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

Overview of default values proposed in bottom-up case applications

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The Project in brief

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

Consortium

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

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1 Introduction

EMEEES has developed 20 case applications of bottom-up calculation methods for energy savings. To enable level 1 calculations, it was intended to propose as many EU default values as possible. These are derived from existing literature and experience, but a reliability coefficient is applied that considers both the reliability and the transferability of the values found in existing sources. The EU level default values are thus conservative: they enable Member States that do not have own values a calculation of energy savings, but provide an incentive to perform country- or measure-specific evaluations and calculations on levels 2 or 3, which will probably yield higher energy savings with higher precision.

The following table provides an overview of the types of EU level default values proposed in the 20 case applications of bottom-up calculation methods. It shows that there are some kinds of default values proposed for 16 out of the 20 case applications. Out of these 16, nine propose default values directly for the average unitary annual energy savings of an equipment or building, or for a percentage of the overall energy consumption of a participant, while seven only propose default values for some parameters of calculation. In these cases, other parameters for calculating the unitary annual energy savings need to be monitored for each unit of end-use action tapped by an energy efficiency improvement measure.

Bottom-up case applications and default values for the calculation of unitary gross annual energy savings

End-use or end-use action, technology, or facilitating measure	**Default value 1**	**Default value 2**
Building regulations for new residential buildings	parameter for non-compliance	time lag 2 years
Improvement of the building envelope of residential buildings	none possible	none possible
Biomass boilers	none possible	none possible
Residential condensing boilers in space heating	EU **average unitary annual energy savings** in kWh/m2/year, for all and additional energy savings	average seasonal energy efficiency (%) of: condensing boilers (94%); new, not energy-efficient boilers (89%); boilers in existing stock (82%)
Energy efficient cold appliances and washing machines	**unitary annual energy savings** of cold appliances: 61 kWh/year	average energy savings per washing cycle of clothes-washers: 0,06 kWh/cycle
Domestic Hot Water – Solar water heaters	none possible	Per capita hot water consumption and standard

End-use or end-use action, technology, or facilitating measure	Default value 1	Default value 2
		hot water temperature
Domestic Hot Water - Heat pumps	none possible	Per capita hot water consumption and standard hot water temperature
Non residential space heating improvement in case of heating distribution by a water loop	EU **average unitary annual energy savings** in kWh/m2/year, for all and additional energy savings, for: condensing boilers efficient distribution system efficient heat emitters (including controls)	average seasonal energy efficiency (%) of: energy-efficient solution; new, not energy-efficient solution; existing stock; each for: boilers distribution system heat emitters (including controls)
Improvement of lighting systems (tertiary sector)	EU **average unitary annual energy savings** in kWh/year for: compact fluorescent lamps electronic ballasts occupancy sensors	average values for the power input (W) for energy-efficient and inefficient luminaires annual hours of use
Improvement of central air conditioning (tertiary sector)	**average unitary annual energy savings** in kWh/m2/year from use of Eurovent class A equipment for each of the EU-15 Member States, for four types of equipment	average unitary annual energy savings in kWh/m2/year from use of free cooling for each of the EU-15 Member States
Office equipment	EU **average unitary annual energy savings** from using **BAT** compared to market inefficient equipment in kWh/year for active, standby, and off modes for: desktop computers laptop computers CRT monitors LCD monitors	EU **average unitary annual energy savings** from using **EuP proposed values** compared to market inefficient equipment in kWh/year for active, standby, and off modes for: desktop computers laptop computers CRT monitors LCD monitors
Energy-efficient motors	average energy efficiency and energy savings (%) of motors, 22 load range categories, for IE1, IE2, and IE3 efficiency classes	EU average hours/year and load factors for 3 load range categories < 22kW, each for six types of end uses in industry and tertiary sector, in total 36 values
Variable speed drives	for motors < 22kW: **average energy savings** (%) from VSDs for six types of end uses; average energy efficiency (%) of motors, 22 load	EU average hours/year and load factors for 3 load range categories < 22kW, each for six types of end uses in industry and tertiary sector, in total 36

End-use or end-use action, technology, or facilitating measure	**Default value 1**	**Default value 2**
	range categories, for IE1	values
Vehicle energy efficiency	baseline energy consumption (kWh/km) by fuel, assuming 130 g CO_2/km as the baseline (N.B.: energy savings from the 130 g CO_2/km standard better to be evaluated top-down; this BU method mainly for additional energy savings from measures promoting BAT)	average energy savings (%) from fuel-saving lubricants and tyres, separate for private and commercial vehicles
Modal shifts in passenger transport	average specific energy consumption in kWh/person-km for: cars long-distance trains airplanes	–
Ecodriving	average share (%) of drivers changing behaviour as a consequence of a measure, each for: specific training including ecodriving in driver license training use of virtual trainers/simulators in-car devices	average energy savings (%) by drivers changing behaviour as a consequence of a measure, each for: specific training including ecodriving in driver license training use of virtual trainers/simulators in-car devices
Energy performance contracting	none possible	none possible
Energy audits	**average energy savings** (% of total consumption of final users receiving an energy audit), separate for electricity and heating fuels, and for industry and tertiary sector	average energy savings (% of total energy savings potential identified in an energy audit), separate for electricity and heating fuels, and for industry and tertiary sector
Voluntary Agreements - billing analysis method	none possible	none possible
Voluntary agreements with individual companies - engineering method	**average energy savings** (% of total consumption of final users participating in the scheme, **only** if it includes a full energy audit), separate for electricity and heating fuels	–

2 EU level default values for individual case applications

In order to understand the meaning of the default values, for each case application we first present the formula for unitary gross annual energy savings at level 1 (or level 2 if there is no level 1), and then the EU level default values proposed for application with this formula, as well as the data needs.

2.1 Building regulations for new residential buildings

2.1.1 Formula for unitary gross annual energy savings

Level 2: The unitary gross annual energy savings for a dwelling in class i as a result of new building codes is calculated according to the formula:

$$UFES_i = UFED_{0i} - nc * UFED_{1i}$$

The $UFED_{.i}$ (.i = 0i or 1i) is calculated as a function of the characteristics of the standard dwelling in class i and the properties of the materials and installations used. This function can be specific for a MS, but must be in conformity with the EPBD methodology. So it can be used both if the building code is requiring an energy performance standard, or performance standards for building components.

$$UFED_{.i} = f(UEL_{.im}, ie, dp_{i(1..p)})$$

Both formulas can be used either if the unit is a m^2 of conditioned floor space, a flat, a building, dwelling, etc.,.

Note that the effect on unitary gross annual energy savings is observed with some time-lag from the date of implementation of a building code. The default timelag is proposed to be 2 years.

Where: $UFES_i$ = Unitary Final Energy Savings for a standard dwelling in class i, per annum

$UFED_{0i}$ = Unitary Final Energy Demand; calculated energy demand for a standard dwelling in class i, under baseline conditions, per annum

$UFED_{1i}$ = Unitary Final Energy Demand; calculated energy demand for a standard dwelling in class i, under the building code to be evaluated, per annum (default timelag: 2 years)

nc = Non-compliance paramater (1 + percentage higher energy use as a result of non-compliance with the building code)

$UEL_{.im}$ = Unitary energy loss for a standard dwelling in class i, for measure m, under a specific building code, per annum

$dp_{i(1..p)}$ = Dimensional (model) parameters (1 thru p) for standard residential dwelling in class i (m^2 conditioned floor space, m^2 glass surface, m^2 insulation, energy efficiency of the heating system, etc.).

ie = Interaction effect

m = Energy efficiency measure (1 thru m) referenced in the building code

Level 3: Formulas are identical to those in level 2; now each unit is an individual dwelling (the unit is its own class).

2.1.2 Indicative default value for annual unitary energy savings

There are no EU level default values for unitary annual energy savings possible. For the non-compliance parameter, a default value of 1.1 is proposed. Furthermore, a default time lag of two years is proposed for a new building code to take effect in the calculation of the unitary gross annual energy savings.

2.1.3 Main data to collect

Data to be collected National method (level 2)	**Examples of corresponding data sources**
heat demand HD	Energy certificates for new buildings, surveys, studies
relevant dimensional parameters for standard residental dwelling per class	Energy certificates for new buildings, surveys, studies
final energy demand FED	Energy certificates for new buildings, surveys, studies
number of m^2 of conditioned floor space or of new buildings according to the building code per class of residential dwellings	Building statistics, reporting from building administration (number of building permits etc.)
Data to be collected National method (level 3)	**Examples of corresponding data sources**
As in level 2 for individal dwellings	

2.2 Improvement of the building envelope of residential buildings

2.2.1 Formula for unitary gross annual energy savings

For this method, the unit used in the formula for the unitary gross annual energy savings is square meters of conditioned area.

If the rebound effect is to be taken into account for evaluation of ESD energy savings, the equation (S1) used in section 3, step 1 for the Level 2b and Level 3 calculation will be:

unitary gross annual energy savings =

$$UFES = UFED_{baseline} - UFED_{action} = \left(\frac{SHD_{baseline}}{\eta_{baseline}} - \frac{SHD_{action}}{\eta_{action}}\right) \bullet (1 - RE)$$

(equation S1a)

Where:

UFES = Unitary Final Energy Savings [kWh/m^2/a]

UFED =Unitary Final Energy Demand [kWh/m^2/a]

SHD = Specific Heating Demand [kWh/m^2/a]

η = energy efficiency of the heating system (seasonal)[1]

RE = coefficient for the Direct Rebound Effect

At levels 2a and 2b, the unitary gross annual energy savings can be estimated as the average gain (in kWh/m²/a) per categories (building types and construction periods) based on a sample and a difference between “before” and “after” Energy Performance Certificates.

Using the same expression at level 3, the unitary gross annual energy savings can be estimated as the actual difference between the “before” and “after” Energy Performance Certificates for each registered building if energy savings

[1] η is not the efficiency of the boiler or the heating system as a technical unit. It is the relation of heat demand to final energy demand for heating and, thus, the characteristics of the whole building have to be considered. The final energy demand (FED) also includes losses by the heating and the distribution system, expressed by efficiency parameters (details in method 4, improvement of the heating system)

are evaluated for all individual buildings involved in a given action or as an average gain per categories based on a regional sample if the method is applied at a regional (sub-national) level.

2.2.2 Indicative default value for unitary gross annual energy savings

It is not possible to define a default or a harmonised value for energy savings related to the building envelope due to the wide heterogeneity of residential buildings in the EU.

2.2.3 Main data to collect

Data needed in calculation for EU values (level 1)	**Corresponding data sources**
Data 1	n.a.
Data 2	n.a.
etc.	

