k$  = EPC project identified with estimated data (possibly reported data for initial annual energy

$C_{j/k,i}$  = initial annual energy consumption of energy carrier  $i$  in EPC project  $k$ , MWh/a

$p$  = number of projects identified, with estimated data

$S_{j,i}$  = annual energy savings of energy carrier  $i$  in EPC project  $j$  (level 3), %

$DV_i$  = national default value for energy saving of energy carrier  $i$ , %

$\eta_i$  = national conversion factor for energy carrier  $i$

$\alpha$  = "quality factor"  $\leq 1$ , a factor that could be used by Member States to penalize EPC projects that have not fully reported energy savings.  $\alpha = 1$  means that all energy savings are accounted for

Member states can use national conversion factors or conversion factors listed in Annex II of the ESD.

The higher the coverage in terms of savings of the first term (level 3 data), the higher is the accuracy of the energy savings. Ideally, with complete follow-up of EPC projects (pure level 3 evaluation), the second part of the formula will equal zero and the formula become (abbreviations as listed above):

$$TGES = \sum_{j=1}^m \sum_{i=1}^n C_{j,i} * S_{j,i} * \eta_i$$

(equation 4.2)

#### 4.2 Step 2.2: Requirements and methods for accounting for the number of actions

Accounting for the number of actions in this case means identifying the number of past (and present) EPC projects. To enable calculation using equation 4.1 in the previous section, knowledge about past and present EPC projects is required (i.e. finding out  $j$  and  $k$  in the equation). The member states will probably have to develop their own procedures and routines, but the following are suggestions;

##### *National EPC associations*

Using the assistance of national associations for EPC service providers and projects is one suggestion to gain knowledge of past and present EPC projects and their individual energy savings (at level 3). The associations could aim at facilitating and reporting EPC projects. Membership of the association has to be voluntary, but to encourage membership in the association, providers of EPC services could be offered some advantages (e.g. links to their home pages from authorities). A condition for membership shall be a requirement to report data from EPC projects, still offering the required level of anonymity both for customer and EPC provider.

##### *Voluntary agreements with ESCOs and/or their associations*

Voluntary agreements between public authorities and EPC providers, preferably through their association is another possibility for data collection.

### *Obligations and voluntary agreements with clients/building owners*

Obligations for State agencies to report on the EPC projects is also a possibility<sup>2</sup>. Also regional and local authorities could be required (for example as a result of a voluntary agreement with the State) to report. The same could apply for municipally owned real estate companies and social housing organisations. As for the private building owners, arrangement with their associations (National property federations) is another possibility. A similar approach could be adopted for the industrial sector. A reporting requirement on EPC projects could be an element in voluntary agreements on energy efficiency with these sectors or with individual companies.

### *Reporting data base*

National data bases are proposed for data collection. The data bases could be designed to allow EPC providers or customers to report data on their EPC projects, but rule out the possibility for others to see what data was delivered by whom. In Sweden, there is a data base for energy statistics in buildings (eNyckeln [www.enyckeln.se](http://www.enyckeln.se)), where real estate owners voluntarily report energy data. The data base could possibly be developed to fit the purpose of reporting EPC projects as well.

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<sup>2</sup> This is line with the ESD where the public sector is appointed a certain responsibility to set a good example regarding energy efficiency.

## 5 Step 3: Total ESD annual energy savings

In this section, the correction factors required by the ESD and potential further correction factors are dealt with. Applying these factors will allow calculating the total ESD annual energy savings from the gross annual energy savings calculated in step 2.

### 5.1 Step 3.1: Formula for ESD annual savings

If all correction factors are applied, the formula for total ESD annual savings, TGESD will read:

$$\sum_{j=1}^m \sum_{i=1}^n C_{j,i} * S_{j,i} * \eta_i + \left( \sum_{k=1}^p \sum_{i=1}^n C_{k,i} * DV_i * \eta_i \right) * \alpha - DC - TI + M - FR$$

(equation 5.1)

Where:

TGESD = Total ESD annual energy savings, MWh/a

$i$  = energy carrier (electricity, fuel, district heating or district cooling)

$j$  = EPC project for which savings are reported individually (level 3)

$m$  = number of projects for which savings are reported individually (level 3)

$k$  = EPC project identified with estimated data (possibly reported data for initial annual energy