Data to be collected national values (level 2a)	**Corresponding data sources**
heat demand HD	Energy certificates for refurbished buildings (before and after EEI measures), surveys, studies, expert judgement
conditioned area	building statistics, reports from building administration (granted subsidies, building permitions), surveys, studies
efficiency of the heating system (seasonal) η	energy certificates, energy certificates database, studies, surveys, expert judgement
final energy demand (FED)	Energy certificates for refurbished buildings (before and after EEI measures), surveys, studies
final energy demand/use (top down)	energy statistics, surveys, studies
number of buildings with EEI measures on the building envelope (and heating system)	Building statistics, reporting from building administration (data on granted subsidies, number of building permitions etc.)
Number of free-riders, multipliers, rebound effects	Ex-post surveys for samples of participants, non-participants and/or trade allies

Data to be collected national values (level 2b)	**Corresponding data sources**
Final energy demand (FED) for space heating before and after end-use actions for a sample of actions	Building energy performance certificates
Number of free-riders, multipliers, rebound effects	Ex-post surveys for samples of participants, non-participants and/or trade allies
Double-counting coefficient / exclusion of double counting	Database tracking participants and end-use actions vs. facilitating measures If no database possible, ex-post surveys for samples of participants

Data to be collected <u>measure-specific</u> (or participants-specific) (level 3)	**Corresponding data sources**
Final energy demand (FED) for space heating before and after end-use actions for all individual builidngs involved in the energy-saving action	Building energy performance certificates
Number of free-riders, multipliers, rebound effects	Ex-post surveys for samples of participants, non-participants and/or trade allies
Double-counting coefficient / exclusion of double counting	Database tracking participants and end-use actions vs. facilitating measures If no database possible, ex-post surveys for samples of participants

2.3 Biomass boilers

2.3.1 Formula for unitary gross annual energy savings

For this method, the unit used in the formula for the unitary gross annual energy savings is an individual EEI programme participant.

Annual energy savings are determined using the engineering calculation described below:

The direct unitary gross annual energy savings Q_{dir} should be corrected for:

(i) energy embedded in fuel preparation, ε_{emb} , in % of the energy content of the biomass fuel,
(ii) energy embedded in transportation of fuel from production site to the consumer, α_{transp} , in % of the energy content of the biomass fuel.

Then the formula for unitary gross annual energy savings is given by:

$$Q_U = Q_{dir} * [\frac{1}{\eta_{FFB}} - \frac{1}{\eta_{BMB}}(\varepsilon_{emb} + \alpha_{transp})]$$

(equation S1)

where:

η_{FFB} - is the efficiency of fossil fuel boiler, and
η_{BMB} - is efficiency of biomass boiler, and
Q_{dir} - is defined in Eq. 1.2 in chapter 1.

Note: if the aim is to calculate all energy savings, η_{FFB} is the efficiency of the replaced old fossil fuel boiler. If the aim is to calculate energy savings additional to autonomous progress, η_{FFB} is the efficiency of a new, average energy efficiency fossil fuel boiler.

In all cases, the number of regional heating degree days (Level 2) averaged over N (Level 1) previous years[2] will be used in the calculations. Since, the

[2] The value of N will need to be agreed upon, we propose N=5 years.

region-by-region variation of the values of degree days is usually significant regional level of averaging should be used rather than the national ones.

Alternatively, for level 1, the normalised energy demand for space heating defined in the ecoboiler study (for the EcoDesign Directive), as recommended by Jérôme Adnot for the method for condensing boilers could be used.

The proposed approach is (i) relative simple, (ii) does not entail significant additional costs and is (iii) pragmatic as regards the determination of heat demand.

2.3.2 Indicative default value for unitary gross annual energy savings

In calculation of the unitary gross annual energy savings, default values for two parameters could be applied, as defined in the case application 4 on gas-fired condensing boilers. One is the average annual energy consumption per m^2, **E = 86 kWh/m^2/year** on EU average, or using national averages (cf. case application 4 on gas-fired condensing boilers). The other one is the energy efficiency of the replaced boiler (i.e., the baseline), as provided in Table 1.

Table 1: level 1 average energy efficiency of replaced gas-fired boiler – value for EU average conditions

	boiler efficiency for regular replacement°	boiler efficiency for early replacement*
Replaced boiler	89%	82%

° if the aim is to calculate energy savings **additional** to autonomous progress

* also for regular replacement, if the aim is to calculate **all** energy savings

2.3.3 Main data to collect

Data needed in calculation for EU values (level 1)	Corresponding data sources
Data 1 Calorific value of different kinds of biomass and other parameters determining the values of ε and α in Eq. S1 (embedded energy in production of pellets, briquettes, and wood chips and biomass transportation losses) m2 of building floor space when using the values from Table 1 and E = 86 kWh/m^2/year	Appendix to this Summary and references therein monitoring of participants
Data 2 Biomass boilers efficiencies for dominant classes of models in the EU market	EN 303-5 Heating boilers–part 5. “Heating boilers for solid fuels, hand and automatically stocked, nominal heat output of up to 300kW- terminology, requirements, testing and marking”
Data 3 Erstwhile boiler efficiency	Default values provided above in section 1.6, taken from case application 4 on gas-fired condensing boilers

Data to be collected national values (level 2)	Corresponding data sources
Data 1 Degree days	Appropriate meterological statistics from the regioal meterological station. Cf. Statistical aspects of the energy economy in 2005 - Issue number 13/2006" , Authors: Antigone Gikas, Rita Keenan and analogous national/regional sources
Data 2 Region-specific characteristics of classes of buildings and their average parameters enabling the experts to assign heat demand for a particular building based on this information	Averaged over a sample of buildings of a given type, size and construction date (engineering estimate). See also below (Level 3 data)
Data 3 Data on domestic (national) production of solid biomass fuel for individual space heating and the corresponding data for imports[3]	tbd
Data 4 Erstwhile boiler efficiency	As above for level 1 or national averages

Data to be collected measure-specific (or participants-specific) (level 3)	Corresponding data sources
Data 1 Energy audit or building characteristics needed for assessment of heat demand	Provided by the participant in the questionnaire accompanying the application form
Data 2 Installation design data, including model and capacity of the boiler, and in house heat distribution system, kind of biomass to be used and source (local, national, potentially imported, if purchased from wholesale dealers)	input parameters provided by the participant or installer in the questionnaire or assigned by the programme evaluation expert (Level 2) based on default values and information in the questionnaire
Data 3 Erstwhile boiler efficiency	As above for level 1 or 2, or boiler replaced in the individual case

[3] These data will be needed only if the proposal to take into account the transportation energy losses is accepted

2.4 Residential condensing boilers in space heating

2.4.1 Formula for unitary gross annual energy savings

For this method, the unit used in the formula for the unitary gross annual energy savings is the area of the building.

Consequently, the equation (S1) used in section 3, step 1 is

unitary gross annual energy savings = (1/efficiency of replaced plant – 1/efficiency of condensing plant) * E (equation S1)

the replaced plant efficiency is different between regular and early replacement; that does not change the formula.
where equation 2 is used for combining components efficiencies to obtain plant efficiency;

and E, the heating need, is on EU-25 average 86 kWh/m2, but must be corrected for heating degree days HDD or E determined nationally (e.g., according to the Ecoboiler study)

It could be logical to only accept energy savings from early replacements, because, at least in a number of MS, replacement of failed boilers by condensing boilers is already the standard. If the MS do not make a common rule, there needs to be a correction on high free-rider shares for some countries, if the aim is to calculate energy savings additional to autonomous progress.

The result of the calculation for EU average values is given in the following Table 2 with the adequate security coefficient of 0.80.

2.4.2 Indicative default value for unitary gross annual energy savings (according to replacement type)

Table 2: level 1 unitary gross annual energy savings for a change of boiler only – value for EU average conditions

	ΔE *in kWh/m2/a for regular replacement°*	ΔE *in kWh/m2/a for early replacement**
E = 86 kWh/m^2/year	5.6	14.7
Based on the following default values for seasonal average boiler efficiency:		
Efficient condensing boiler	94%	94%
Replaced boiler	89%	82%

° if the aim is to calculate energy savings **additional** to autonomous progress
* also for regular replacement, if the aim is to calculate **all** energy savings

These values need to be modified for each Member State. This could be done either by heating degree days or by the values for the annual useful heating energy demand per m^2 from the Ecoboiler study (p.58 of ecoboiler task 3 final report; useful heating energy demand is termed “heat load” in that source). It needs to be discussed what is the better choice. Heating degree days reflect the climate and would thus reward countries who have already a better insulated building stock. The annual the annual useful heating energy demand per m^2 will better reflect the actual situation of the building stock. Table 3 and Table 4 are providing more information on the adaptation factors per MS that either choice would entail.

Table 3: factors to adapt the EU level default value for unitary gross annual energy savings to each EU Member State based on heating degree days

Member State	Heating degree days (Kelvin*day/year)	Adaptation Factor
MT	**581**	0.18
CY	**704**	0.22
PT	**1364**	0.43
EL	**1596**	0.50
ES	**1926**	0.60
IT	**2031**	0.63
FR	**2469**	0.77
IE	**2682**	0.84
NL	**2716**	0.85
BE	**2734**	0.85
HU	**2951**	0.92
SK	**2953**	0.92
UK	**3100**	0.97
LU	**3107**	0.97
SI	**3119**	0.97
DE	**3162**	0.99
DK	**3254**	1.01
CZ	**3518**	1.10
PL	**3533**	1.10
AT	**3606**	1.12
LT	**4031**	1.26
LV	**4199**	1.31
EE	**4313**	1.34
SE	**5183**	1.62
FI	**5415**	1.69
EU-25	**3207**	**1**

Basis: data for 2004 and 2005

Table 4: factors to adapt the EU level default value for unitary gross annual energy savings to each EU Member State based on heating needs from Ecoboiler study

Member State	Heating needs (kWh/m^2/year)	Adaptation Factor
MT	**16**	0,19
PT	**25**	0,29
CY	**32**	0,37
ES	**37**	0,43
IT	**54**	0,63
NL	**61**	0,71
EL	**69**	0,80
DK	**79**	0,92
FR	**80**	0,93
HU	**90**	1,05
SK	**93**	1,08
UK	**94**	1,09
DE	**100**	1,16
IE	**101**	1,17
LV	**102**	1,19
CZ	**104**	1,21
PL	**104**	1,21
AT	**113**	1,31
SE	**118**	1,37
LU	**123**	1,43
SI	**124**	1,44
BE	**141**	1,64
LT	**149**	1,73
FI	**158**	1,84
EE	**186**	2,16
EU-25	**86**	**1**

Source: VHK Preparatory Study on EcoDesign of Boilers (2007) (http://www.ecoboiler.org), Task 3 final report, p. 58

2.4.3 Main data to collect

Level 1 : number of treated dwellings and average dwelling area in country

Level 2 : area treated in each dwelling and exact location for climatic correction

For levels 1 and 2 also: data on technical interaction with thermal insulation

Level 3 : area treated in each dwelling and the other improvements at the level of each building (by doing this the interactions with other measures, like the insulation of the same building which decreases the demand and the distribution network improvements that increase the gain are taken into account)

For all three levels: data on double-counting between facilitating measures, free-rider, and multiplier effects

2.5 Energy efficient cold appliances and washing machines

2.5.1 Formula for unitary gross annual energy savings

For this method, the unit used in the formula for the unitary gross annual energy savings is one appliance. The formula itself is different for cold appliances and washing machines.

- **Cold appliances**: the energy label provides data on the annual unit consumption (UC).

Unitary gross annual energy savings of an energy-efficient cold appliance

=

$$\textbf{([annual energy consumption]}_{BL}\textbf{ - [annual energy consumption]}_{BAT}\textbf{)* F}$$

Where:

- BL stands for the baseline, depending on the level of effort; for methods counting participants:
  - o normal replacement:
    - a) if the objective is to calculate only additional energy savings[4]:
      average of the A+ to C appliances on market offer *
    - b) if the objective is to calculate all energy savings:
      average stock appliance*
  - o early replacement: average stock appliance for the number of years that the replacement has been advanced*; average of the A+ to C appliances on market offer thereafter *
- BAT (best available technology): the best energy class on the market (currently A++)
- F: correction factor reflecting the ratio of the consumption under the standard test conditions and the measured consumption in real life

* N.B.: as soon as the EuP minimum energy performance requirements will be introduced, this baseline will need to be adapted. This method then continues to be applicable for facilitating measures promoting the purchase of BAT appliances. The baseline will be the average of the appliances that are meeting the EuP requirement but are not BAT. This does not mean that the energy savings due to the EuP requirement will not count towards the ESD energy savings target. Whether they count is up to decision by the European Commission with the ESD Committee. If they count, the best way to measure these savings will probably be to multiply the unitary annual energy savings due to the EuP requirement with the number of cold appliances sold. These unitary annual

4 Additional energy savings are those that, as an effect of an EEI measure, come on top of those that energy consumers, investors, or other market actor would have done by themselves anyway (cf. EMEEES WP 4 summary report, Vreuls et al.) for more explanations)

energy savings due to the EuP requirement could be calculated from the difference in average annual energy consumption for the respective country between the dynamic baseline (e.g., projecting past trends from a specific energy consumption indicator, e.g., ODYSSEE) and the appliances that just meet the EuP requirement.

As a background information, the following table presents the energy efficiency index values defining energy efficiency classes of the EU energy label.

Cold appliances: maximum energy efficiency index values defining energy efficiency classes of the EU energy label

Energy efficiency class	Energy efficiency index (%)
A++	30
A+	42
A	55
B	75
C	90
D	100
E	110
F	125
G	155

- **Washing machines**: the energy label displays the standard cycle consumption. It is therefore necessary to estimate the average number of cycles per year.

Unitary gross annual energy savings of an energy-efficient washing machine

=

$$([CC*AC]_{BL} - [CC*AC]_{BAT})*F$$

Where:

- CC: Cycle Consumption as stated on the energy label
- AC: Annual number of Cycles for the average household
- BL stands for the baseline, depending on the level of effort
    - normal replacement:
        - a) if the objective is to calculate only additional energy savings:
          average of the A+ to C appliances on market offer *
        - b) if the objective is to calculate all energy savings:
          average stock appliance*
    - early replacement: average stock appliance for the number of years that the replacement has been advanced*; average of the A+ to C appliances on market offer thereafter *
- BAT (best available technology): the best energy class on the market (currently those below 0.17 kWh/kg)

- F: correction factor reflecting the ratio of the consumption under the standard test conditions and the measured consumption in real life

* the same considerations apply here with respect to EuP requirements as for the cold appliances.

Washing machines: maximum energy efficiency index values defining energy efficiency classes of the EU energy label

Energy efficiency class	Energy efficiency index (kWh/kg)
A	0,19
B	0,23
C	0,27
D	0,31
E	0,35
F	0,39
G	0,43

The data displayed on the label corresponds to one year of functioning or one standard cycle under the standard test conditions, which is merely an indicator designed to compare the energy performance of different appliances. Actual consumption depends on the conditions of use. A correction factor may be applied to reflect the actual cycle or annual consumption. However this parameter is not available in most countries, so a default value of 1 may be applied.

2.5.2 Indicative default value for unitary gross annual energy savings

The following values are suggested as level 1 default values.

Unitary annual energy savings: **EU default/harmonised values**	
EU default values for the market offer excluding BAT baseline; i.e., will calculate additional energy savings in normal replacement cases. No EU default value is possible for the stock baseline, which is highly country-specific.	Cold appliances Default annual unitary gain between A+ and A++ = 61 kWh/year Washing machines Default unitary gain per cycle between just A and the most energy-efficient appliances (below 0.17 kWh/kg) = 0.06 kWh/cycle

These values are based on French retailer catalogues and Eurotopten.

2.5.3 Main data to collect

Data needed in calculation using EU values (level 1)	**Corresponding data sources**

Data 1: Average standard cycle consumption of BAT and market baseline appliances on offer	Level 1 EU Market survey (retailers: shop visits or online catalogue), based on the energy label, and/or GfK / Nielsen data; applying safety factor of 0.8
Data 2: Correction factor: actual average cycle consumption	Level 2 Measurement campaign (e.g. Remodece) or statistical survey
Data 3: Consumer habits: number of cycles per year (for washing machines)	Level 2 or 3 Market survey (consumers)
Data 4: Sales data: volume and breakdown by class (for total gross annual energy savings)	Level 2-3 GfK-GIFAM
Data 5: Number of households	Level 2 National statistics
Data 6: Equipment ownership rate Stock volume (reference year) Replacement ratio	Level 2 National statistics, CECED or national associations of manufacturers/retailers
Data 7: Number of BAT appliances sold under the scheme. Number of purchases claiming financial benefit from the measure	Level 3 Ex post data from participant monitoring and/or market survey (depending on type of facilitating measure)
Data 8: data on double-counting between facilitating measures, free-rider, and multiplier effects	Level 2 or 3: Surveys of participants and non-participants on which EEI measures influenced their purchasing decision, and how they influenced it Interviews with appliance retail trade and manufacturers on how the EEI measures influenced the appliance offer on the market

Data to be collected <u>national values</u> (level 2)	**Corresponding data sources**
Data 1: National average standard cycle consumption of BAT and market baseline appliances on offer	Level 2 National Market survey (retailers: shop visits or online catalogue), based on the energy label, and/or GfK / Nielsen data;
Data 2 to 8	Same as above

Data to be collected <u>measure-specific</u> (or participants-specific) (level 3)	**Corresponding data sources**
Data 1: Measure-specific average standard cycle consumption of BAT (may be defined specific for the measure) and market baseline appliances (i.e,, those not BAT) on offer	Level 2 Measure-specific Market survey (retailers: shop visits or online catalogue), based on the energy label, and/or GfK / Nielsen data;
Data 2 to 8	Same as above, but all at level 3 if needed

2.6 Domestic Hot Water – Solar water heaters

2.6.1 Formula for unitary gross annual energy savings

A) The basic assumption is that the ESD savings in provision of domestic hot water are equal to the (physical) amount of *chemical energy, ΔE_0, replaced* by the energy of solar radiation converted by the solar system into heat in the delivered hot water. More specifically, it is the amount of energy used to heat-up the grid water entering the in-house piping system with temperature T_0 (see [14,15]) to increase its temperature to the required hot water temperature T_1 (typically ca 50-60 ^{0}C).

B) The unit considered here for determination of unitary gross annual energy savings is *a participant*, i.e. an individual household (or facility), characterised by the number of occupants, the type of the existing hot water system, the building characteristics and the solar fraction of the solar system installed[5].

The formula for unitary gross annual energy savings is then:

$$\Delta E_{0,gross} = \Delta E_0 + \Delta E_b - E_{s1} - E_{s2} =$$

$$= (\eta_{cp} / \eta_b \eta_{bp}) N_{occ} \beta\rho \chi v [T_1 - T_0] + \Delta E_b - E_{s1} - E_{s2}, \qquad \text{(S1)},$$

The notation in Eq. (S1) is:

a) ρ – density of water
ρ = 995,64 kg/m^3, corresponding to 30°C (i.e. average value between 10 and 50 °C)

b) χ - specific heat of water, χ = 4190 J/kgK

c) N_{occ} - the (average) number of occupants (or users) of the given house or facility (provided by the participant)

d) ΔE_b - the energy saved annually by the boiler pump (provided by the participant)

5 One might consider that the natural choice for a unit would be an individual beneficiary of the progamme (a person). However, such choice would present a distorted picture, because the savings depend on the installation characteristics, which are related to a building rather than to a person.

e) T_1 - hot water temperature. The proposal is to use: $T_1 = 55°C$ as a default Level 1 value, determined by hygienic requirements (e.g. according to the Polish Standard)

f) T_0 - grid (cold) water temperature. To be determined as Level 2 (regional) technical constant

The value of T_0 is quite critical in the determination of the savings. For instance, according to [14] in Stockholm the cold water temperature varies from 2.1 to 14.9 °C. Even more significant are regional variations of annual averages reported in [15] for the USA.

g) v - the *per capita* default (annual average) volume of hot water, expressed in [m^3/year], usually quoted in the literature (cf. Fig. 2, where the average is 10,22 m^3/year/cap).

h) η_b – rated efficiency of the erstwhile boiler, assumed to be η_b = const. (provided in the questionnaire)

i) $\eta_{bp,}$ – losses of heat in the in-house hot water installation, leading from the boiler to the tap (provided in the questionnaire)

j) E_{s1} - annual energy consumption by the working medium pump (based on the documentation of the technical project[6])

k) E_{s2} - annual energy consumption by the additional circulation pump (if installed), based on the documentation of the technical project

l) η_{cp} – pipe losses in the additional piping system needed to distribute water heated (preheated) by the solar collector. Those include losses in pipes leading from the solar collector to the (primary) hot water accumulator and between the primary and the secondary hot water accumulator in a cascade system[7] (based on the documentation of the technical project).

m) β - the solar fraction (see Figure 3, Appendix I)

E_{s1} and E_{s2}, as well as ΔE_b, are typically of the order of 10% of the energy needed to heat up the corresponding volume of water. One should note that ΔE_b may roughly cancel with E_{s1} and/or E_{s2}. Consequently, in the first approximation one may neglect the electrical power corrections, although those can be easily accounted for, if the appropriate data are included in the questionnaires.

[6] If such documentation is not available, aproximate values should be used by experts evaluating the application, using default values corresponding to the size of the building.

[7] It is a common situation that water preheated by solar collector has to be heated up by an auxiliary energy source (e.g. gas or electric boiler)

2.6.2 Indicative default value for unitary gross annual energy savings

N/A, because the insulation conditions are dramatically different from region to region.