$C_{j/k,i}$  = initial annual energy consumption of energy carrier  $i$  in EPC project  $k$ , MWh/a

$p$  = number of projects identified, with estimated data

$S_{j,i}$  = annual energy savings of energy carrier  $i$  in EPC project  $j$  (level 3), %

$DV_i$  = national default value for energy saving of energy carrier  $i$ , %

$\eta_i$  = national conversion factor for energy carrier  $i$

$\alpha$  = "quality factor"  $\leq 1$ , a factor that could be used by Member States to penalize EPC projects that have not fully reported energy savings.  $\alpha = 1$  means that all energy savings are accounted for

DC = correction term (energy savings to be subtracted) for double counting

TI = correction term (energy savings to be subtracted) for technical interaction

M = correction term (energy savings to be added) for the multiplier effect

FR = correction term (energy savings to be subtracted) for the free-rider effect (only if the aim is to calculate additional energy savings)

In this case application, these corrections are better made in absolute terms, not as factors between 0 and 1 as in other case applications, assuming they are estimated on a per customer base. If this is not the case but these effects have to be estimated as averages from a sample, the approach using correction factors (shares) between 0 and 1 may also be used here.

According to Annex II of the ESD, Member states can use national conversion factors or conversion factors listed in the Annex.

## 5.2 Step 3.2: Requirements for double counting

There is potential double counting with other EEI facilitating measures (such as voluntary agreements, energy audits and measures under a white certificates scheme) involving the same end-use actions. Overlap is also possible with all end-use actions taken as part of an EPC project and at the same time evaluated by itself (e.g. actions influencing heating, cooling, ventilation and lighting). Below is an example matrix describing potential double counting situations, in this particular case based on end-use actions and (EEI) facilitating measures for which bottom up methods are developed within the EMEEES project. Naturally, there exist other overlap situations as well.

**Table 5.1. Example of potential double counting, based on (EEI) facilitating measures and end-use actions for which evaluation methods are developed in EMEEES WP 4.2.**

	EPC – tertiary	EPC – industry
<b>(EEI) Facilitating measures</b>		
Energy audits	X	X
Energy performance of buildings	X	
Voluntary agreements (industry)		X
Voluntary agreements (tertiary)	X	
<b>End-use actions</b>		
4 Residential condensing boilers in space heating	X	
9 Improvement of lighting systems (tertiary sector)	X	X

10 Improvement of central air conditioning (tertiary sector)	X	
11 Office equipment	X	
12 Energy-efficient electric motors		X
13b Variable speed drives		X

The best way to avoid double counting is to evaluate the whole package of (EEI) facilitating measures acting on each end-use action taken in every EPC project. This will include the EPC project and all measures governed by public authorities (e.g., energy audit programmes, soft loans, voluntary agreements). If this is not possible on level 3, a sample of EPC projects should be studied to estimate the percentage of double-counted energy savings on level 2.

If needed, e.g., since the package approach is not possible at all, or to suit national needs of allocation of energy savings to different market actors and the state, allocation of energy savings between end-use (EEI) actions and/or (EEI) facilitating measures, in case of overlap, should be made by the MS.

### 5.3 Step 3.3: Requirements for technical interactions

EPC projects most often involve several end-use actions commonly influencing the consumption of the same energy carriers. The EPC provider has the competence to calculate deemed energy savings resulting from all actions and thereby offering the customer a guaranteed amount of savings. Technical interaction is therefore, an important task for the EPC provider and should always be taken into account. Correction for technical interaction in equation 5.1 is thus not applicable for EPC.

### 5.4 Step 3.4: Requirements for multiplier energy savings

Multiplier effects might occur if end-use actions taken within an EPC project are copied to other buildings or facilities. Some effects have been observed, but they are difficult, if not impossible, to quantify. Multiplier effects cannot be followed up in normal EPC procedure, and would require further efforts such as interviews or questionnaires.

### 5.5 Step 3.5: Requirements for the free-rider effect

Free-rider effects are not explicitly mentioned in the ESD and is most interesting when evaluating the effects from policy instruments. It has not yet been decided by the European Commission and the ESD committee, whether this effect shall be included in the total ESD annual energy savings or eliminated from them. In the latter case, the following requirements apply.