2.6.3 Main data to collect

Data needed in calculation for <u>EU</u> values (Level 1)	**Corresponding data sources**
Data 1 Hot water temperature	EU (or national) standard value, e.g. 55C
Data 2 Harmonised average *per capita* hot water consumption	Weighted average of national averages[8]
Data 3 Parameters characterizing the surrounding	See Ref. [17].
Data 4 Time intervals for averaging grid (cold) water temperatures	The proposal is: March 21 - September 22 (for “summer” season) and September 23 – March 20 (for “winter” season)[9]
Data 5 EU standarised model for calculation of functions I_d, I_{iso} and I_r of Level 2 (cf. Appendix II)	E.g. anisotropic or isotropic model [16,19]

Data to be collected <u>national values</u> (Level 2)	**Corresponding data sources**
Data 1 Grid water (cold water) temperature averaged over defined periods of time (e.g.months)	Data exist in many cases. If not, they are very easy to collect, see e.g. [14,15]
Data 2 Average *per capita* hot water consumption (if Data 2 in Level 1 is not accepted)	See above
Data 3 Functions I_d, I_{iso} and I_r	Simulation on meteorological files

Data to be collected <u>measure-specific</u> (or participants-specific) (Level 3)	**Corresponding data sources**
Data 1 Number of occupants (or users of building/facility)	Data in the EU-harmonised questionnaire provided by an EEI programme participant (for Data 4 see Ref. [17])
Data 2 Erstwhile boiler characteristics	
Data 3 Building characteristics to include in-door hot water distribution system losses	
Data 4 Characteristic of surroundings for inserting in calculation of I_r function	

8 As seen in Fig. 2 the differences beetwen the national averages of hot water use are dramatic. This would mean that taking national averages would favour a lavish use of hot water, which should not be promoted. Therefore a better solution would be to take as harmonised value the EU average (possibly weighted by the population numbers). One can also consider taking a fraction of that value (say 80%).

9 One could also consider an equivalent to degree-days for the difference between hot water temperature and daily (or weekly) average cold water temperature.

Apart from the data, the proposed method heavily relies on the EU harmonised calculation procedures (algorithms).

2.7 Domestic Hot Water - Heat Pumps

2.7.1 Formula for unitary gross annual energy savings

For this method, the unit used in the formula for the unitary gross annual energy savings is an EEI programme participant (a family living in a given house; public/tertiary building of a specified function; etc.).

The unitary gross annual energy savings are given by the equation (S1), used also in section 3, step 1

$$\Delta E_U^{(HP)} = (D - \Delta E_{SC} - \Delta E_{BM} - \Delta E_{FF}) \bullet \left(1/\eta_{FF} - 1/\eta_{HP}\right) \tag{S1}$$

If the condition we propose in chapter 1.4 is accepted, this will hold only for

$$TEWI_{HP} < TEWI_{FF} \tag{S1.1}$$

The notation used is:

$$D = n \cdot v \cdot \left(T_1 - T_0\right) \cdot \rho \cdot \chi \tag{S1.2}$$

(D is annual heat demand for domestic hot water),

and:

n	number of occupants or users of the building
υ	average annual *per capita* hot water consumption [m^3/cap/year]
T_1, T_0	temperature of hot and cold water, respectively
ρ	density of water ρ = 995,64 kg/m^3, corresponding to 30°C (i.e. average value between 10 and 50 °C)
χ	specific heat of water, χ = 4190 J/kgK
$\Delta E_U^{(HP)}$	annual heat supply provided by an installed heat pump;
ΔE_{SC}	annual heat provided by a solar collector (if installed);
ΔE_{BM}	annual heat provided by a biomass boiler (if installed);
ΔE_{FF}	annual heat derived from fossil fuel boiler (if installed) to meet the heat demand when renewable heat sources are insufficient; it also includes heat purchased from the grid. In the latter case, the coresponding emission factors will have to be used, if e.g. DH is geothermal or biomass;
η_{FF}	efficiency of the erstwhile fossil fuel boiler

η_{HP} efficiency of the heat pump

TEWI Total Equivalent Warming Impact – defined in Appendix I.

$\Delta E_U^{(HP)}$ is determined by technical design taking into account the COP value, maximum heat output (Level 3) and Level 2 parameters, such as temperature of grid water and the standarised hot water temperature (Level 2 or Level 1).

D is determined by the number of occupants (or users of the building/facility) and the standardised (Level 1 or Level 2) annual *per capita* demand for hot water.

In equation S1 ΔE_{SC} and ΔE_{BM} are mentioned explicitly, because it is assumed that their corresponding TEWI are always smaller than that of the HP[10].

If condition S1.1 is accepted but not fulfilled,

$$\Delta E_U^{(HP)} = 0 , \qquad \text{(S1.3)}$$

and heat demand D is met by ΔE_{SC}, ΔE_{BM} and ΔE_{FF}. This also means that if any of the latter has a lower TEWI, the HP energy savings will not not eligible even if the heat pump has been installed.

The TEWI will have to be calculated according to Appendix I for each country (Level 2) separately and for each erstwhile heating source (Level 3). This implies that for each case there will be a minimum COP of the HP system to meet the eligibility criterion. The examples of the minimum (national) COP values for selected cases are given in the Appendix II.

2.7.2 Indicative default value for unitary gross annual energy savings

In the situtation outlined above, setting any EU default values for unitary gross annual energy savings will not be relevant.

2.7.3 Main data to collect

Data needed in calculation for EU values (Level 1)	Corresponding data sources
Data 1 Hot water temperature	EU (or national) standard value, e.g. 55C or 60 C

[10] This may not be the case for Norway with their fraction of hydro electricity. This and similar cases will have to be considered separately.

Data 2 Specific CO_2-equivalent emissions for a given fuel (e.g. natural gas, oil, biomass[11] for determination of TEWI	For example, values used in ETS
Data 3 Harmonised average *per capita* hot water consumption	EU-common value or weighted average of national averages[12]
Data 4 Time intervals for averaging grid (cold) water temperatures	The proposal is: March 21 - September 22 (for "summer" season) and September 23 – March 20 (for "winter" season)[13]

Data to be collected <u>national values</u> (Level 2)	**Corresponding data sources**
Data 1 National emission factors	Official national data
Data 2 Monthly averages of ambient temperature (particularly important for air-to-water HPs)	Simulation based on meteorological files
Data 3 Grid water (cold water) temperature averaged over defined periods of time (e.g.months)	Data exist in many cases. If not, they are very easy to collect
Data 4 Average *per capita* hot water consumption (if Data 3 in Level 1 is not accepted)	See above
Data 5	Average real life COP of different types of heat pumps over the year; average energy efficiency of replaced erstwhile hot water boiler

Data to be collected <u>measure-specific</u> (or participants-specific) (Level 3)	**Corresponding data sources**
Data 1 Number of occupants (or users of building/facility)	EU harmonised questionnaire provided by an EEI programme participant
Data 2 Erstwhile heat source characteristics (including solar fraction for combined HP+SC)	
Data 3 Building characteristics to include in-door hot water distribution system losses	

Apart from the data, the proposed method heavily relies on the EU harmonised calculation procedures (algorithms).

[11] If energy embedded in e.g. pellet production is attributed to fossil fuels

[12] **Note:** as seen in Fig. 2 of the case application 6 on solar water heaters, the differences beetwen the national averages of hot water use are dramatic. This would mean that taking national averages would favour a lavish use of hot water, which should not be promoted. Therefore, a better solution would be to take as harmonised value the EU average (possibly weighted by the population numbers). One can also consider taking a fraction of that value (say 80%).

[13] One could also consider an equivalent to degree-days for the difference between hot water temperature and daily (or weekly) average cold water temperature.

2.8 Non residential space heating improvement in case of heating distribution by a water loop

2.8.1 Unitary gross annual energy savings

General formula and calculation model

Annual energy savings (kWh/year/unit) are determined by using the following engineering estimate.

$$\Delta E = \left(\frac{1}{\eta_{p,st} \cdot \eta_{e,st} \cdot \eta_{d,st}} - \frac{1}{\eta_{p,eff} \cdot \eta_{e,eff} \cdot \eta_{d,eff}} \right) \cdot E \cdot S \qquad \text{[kWh/year]} \qquad (1)$$

- ΔE = Total gross final energy savings from the EEI Action
- E: useful heat demand for the specific tertiary building and climatic zone (kWh/m^2/year): average for level 1 or 2 calculations, building-specific for level 3 calculations
- S: Heated surface area interested by Action (m^2)
- $\eta_{p,eff}$: efficiency of the efficient heat generator
- $\eta_{e,eff}$: efficiency of the efficient emission system
- $\eta_{d,eff}$: efficiency of the efficient distribution system
- $\eta_{p,st}$: efficiency of the standard heat generator
- $\eta_{e,st}$: efficiency of the standard emission system
- $\eta_{d,st}$: efficiency of the standard distribution system
- $\eta_g = \eta_p \cdot \eta_e \cdot \eta_c \cdot \eta_d$: global efficiency of the heating system

The following sections provide numerical estimates for a Level 1 evaluation effort by using data from existing studies or by making reasoned assumptions (where no specific data exists) for the general situation in Europe. Level 2 or 3 is required for all buildings over 1000 m^2 (EPB Directive) and for special types of heat generators (cf. chapter 1.9).

The equation (1) above may be used to achieve Level 2 and Level 3 evaluation efforts in estimating energy savings at the country or the single action level.

Note: for level 1 data, efficient and inefficient equipment performances are estimated by considering EU market and stock averages.

In case a Member State decides to incentive efficiency measures directed to improve the heating system as a whole, the energy savings achieved may be evaluated by estimating the individual efficiency values reported the equation (1) as indicated in the following paragraphs. However, since the improvement of a single system component (e.g. the heat generator) may lead to increase the efficiency of another system component (e.g. the distribution and/or the emission system), a more realistic approach should consider the reciprocal influence of such components, as made in some of the examples described in this report.

The following pages will illustrate how E and the efficiency parameters reported in the formula above may be estimated.

Estimate of E: Thermal demand per unit surface (kWh/m^2/year)

The databases consulted in order to acquire detailed information about the thermal demand in the tertiary sector are the followings:

- **SAVE II** Labelling & other measures for heating systems in dwellings, 1999. Contract no. 4.1031/Z/99-283. This review of standards describes the partner country's national standards which are applied to improve energy efficiency, governing design, installation & maintenance of heating systems in dwellings.
- **Odyssee** database (http://www.odyssee-indicators.org), provides specific data of thermal energy consumption in Europe.
- **Eurostat** "Energy Consumption in the Services Sector" project (data 1995-1999): the purpose of this project was to collect information on energy consumption in the services sector directly through surveys complemented by other studies. Energy statistics have been collected and analysed from the supply side. For this reason, information on energy consumption in the services sector is estimated indirectly, making this approach not precise. Moreover, the disaggregation of the energy consumption in services for the various branches of activity and the knowledge of the consumption in the different uses was rather poor in most Member States. Eurostat data were hence not considered for this study.
- **VHK** Preparatory Study on Eco-Design of Boilers (2007) (http://www.ecoboiler.org), provides specific data of thermal energy consumption in Europe, in the context of the Ecodesign of Energy-Using Products Directive 2005/32/EC. As such study reports data for the tertiary sector, <u>this has been the data source used for most of the estimates made in this study</u>.

The Odyssee database provides thermal energy consumption (toe/m^2/year) for the commercial sector in six countries. The Commercial Sector (*Services*) is defined to include activities like hotel and restaurant, health, education, administration, trade, offices, though no distinction is made between these separate categories.

The Odyssee database provides also thermal energy demand (toe/dwelling) for the residential sector in fifteen countries.

More data are available for the residential sector than for the Commercial sector.

The 1999 SAVE II Study provides a detailed analysis of the heating systems for the residential sector, included average energy demand and efficiency of the existing stock. The study also includes a stock model which considers the possible development of heating systems for 15 countries in the period 2000-2020.

The question is how well do the figures for the residential sector match with those for the tertiary sector.

Building energy demand mainly depends on climate, building energy codes and usage patterns.

In most EU countries similar building codes are applied to both the tertiary and residential sectors so that buildings built in the same period will have similar thermal performance characteristics (for example insulation levels). In some cases buildings in the tertiary sector may have higher unit specific heating consumption (kWh/m^2/year) due to particular geometric features (e.g. height).

However on the other hand the operating hours in the tertiary sector are probably less than the residential sector, because of the limited occupancy time (typical 8 hour shift work, week-end, festivity). We assume that the operating hours in the tertiary sector are in the region of 20% lower than operating hours in the domestic sector.

Therefore, as a very rough approximation, we could say that the two effects (increased specific consumption vs. lower heating hours) cancel each other, and roughly specific heat demand for the two sectors is the same.

Therefore, the two sectors (residential and tertiary), with the exception of specific cases, such as Hospitals, should have similar energy consumption for heating.

However, VHK Study (2006) provided some useful data regarding particularly the tertiary sector. Therefore most of the assumptions made will be based on these data, because of their specific reference to the tertiary sector.

Assessment of the number of tertiary boilers is extremely difficult. For instance, about 8% (0,5 mln.) of "residential" boiler sales may actually be sales to the tertiary sector. The tertiary sector is highly heterogeneous and it is almost impossible to make an assessment at the point-of-sales whether a customer is residential or tertiary. So for sure we can assume that a fraction of the residential sales data may be "contaminated" with tertiary sales, e.g. to small offices, shops, bars, etc.. To make matters worse, many of these smaller enterprises are sharing the heating boiler, not only with each other (e.g. in an office building) but also with residential customers (e.g. shop or bar in the ground floor of an apartment building).

According to VHK Study, we can make a rough estimate that, excluding the boilers shared with the residential sector, the number of installed tertiary boilers in the EU-25 will amount to around 8 million units (included 1 mln. boilers in the industrial sector) with an average capacity of around 100 kW. The accuracy of these figures is believed to be no higher than ±20%.

In conclusion, the situation for residential buildings is still relatively transparent compared to commercial and institutional buildings and buildings that have a mixed use, e.g. residential buildings with bars, restaurants and shops at the ground floor. On these items information is quite scarce.

Another problem is the definition of the sectors. There have been several attempts to capture the floor area in m^2 of the “services sector” or “the other sector” which all have failed for the same reason. Examples are the Odyssee indicators project and the Ecoheatcool project, which are each estimated to make errors of up to a factor of 2.

We have decided to refer to the very first attempt by VHK to calculate an average heat load from the available EU-wide data, with particular reference to the tertiary sector.

EU Tertiary sector Heat Load Assessment (VHK 2006)

VHK/Eurostat 2003	TERTIARY Sector
Country	**Heating load**
	$kWh/m^2/y$
EU-25	**117**

However, we assume this reference value also for buildings not larger than 1,000 m^2. For greater buildings it is necessary to obtain more detailed data (level 3), especially considering that the tertiary sector include a wide variety of building types and sizes (height > 4 m for example).

More weight has been given to the results of the VHK Study, because:

- it is well documented and provides data specific for tertiary sector;
- data provided seem to be more consistent.

It is basically because of these reasons that the value (kWh/m^2/year) reported in the table above has been assumed as the reference value for the energy consumption in the tertiary sector.

However, this value needs to be **modified for each Member State**. This could be done **either by heating degree days or by the values for the annual useful heating energy demand per m^2 from the Ecoboiler study** (p.62 of ecoboiler task 3 final report; useful heating energy demand is termed “heat load” in that source). It needs to be discussed what is the better choice. Heating degree days reflect the climate and would thus reward countries who have already a better insulated building stock. The annual useful heating energy demand per m² will better reflect the actual situation of the building stock. Table 5 and Table 6 are providing more information on the adaptation factors per MS that either choice would entail.

Table 5: factors to adapt the EU level default value for unitary gross annual energy savings to each EU Member State based on heating degree days

Member State	Heating degree days (Kelvin*day/year)	Adaptation Factor
MT	**581**	0.18
CY	**704**	0.22
PT	**1364**	0.43
EL	**1596**	0.50
ES	**1926**	0.60
IT	**2031**	0.63
FR	**2469**	0.77
IE	**2682**	0.84
NL	**2716**	0.85
BE	**2734**	0.85
HU	**2951**	0.92
SK	**2953**	0.92
UK	**3100**	0.97
LU	**3107**	0.97
SI	**3119**	0.97
DE	**3162**	0.99
DK	**3254**	1.01
CZ	**3518**	1.10
PL	**3533**	1.10
AT	**3606**	1.12
LT	**4031**	1.26
LV	**4199**	1.31
EE	**4313**	1.34
SE	**5183**	1.62
FI	**5415**	1.69
EU-25	**3207**	**1**

Basis: data for 2004 and 2005

Table 6: National reference value for the parameter E (VHK 2006)

	Country	**Tertiary Heat demand (E) [kWh/m^2 year]**
MT	Malta	42
CY	Cyprus	51
EL	Greece	55
SI	Slovenia	62
LU	Luxembourg	75
ES	Spain	91
DE	Germany	98
UK	United Kingdom	100
NL	Netherlands	102
PT	Portugal	109
IT	Italy	117
DK	Denmark	127
FR	France	128
PL	Poland	134
SK	Slovakia	139
BE	Belgium	142
AT	Austria	144
HU	Hungary	154
CZ	Czech Republic	155
IE	Ireland	168
LV	Latvia	207
EE	Estonia	235
LT	Lithuania	239
FI	Finland	240
SE	Sweden	289
EU-25	**EU-25**	**117**

2.8.2 Indicative Level 1 default value for annual unitary energy savings

As already noted, single actions can be implemented alone or in combination as part of a comprehensive end-use Action. Here energy savings that may be associated to:

- improvements of heat generators, emitters and control apparatus, and distribution system, when undertaken as stand alone single actions
- integrated improvement actions for the whole heating system are

estimated.

In the Table 7 below and in the tables reported in the paragraphs from 1.6.1 to 1.6.3, the reference values to be used for the level 1 evaluation effort in case of some typical EEI actions are indicated. In paragraphs 3.2, 3.2.3, 3.3 and 3.4 it is explained how these values have been estimated.
Each of the following examples has been calculated both with the stock baselines for all energy savings, and with the market inefficient baselines for additional energy savings.
Level 2 or 3 is required for all buildings over 1000 m^2 (EPB Directive).

Table 7: Level 1 default efficiency values for the heating systems

System	Stock Baseline (%)	Market inefficient Baseline (%)	Minimum efficiency for efficient solutions (%)
Heat generation	82,0	89,0	94,0
Emission	78,0	83,0	93,0
Distribution	93,0	-	97,0

2.8.2.1 Efficient Heat generators: Installation of condensing boilers

This example concerns Level 1 estimated energy savings generated by replacing standard boilers with condensing boilers. The rest of the heating system remains unchanged.

According to the general rules proposed by the EMEEES project, a safety factor of 0.8 is always applied, even in case of reliable EU average values calculated from literature and statistical data, to take possible uncertainties into account. This holds for all level 1 data on unitary gross annual energy savings given hereunder.

Table 8: Level 1 default values for annual unitary energy savings provided by substituting a standard boiler with an efficient one (condensing boiler)

	Variables in relation to Equation (1)	Level 1 Data	
Baseline			
Average efficiency of the standard boiler – **stock baseline**:	$\eta_{p,st}$	**82,0**	%
Average efficiency of the standard boiler – **market inefficient baseline:**	$\eta_{p,st}$	**89,0**	%
Average efficiency of the standard emitter and controls system:	$\eta_{p,st}$		

- with stock baseline boiler - with market inefficient baseline boiler		78,0 84,0	% %
Average efficiency of the standard distribution system:	$\eta_{p,st}$	93,0	%
Efficient Models			
Average efficiency of the **efficient** condensing boiler	$\eta_{p,eff}$	**94,0**	%
Average efficiency of the standard emitter system:	$\eta_{p,st}$	**84,0**	%
Average efficiency of the standard distribution system:	$\eta_{p,st}$	**94,1**	%
Thermal demand	E	117*	kWh/m²/y
Heated surface	S	1	m²
Annual unitary energy savings ΔE condensing boiler vs. stock baseline condensing boiler vs. market inefficient baseline	equation (1)	**39,2*** **12,8***	**kWh/m²/year**
Safety factor	-	0,8	
Energy Savings: condensing boiler vs. stock baseline condensing boiler vs. market inefficient baseline	**ΔE (all)** **ΔE (additional)**	**31,4*** **10,3***	**kWh/m²/year**

* value **must be corrected with national correction factor** as given in Table 5 or Table 6. Stock baselines used for calculating all energy savings. Market inefficient baselines for calculating additional energy savings.
Note: the other efficiency values considered are indicated in Table 7.

As it can be noted, the efficiency values of emission and distribution systems improve because of the operating temperature reduction. Actually, the installation of a condensing boiler is likely to cause a slightly greater improvement in the efficiency of emission and distribution systems with respect to a non-condensing boiler, but this difference has been neglected to simplify.

2.8.2.2 Emitters:

Level 1 estimated energy savings generated by replacing conventional emitters with efficient emitters.

To be realistic, it has been assumed that the generator efficiency is improved in conjunction with emitters replacement. In fact, simple emitters replacement may be quite unlikely because achievable energy savings are not as high as those obtainable with a more integrated approach (i.e. heat generator+emitters improvement). As a side effect, this solution may lead to a distribution system efficiency improvement, because of a general reduction in supply/return temperature. This effect may be evaluated at a level of effort 2 or 3 , but it has been considered in the estimate below as well.