Free-rider effects can occur in EPC projects, e.g. an old heating system or broken equipment in need of exchange and an energy-efficient new equipment installed even without the EPC project. Some conversion from oil heating would probably have occurred anyway, but the conversion is most likely more effective when part of an EPC project as consideration is paid to both utilisation and effect demand. Furthermore, an end-use action included in an EPC project might have been carried out even without additional supporting or facilitating policies and measures. Free-rider effects cannot be followed up in normal EPC procedure, and would require further efforts such as interviews or questionnaires.

## 6 Step 4: total ESD energy savings for 2010 and 2016

### 6.1 Requirements for the energy saving lifetime

EPC projects refer mainly to end-use actions influencing heating, cooling, ventilation and lighting. Most EPC projects involve several end-use actions having different lifetimes. Assessment of which actions resulted in what energy savings from an EPC project involving many different end-use actions would, if at all possible, require advanced and probably costly monitoring systems. These would also be beneficial to avoid double-counting with other measures facilitating an individual action (cf. chapter 5.2). If it is not possible, the set of actions implemented could be analysed for a sample of participants to calculate national default values of average lifetimes of savings per energy carrier.

The actions may be technical as well as “soft measures”, such as education of staff and energy management systems, although soft measures are never (or at least seldom) taken alone. Because EPC involves follow-up and maintenance support, the EPC provider assures longer lifetimes for soft measures as well.

As long as the measures have lifetimes exceeding 9 years, all measures taken from 2008 and forth will still have an effect after 2016. The problems thus arise when EPC projects involve measures with shorter lifetime than 9 years and/or when considering early actions. The latter (early action) is discussed in section 6.2 below.

In CEN/CENELEC Workshop Agreement 27 from 2007, a list of saving lifetimes for commonly applied EEI measures are presented (CWA27, 2007). The absolute majority of listed end-use actions commonly taken within EPC projects have lifetimes exceeding 9 years.

The actions with lifetimes less than 9 years involve soft/organisational measures with lifetimes of 2 years, such as energy management systems. However, in the case of EPC, these actions could be considered taken care of during the maintenance phase of the EPC project. The lifetime of such actions may be considered ended 2 years after the finalisation of the EPC contract, if a new EPC contract is not signed. Evaluation has to be done from case to case, e.g. by the EPC providers. There are also a few technical actions listed in CWA27 with lifetimes less than 9 years (commercial refrigeration, energy efficient office appliances and combined heat and power). If any of these actions are part of an EPC project case specific assessment of overall saving lifetime has to be done, e.g. by the EPC providers.

## 6.2 Special requirements for early actions

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 2008, with the end-use actions having a lasting effect in 2010 (for the intermediate target) or 2016 (for the overall target).

Note:

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. This needs to be proven. The same holds, respectively, for the intermediate target in 2010.

This requires case specific analysis of end-use actions taken within each EPC project, their relation to each other and their lifetimes.

## 6.3 Uncertainties

EPC is by definition a model with thorough routines for estimation and follow-up of energy savings made by EPC providers with high capability and experience of analysing, performing and following up of large-scale energy efficiency improvements. Still, there exist uncertainties, e.g.:

- Coverage of EPC projects – lower coverage of EPC projects means higher uncertainty
- Level of calculation – the uncertainty increases with decreased element of level 3 calculation (reported saving from individual EPC projects). Ex-post measurement offers the highest accuracy, followed by enhanced engineering estimates (guaranteed savings) and eventually default values.
- Quality of data collected – the uncertainties increase with increased element of estimation compared to ex-post measurement
- Lifetimes of savings – EPC involves several end-use actions with different lifetimes and it is difficult to allocate savings between different

actions. If the lifetime of one or more end-use actions is below the number of years left until 2016 (and the EPC providers are not still present in the project assuring prolonged lifetime) evaluation needs to be done to assess how much of the savings are still due after 2016

Uncertainties should be identified and reported. Member states could encourage EPC providers or building owners (depending on choice of data collection method) to take uncertainties into account when reporting data on EPC projects.

## Appendix I: Justifications and sources

### Literature:

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Stefan Thomas, Wuppertal Institute

Also comments from Glenn Widerström, Dag Lungblad and Arne Andersson from the Swedish Energy Agency

### Abbreviations:

EEI      Energy Efficiency Improvement

EPC      Energy Performance Contracting

- ESCO Energy Services Company
- ESD EU Directive on Energy End-Use Efficiency and Energy Services
- MS Member State of the EU