Table 9: Level 1 default values for annual unitary energy savings related to the use of efficient emitters in the place of the conventional ones

	Variables in relation to Equation (1)	**Level 1 Data**	
Baseline			
Average efficiency of the standard boiler – **stock baseline**:	$\eta_{p,st}$	82,0	%
Average efficiency of the standard boiler – **market inefficient baseline:**	$\eta_{p,st}$	**89,0**	%
Average efficiency of the standard emitter system:	$\eta_{p,st}$	**78,0**	%
Average efficiency of the standard distribution system:	$\eta_{p,st}$	93,0	%
Efficient Systems			
Average efficiency of the **efficient** boiler:	$\eta_{p,eff}$	**94,0**	%
Average efficiency of the **efficient** emitter system:	$\eta_{p,st}$	**93,0**	%
Average efficiency of the standard distribution system:	$\eta_{p,st}$	94,1	%
Thermal demand	E	117*	kWh/m²/y
Heated surface	S	1	m²
ΔE vs. stock baseline vs. market inefficient baseline	equation (1)	**54,5*** **28,1***	**kWh/m²/year**
Safety factor	-	0,8	
Energy Savings: vs. stock baseline vs. market inefficient baseline	ΔE (all) ΔE (additional)	**43,4*** **22,5***	**kWh/m²/year**

* value **must be corrected with national correction factor** as given in Table 5. or Table 6. Stock baselines used for calculating all energy savings. Market inefficient baselines for calculating additional energy savings.

Just to have an idea of the reciprocal interaction between generator and emitter efficiency, it might be worth noticing that in case of condensing boilers the heat generator efficiency improves by 2÷2,5% for a 10°C decrease in the return temperature. For example, emitter systems with an operating temperature of 35°C (radiant panels) instead of 85°C (radiators) would improve the generator efficiency by 10-12,5%.

It is hence recommended to carry on a Level 3 evaluation effort to better estimate the savings obtainable with the combined installation of condensing boilers and radiant panels. This more accurate and specific evaluation can be carried out by considering the prEN Standards listed in the Appendix I of this paper.

2.8.2.3 Distribution systems:

Level 1 estimated energy savings generated by replacing conventional distribution systems with efficient distribution systems. Again, it is assumed that the boiler will also be replaced by a condensing boiler.

Table 10: Level 1 default values for determining annual energy savings provided by using efficient distribution systems.

	Variables in relation to Equation (1)	**Level 1 Data**	
Baseline			
Average efficiency of the standard boiler – **stock baseline**:	$\eta_{p,st}$	82,0	%
Average efficiency of the standard boiler – **market inefficient baseline:**	$\eta_{p,st}$	**89,0**	%
Average efficiency of the standard emitter system:	$\eta_{p,st}$	78,0	%
Average efficiency of the standard distribution system:	$\eta_{p,st}$	**93,0**	%
Efficient Systems			
Average efficiency of the **efficient** boiler:	$\eta_{p,eff}$	94,0	%
Average efficiency of the standard emitter system:	$\eta_{p,st}$	84,0	%

Average efficiency of the **efficient** distribution system:	$\eta_{p,st}$	**97,0**	%
Thermal demand	E	117*	kWh/m²/y
Heated surface	S	1	m²
ΔE vs. stock baseline vs. market inefficient baseline	equation (1)	**43,9*** **17,5***	**kWh/m²/year**
Safety factor	-	0,8	
Energy Savings: vs. stock baseline vs. market inefficient baseline	**ΔE (all)** **ΔE (additional)**	**35,2*** **14,0***	**kWh/m²/year**

***** value **must be corrected with national correction factor** as given in Table 5 or Table 6. Stock baselines used for calculating all energy savings, market inefficient baselines for calculating additional energy savings.

Energy efficient distribution system installation has been assumed to happen in conjunction with the installation of an efficient heat generator and control system in the example addressed in table above.

2.8.3 Main data to collect

Level 1 : average tertiary building heated area addressed by the (EEI) facilitating measure being evaluated plus number of end-use (EEI) actions implemented (i.e. number of buildings addressed by the facilitating measure).

Level 2 : average tertiary sector heated area addressed by the facilitating measure possibly corrected for climatic effects, plus national estimates of efficiency factors used in equation 1 and number of end-use actions totally implemented.

For level 2, data to collect should take interactions with thermal insulation actions into account in case the facilitating measure being evaluated includes these kind of actions.

Level 3 : area heated in each tertiary building addressed by the facilitating measure plus end-use action specific efficiency factors to be used in equation 1. Other end-use actions besides the heating action possibly implemented should be taken into account in order to estimate possible interaction effects (e.g. insulation of the same building which decreases the heating demand; distribution network improvements that increase the total gain).

For all the three levels: data on double-counting between facilitating measures, free-riders, rebound effect and multiplier effects should be collected in order to estimate "all" and additional energy savings

Concerning the counting of the number of end-use actions implemented, financial incentive schemes, eg., under White certificates, plans for renovation of building stock, application of article 6 of EPBD, etc. give all the necessary data. They just need to be monitored.

Level 2 and Level 3 evaluation efforts

In the present methodology energy savings are determined through engineering calculations which take account of

- the type and power of installed heat generator
- the type of installed emitters
- the control apparatus type
- the distribution system type

The Level 1 default values reported in Tables 8 to 10 were determined by considering conservative estimates for all the above typologies both in relation to the stock and the market average values used.

It has proven possible to define per unit Level 1 values for the following end-use actions

- replacement of standard heat generators with efficient generators
- replacement of standard emitters with efficient emitters
- improvement of distribution system

Estimate of energy savings achievable by the following end-use actions requires instead Level 3 data:

- use of air-source heat pumps (prEN 15316-4-2)
- use of CHP systems (prEN 15316-4-4)
- use of district heating (prEN 15316-4-5)
- use of biomass combustion systems (prEN 15316-4-7), cf. EMEEES case application 3
- use of thermal solar systems (prEN 15316-4-3)), cf. EMEEES case application 6.

Level 2 or 3 is required for all buildings over 1000 m^2 (EPB Directive)

Concerning heat pumps, it is necessary to achieve a level 2 or 3 evaluation effort to obtain more reliable estimations, level 3 especially for air-source heat pumps, whose performances highly depend on local climatic conditions.

The same calculation procedure used for the Level 1 evaluation effort and based on the Equation (1) in Chapter 3.1 may be used in principle to determine Country- (Level 2) or Measure- Specific (Level 3) energy savings.

This requires collecting more detailed data for the three action typologies above mentioned.

Potential data sources for the Level 2 and Level 3 evaluation efforts may be :

- End-use Metering campaigns
- Detailed building audits (which may or may not include energy metering)
- Existing studies and databases: Odyssee Database, Previous European (e.g. SAVE II 1999, Eurostat, VHK Study) and MS Studies (EEC in UK, White Certificates in France and Italy), case studies (e.g. GreenBuilding)
- Manufacturer and product catalogues

2.9 Improvement of lighting systems (tertiary sector)

2.9.1 Formula for unitary gross annual energy savings

Annual energy savings (kWh/year/participant) are determined using the following engineering calculation.

$$\Delta E = H \cdot \left[F_{O,st} \cdot F_{D,st} \cdot \sum_{i=1}^{Nst} \left(N_{l,st} \cdot P_{l,st} + N_{b,st} \cdot P_{b,st} \right)_i - F_{O,ef} \cdot F_{D,ef} \cdot \sum_{i=1}^{Nef} \left(N_{l,ef} \cdot P_{l,ef} + N_{b,ef} \cdot P_{b,ef} \right)_i \right]$$

(equation 1)

- ΔE = Total gross annual energy savings from end-use action per participant
- H : number of operating hours [hours/year]
- N_{st} : number of standard luminaires [n.]
- F_O = occupancy dependency factor; factor relating the usage of the total installed lighting power to occupancy period in the room or zone; $0 \leq F_O \leq 1$
- F_D = daylight dependency factor; factor relating the usage of the total installed lighting power to daylight availability in the room or zone; $0 \leq F_D \leq 1$
- N_{ef} : number of efficient luminaires [n.]
- $N_{l,st}$: Number of standard lamps per luminaire [n.]
- $N_{l,ef}$: Number of efficient lamps per luminaire [n.]
- $N_{b,st}$: Number of standard ballasts per luminaire [n.]
- $N_{b,ef}$: Number of efficient ballasts per luminaire [n.]
- $P_{l,st}$: electrical power (effective, not simply nominal) absorbed by the standard lamps [W]
- $P_{l,ef}$: electrical power (effective, not simply nominal) absorbed by the efficient lamps [W]
- $P_{b,st}$: electrical power absorbed by the standard ballasts [W]
- $P_{b,ef}$: electrical power absorbed by the efficient ballasts [W]

Instead of addressing lamps and ballasts separately as in equation 1, it is also possible to address lamp-ballast systems, as done in chapter 3.2.4.

The following sections present Level 1 estimates of energy savings by using data from existing studies or by making reasoned guesses (where no specific data exists) for the overall situation in European countries.

The same formula can be used to develop more precise Level 2 and Level 3 Country and Action specific estimates of energy savings. While developing Level 2 and Level 3 estimates, special attention must however be given to the hours of use of the standard and efficient lighting system (variable H in equation

2).

As equation (1) makes explicit, a reduction in the hours of use can only be achieved by the introduction of improved specific control apparatus whose effects reflect in the values of the parameters F_{Oef} and F_{Def} of this equation . Energy audits or end use measurement campaigns might reveal a change in the number of hours of use in correspondence with the introduction of the end-use action. However a change in the number of operating hours can be caused by a change in use of the indoor spaces subject to monitoring and not reflect any inherent increase in energy efficiency of the lighting plant. Therefore any reductions in operating derived from audits or metering must nevertheless be explicitly shown to be due to improved control apparatus

Equation (1) allows energy savings derived from nearly all possible improvements to lighting systems to be evaluated.

The formula reported above has been proposed in order to cover all the possible cases involving lighting systems, as defined in section 1.3 of the case application report. In fact:

- improvements of lamps are considered by the parameters N_l and P_l
- improvements of ballasts are considered by the parameters N_b and P_b
- improvements of luminaires imply possible changes in the parameter N_{ef} with respect to N_{st} (delamping)
- improvements of control strategies reflect in the values of the parameters F_{Oef} and F_{Def} (see section 3.4.1).

2.9.2 Indicative Level 1 default value for annual unitary energy savings

As already noted, end-use (EEI) actions can be undertaken singularly or together as part as a combined comprehensive end-use action. Here we report the energy savings in respect of

- improvements to lamps, ballasts and control apparatus when undertaken as stand alone single actions
- combined improvements to the lamp – ballast system

Other combined actions need to be evaluated using the generalised formula as expressed in Equation (1).

2.9.2.1 Lamp: Introduction of CFLs

Level 1 estimated energy savings generated by replacing incandescent lamps with Compact Fluorescent Lamps, either with integrated or external ballast. According to general rules proposed by the EMEEES project, a safety factor of 0.8 is applied even on reliable EU average values calculated from literature and statistical data, to consider remaining uncertainties. This holds for all level 1 data on unitary gross annual energy savings given here.

Table 11: Level 1 default values for annual unitary energy savings provided by substituting an incandescent lamp with a CFL

	Variables in relation to Equation (1)	Level 1 Data	
Stock Baseline: Average power absorbed by the standard incandescent lamp:	$(N_{l,st}P_{l,st} + N_{b,st}P_{b,st})$	65,7	W
Market Efficient Technology: Average Power absorbed by the efficient (CFL) lamp:	$(N_{l,eff}P_{l,eff}+ N_{b,eff}P_{b,eff})$	14,8	W
Difference of absorbed power:		50,9	W
Baseline Use: Hours	H	2500	h
Energy Savings:	Δ**E**	0.8 * 127 = **102**	**kWh/year/CFL**

2.9.2.2 Ballast: Introduction of electronic ballasts

Level 1 estimated energy savings generated by replacing electromagnetic with electronic dimmable or non dimmable ballasts.

Table 12: Level 1 default values for annual unitary energy savings related to the use of efficient lighting systems (electronic ballast-lamp) in the place of the conventional ones (electromagnetic ballast-lamp)

	Variables in relation to Equation (1)	Level 1 Data	
Stock Baseline: Average power absorbed by the existing (stock) ballast/lamp/luminaire system:	$(N_{l,st}P_{l,st} + N_{b,st}P_{b,st})$	95	W
Market Inefficient Baseline: Average power absorbed by the new, not efficient ballast/lamp/luminaire system:	$(N_{l,st}P_{l,st} + N_{b,st}P_{b,st})$	90	W
Market Efficient Technology: Average Power absorbed by the new, efficient ballast/lamp/luminaire system:	$(N_{l,eff}P_{l,eff}+ N_{b,eff}P_{b,eff})$	80	W
Difference of absorbed power vs. stock:		15	W
Difference of absorbed power vs. new not efficient		10	W
Baseline Use: Hours	H	2500	h / year
Average number of luminaires affected per	N_{st}, N_{eff}	0.6	

ballast			
Energy Savings vs. stock:	**ΔE**	0.8 * 22.5 = **18**	**kWh/year/ ballast**
Energy Savings vs. new not **efficient:**	**ΔE**	0.8 * 15 =**12**	**kWh/year/ ballast**

2.9.2.3 Luminaire: Using more efficient luminaires using electronic ballasts instead of standard (non-efficient) luminaires

Replacement of non-efficient luminaires using T8 magnetic ballasts with efficient luminaires using T8 electronic ballasts is considered here. Therefore, energy savings to be estimated are supposed to be due both to the higher energy performances of energy efficient luminaires installed (resulting in a lower number of luminaries to be installed and taken into account in equation 1 by the value of N_{eff} to be considered) and the higher performances of the T8 systems with electronic ballasts. End-use actions addressing luminaries and not relating also to the above mentioned replacement of an inefficient T8 system should not be evaluated by using the default values reported in Table 13.

Table 13: Level 1 default values for determining unitary annual energy savings provided by substituting standard luminaires with higher efficiency alternative using electronic ballasts

	In relation to Equation (1)	Example data	
Market not efficient Baseline: Power absorbed by the standard systems	$(N_{l,st}P_{l,st} + N_{b,st}P_{b,st})$	90	W
Market Efficient Technology: Power absorbed by the efficient systems	$(N_{l,edd}P_{l,eff} + N_{b,eff}P_{b,eff})$	80	W
Number of standard luminaires removed. **Level 2 or Level 3 data required.**	N_{st}		
Number of efficient luminaires introduced. **Level 2 or Level 3 data required.**	N_{eff}		
Hours of Use	H	**2500**	h/year

As the energy savings are highly dependent on the case-specific situation, no EU default value for the unitary annual energy savings can be defined. Instead, it is recommended to calculate them at level 3 evaluation effort by using equation 1 and the values in Table 13.

2.9.2.4 Luminaire: Using luminaires with T5 lamps instead of standard (non-efficient) luminaires with T8 lamps

Table 14: Level 1 default values for determining unitary annual energy savings provided by substituting standard luminaires with T5 systems

	In relation to Equation (1)	Example data	
Market not efficient Baseline: Power absorbed by the standard systems	$(N_{l,st}P_{l,st} + N_{b,st}P_{b,st})$	90	W
Market Efficient Value: Power absorbed by the efficient systems	$(N_{l,edd}P_{l,eff} + N_{b,eff}P_{b,eff})$	80	W
Number of standard luminaires removed. **Level 2 or Level 3 data required.**	N_{st}		
Number of efficient luminaires introduced. **Level 2 or Level 3 data required.**	N_{eff}		
Hours of Use	H	**2500**	h/year

Again, no EU default value for the unitary annual energy savings can be defined. Instead, it is recommended to calculate them at the level 3 evaluation effort by using equation 1 and the values in Table 14.

2.9.2.5 Control apparatus: Occupancy Sensors

Table 15: Level 1 default values for unitary annual energy savings provided by introducing Occupancy Sensors

	In relation to Equation (1)	Example data	
Market Efficient Value (applied in order to be conservative): Power absorbed by the post action system	$(N_{l,edd}P_{l,eff} + N_{b,eff}P_{b,eff})$	80	W
Average number of luminaires affected per sensor	$N_{eff} = N_{st}$	2 x number of sensors sold or distributed in context of action	
Control Factor Stock	$F_{O,st}$	1	

Control Factor post Action (already very conservative)	$F_{O,eff}$	0.8	
Hours of Use	H = H	2500	H
Annual energy savings offered per sensor		**40**	**kWh/Year/Occupancy Sensor**

2.9.3 Main data to collect

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 luminaire	Default values given in this report
Operating hours	Default values given in this report
Number of luminaires installed or replaced	Level 3 (participant-specific) or maybe Level 2 input

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 particiants 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

2.10 Improvement of central air conditioning (tertiary sector)

2.10.1 Formula for unitary gross annual energy savings

For this method, the unit used in the formula for the unitary gross annual energy savings is the square meter of non residential building being cooled, and the deemed energy savings estimates are expressed in kWh/year/m^2. They are called here ΔSEC.

The equation (S1) used in section 3, step 1 is:

Gross annual energy savings for one building =
area of building to which the action is applied * ΔSEC.

unitary gross annual energy savings = ΔSEC given in the following table

(equation S1)

2.10.2 Indicative default value for unitary gross annual energy savings

The following values are suggested as default values. Values are in kWh/year/m^2. They have been obtained by simulation with the DOE 2 software. The limitation of the universe of simulations (three climates, with a building adapted to local regulations) is the weakness of the method. However, this is only a default value. The default value of unitary savings per square meter ΔSEC is given in Table 16 for moving cold generating equipment to Eurovent-class A, or for introducing free cooling in an air distribution system. Reversible (i.e. Winter) behaviour of the system is not included. It could both decrease or increase net energy savings, depending on the choices made by the MS (cf. chapter 3.4.2 on the rebound effect). It is recommended to analyse this for level 2 and 3 calculations.

Table 16: default values of unitary gross annual energy savings

Country	(1) ΔSEC for moving unknown cold generating equipment to Eurovent- A	(2) ΔSEC for moving a chiller to Eurovent-class A	(3) ΔSEC for moving a large package or split to Eurovent-class A	(4) ΔSEC for moving small split equipment to Eurovent-class A	(5) ΔSEC for introducing free cooling in an air distribution system[14]
Aus	1,1	1,1	1,4	2,3	17,3
Bel	0,9	0,9	1,0	1,8	12,4
Den	0,6	0,6	0,7	1,3	9,0
Fin	0,6	0,6	0,8	1,4	11,0
Fra	1,4	1,4	1,7	2,9	10,6
Ger	1,0	1,0	1,2	2,0	14,2
Gre	2,2	2,2	2,5	4,2	7,0
Ire	0,9	0,9	1,0	1,8	11,8
Ita	2,2	2,2	2,6	4,4	7,2
Lux	0,9	0,9	1,0	1,7	12,9
Neth	0,8	0,8	1,0	1,6	11,9
Por	2,2	2,2	2,6	4,4	6,6
Spa	3,6	3,6	4,2	7,2	4,9
Swe	0,6	0,6	0,8	1,4	11,0
UK	0,9	0,9	1,0	1,8	11,8
Other	1,1	1,1	1,4	2,3	17,3

The ΔSEC value is based on the simulations described in the report "Energy Efficiency and Certification of Central Air Conditioners (EECCAC) for the Directorate General Transportation-Energy of the Commission of the European Union, May 2003 ".

After introduction of an EcoDesign requirement for central air conditioners under the EuP Directive, there may be the need to split the above default values into two values: one presenting the energy savings from the EcoDesign requirement compared to the original baseline, and one for the energy savings from best available technology compared to the EcoDesign requirement. However the system in consideration here is very late in the EcoDesign agenda and this is likely to remain a theoretical question.

2.10.3 Main data to collect

Data needed in calculation for EU values (level 1)	Corresponding data sources
Data 1 Area with introduction free cooling in an air distribution system	Field indication for instance in a White Certificate system, in a subsidy scheme, in an energy audit scheme with a follow up
Data 2 Area with upgrade of a chiller to Eurovent-class A	Field indication for instance in a White Certificate system, in a subsidy scheme, in an energy audit scheme with a follow up

[14] Based on last column of table 2 and default % gains of table 4 of detailed document

Data 3 Area with upgrade of a large package or split to Eurovent-class A	Field indication for instance in a White Certificate system, in a subsidy scheme, in an energy audit scheme with a follow up
Data 4 Area with upgrade of a small split equipment to Eurovent-class A	Field indication for instance in a White Certificate system, in a subsidy scheme, in an energy audit scheme with a follow up
Data 5 Area with upgrade of an unknown cold generating equipment to Eurovent-A	Field indication for instance in a White Certificate system, in a subsidy scheme, in an energy audit scheme with a follow up

Data to be collected national or participant values (level 2 or 3)	**Corresponding data sources**
Data 0 same data as for level 1	See above
Data 1 Special climates (deviating a lot from national average)	Simulation on meteorological files
Data 2 Comfort levels	Simulation on meteorological files and building data
Data 3 Special occupancy hours	Simulation on meteorological files and building data

2.11 Office equipment

2.11.1 Formula for unitary gross annual energy savings

For this method, the formula for the unitary gross annual energy savings is **defined by type of office appliance** and not for the office equipment as a whole, since the energy savings potentials are different for each type. For the same reason, it makes sense to distinguish between **active and standby mode** in the case of ICT end-use devices. If an (EEI) facilitating measure is both directed at improving energy efficiency of office equipment in active mode and standby mode, these **savings have to be added**.

The resulting formula for the active mode is:

Unitary gross annual energy savings = $(P_{j\ active\ BL} - P_{j\ active\ BAT}) * h_{j\ active}$

(equation S1a)

The resulting formula for the standby mode is:

Unitary gross annual energy savings = $(P_{j\ standby\ BL} - P_{j\ standby\ BAT}) * h_{j\ standby}$

(equation S1b)

Where:

P - Electrical power input in Watt per appliance

j - Type of office equipment:

- PC (desktop, laptop, PDA)
- Computer monitor
- Printer
- Copier
- Scanner
- MFD
- Modems
- Phones
- Fax
- Servers
- Networks (wired/wireless)

active active mode

standby standby mode

BL baseline, defined as "market average of appliances excluding BAT"
Note: if minimum energy efficiency standards under the EuP Directive are set for an appliance, the initial level of the baseline for bottom-up calculations using this method will change taking into account the standard set under the EuP. Energy savings from the EuP standards will have to be calculated separately, using the difference between the original baseline and the EuP standard, or a top-down method.

BAT best available technology

h annual number of working hours (time of use);
in case of ICT infrastructure, the number of working hours will normally amount to 24 h per day.

2.11.2 Indicative default value for unitary gross annual energy savings

The following values are suggested as a default value:

Unitary annual energy savings: **EU default values**	
EU default	Default values are necessary for (a) Power input per equipment type in active and standby mode (b) Annual working hours in active and standby mode or directly the (c) Unit consumption per equipment type in active and standby mode (a value which both includes power input and annual working hours) At the moment, it is recommended to take over the values which are proposed in the EuP Preparatory Studies on "Personal Computers and Computer Monitors" (Lot 3) and on "Imaging Equipment" (Lot 4) and for the standby mode also the study on "Standby and off-mode losses of EuPs" (Lot 6) as EU default values. Cf. Table 18 for some examples.

The values which are proposed in the EuP Preparatory Studies take into account most of the relevant data source both at the European and the national level and therefore represent a reliable basis for the calculation of default values at level 1. Besides, the values have been discussed with the relevant stakeholders, which further strengthen their reliability. Table 17 shows the respective default values of the baseline and the best available technologies for computers and monitors in offices from Lot 3 (for active mode) and Lot 6 (for standby and off-mode) as an example. For the time of use and the power consumption in active mode, the data from the EuP studies on computers (Lot 3) are recommended as default values and for standby and off-mode the data from the EuP study on standby (Lot 6). In addition to standby, a soft off-mode is distinguished which draws energy. In order to simplify the default values with regard to the ESD directive, the standby and off mode could be summed up (see last column in Table 17).

Table 17: Example for European default values (level 1): base data for the calculation of unitary savings for computers and monitors in offices

Type of office equipment	**Active mode**	**Standby mode**	**Off mode**	**Standby incl. off mode**
	Time of use: all cases (hours/year)			
Desktop PC	2279	3196	3285	6481
Laptop PC	2613	2995	3153	6148
Monitor	2586	3798	2375	6173
	Power consumption baseline =market average (Watt)			
Desktop PC	78.2	4.0	2.7	3.3
Laptop PC	32	3.0	1.5	2.2
Monitor CRT	69.5	6.3	1.5	4.5
Monitor LCD	31.4	2.3	1.35	1.9
	Unit consumption per appliance baseline = market average (kWh/year)			
Desktop PC	178.2	12.8	8.9	21.7

Laptop PC	83.6	9.0	4.7	13.7
Monitor CRT	179.7	23.9	3.6	27.5
Monitor LCD	81.2	8.7	3.2	11.9
	Power consumption BAT (Watt)			
Desktop PC	23	2.2	0.8	1.6
Laptop PC	6.8	0.5	0.38	0.5
Monitor CRT	51.7	0.6	0.2	0.5
Monitor LCD	17.1	0.4	0.3	0.4
	Unit consumption per appliance BAT (kWh/year)			
Desktop PC	52.4	7.0	2.6	9.7
Laptop PC	17.8	1.5	1.2	2.7
Monitor CRT	133.7	2.3	0.5	2.8
Monitor LCD	44.2	1.5	0.7	2.2

Source: EuP Preparatory Studies, Lot 3, August 2007 (time of use and power consumption in active mode) and Lot 6, October 2007 (power consumption standby and off mode).

Table 18 shows the corresponding unitary gross annual energy savings for computers and monitors which are calculated based on the default values in Table 18 using equations S1a and S1b. According to the general rules proposed by the EMEEES project, a safety factor of 0.8 is applied even on annual saving calculations which are based on reliable EU average values.

Table 18: Level 1 default values for unitary gross annual energy savings for computers and monitors in offices

Type of office equipment	Active mode	Standby mode	Off mode	Standby incl. off mode
	Calculated unitary savings BL 1 / BAT (kWh/appliance/year)[1)]			
Desktop PC	125.8	5.8	6.2	11.1
Laptop PC	65.8	7.5	3.5	10.9
Monitor CRT	46.0	21.6	3.1	24.3
Monitor LCD	37.0	7.2	2.5	9.7
	Proposed EU level (Level 1) Default values: Unitary savings with safety factor of 0.8 (kWh/appliance/year)			
Desktop PC	**100.6**	**4.6**	**5.0**	**8.8**
Laptop PC	**52.7**	**6.0**	**2.8**	**8.7**
Monitor CRT	**36.8**	**17.3**	**2.5**	**19.4**
Monitor LCD	**29.6**	**5.8**	**2.0**	**7.8**

1) Calculation based on the level 1 data given in Table 17 and using equations S1a and S1b (original calculation without safety factor of 0.8)

2.11.3 Main data to collect

Data needed in calculation for EU values (level 1)	Corresponding data sources
Electrical power input of ICT end-use devices (active mode, standby mode)	EuP Preparatory Studies on PCs and monitors (www.ecocomputer.org), imaging equipment (www.ecoimaging.org) and standby (www.ecostandby.org)
Annual number of working hours (EU	

average)	
Electrical power input of ICT infrastructure (mainly servers)	EU-IEE project on energy efficient servers (www.efficient-servers.eu); studies for U.S. (Koomey 2007) and Germany (Fichter 2007).

Data to be collected national values (level 2)	**Corresponding data sources**
Electrical power input (only if available, should be similar to level 1 values in case of office equipment) Annual number of working hours (national value)	National statistics or national surveys; data from EU projects including national surveys (especially the El Tertiary project; www.eu.fhg.de/el-tertiary/)
Stock volume in offices	National statistics or national studies

Data to be collected measure-specific (or participants-specific) (level 3)	**Corresponding data sources**
Electrical power input	Data from measurements
Number of BAT appliances sold under the specific EEI measure	Ex-post data from market survey

2.12 Energy-efficient motors

2.12.1 Formula for unitary gross annual energy savings

Average savings by power level and end-use **(if data not directly available)**:

$$\text{unitary gross annual energy savings} = \left(\frac{1}{\eta_{standard}} - \frac{1}{\eta_{efficient}}\right) * P_N * h * LF$$

(Equation S1a)

Where:

$\eta_{standard}$ - Efficiency of the standard motor;

$\eta_{efficient}$ - Efficiency of the energy efficient motor;

P_N - Mechanical power of the motor;

h - Number of operating hours;

LF - Load Factor.

Average savings by power range and end-use **(if data is directly available - level 3)**:

$$\text{unitary gross annual energy savings} = \sum_i \left(\left(P_S^i - P_{EEM}^i\right) * h^i\right)$$

(Equation S1b)

Where:

P_S^i – Electrical Power, with standard motor (IE 1)[3].

P_{EEM}^i – Electrical Power, with EEM

h^i – Number of working hours for each power level

i – Load profile index (Number of hours for each load range).

Level 3 should only be applied voluntarily. The energy savings by replacing an installed induction motor with an energy efficient motor are guaranteed for motors running above 20% of their rated power [1].

2.12.2 Indicative default value for unitary gross annual energy savings

EU default/harmonised values	
Unitary annual energy savings Default/harmonised	Default values for (a) Annual operating hours, (b) Load factors, and (c) efficiency of motors are included in this document (Table 19 and *Table 20*).

*Table 19 – Motor Efficiency values and relative energy savings per power level [3]**.*

PN(kW)	Efficiency				
	Standard	High Efficiency	Premium Efficiency	$\eta_h = \left(\frac{1}{\eta_{standard}} - \frac{1}{\eta high} \right)$	$\eta_p = \left(\frac{1}{\eta_{standard}} - \frac{1}{\eta_{premium}} \right)$
	(IE1)	(IE2)	(IE3)	standard to high efficiency	standard to premium efficiency
0,75	72,1	81,1	84	15%	20%
1,1	75	82,7	85,3	12%	16%
1,5	77,2	83,9	86,3	10%	14%
2,2	79,7	85,3	87,5	8%	11%
3	81,5	86,3	88,4	7%	10%
4	83,1	87,3	89,2	6%	8%
5,5	84,7	88,2	90	5%	7%
7,5	86	89,1	90,8	4%	6%
11	87,6	90,1	91,7	3%	5%
15	88,7	90,9	92,3	3%	4%
18,5	89,3	91,4	92,7	3%	4%
22	89,9	91,7	93,1	2%	4%
30	90,7	92,4	93,6	2%	3%
37	91,2	92,8	94	2%	3%
45	91,7	93,1	94,3	2%	3%
55	92,1	93,5	94,5	2%	3%
75	92,7	94	95	1%	3%
90	93	94,2	95,2	1%	2%
110	93,3	94,5	95,4	1%	2%
132	93,5	94,7	95,6	1%	2%
160	93,8	94,9	95,8	1%	2%
200 up to 370	94	95,1	96	1%	2%

****When replacing an old motor by an EEM, it is important to know how many times the old motor has been rewound. Based on several studies repair/rewinding inevitably decreases motor efficiency by 1-5% when a motor is rewound, even more with repeated rewinds. [14, 15].**

Table 20 – Estimated values from previous studies [4].

Power ranges	Type of Applications	Industry			Tertiary		
		Hours (h)	Load factor	LFH (Load Factor*Hours)	Hours (h)	Load factor	LFH(Load Factor*Hours)
[0,75;4[	Pumps	3.861,03	0,55	2.123,57	3.800,00	0,55	2.090,00
[4;10[							1.830,00

		4.501,94	0,58	2.611,13	3.050,00	0,60	
[10;22[		5.040,47	0,59	2.973,88	3.000,00	0,60	1.800,00
[0,75;4[	Fans	4.910,47	0,53	2.602,55	2.250,00	0,60	1.350,00
[4;10[		4.137,76	0,56	2.317,15	2.500,00	0,65	1.625,00
[10;22[		5.210,64	0,59	3.074,28	2.500,00	0,65	1.625,00
[0,75;4[	Air Compressor	2.177,99	0,63	1.372,13	1.030,00	0,40	412,00
[4;10[		4.057,72	0,60	2.434,63	1.000,00	0,45	450,00
[10;22[		4.625,99	0,68	3.145,67	980,00	0,45	441,00
[0,75;4[	Conveyors	3.060,75	0,42	1.285,52	621,00	0,61	378,81
[4;10[		2.787,90	0,41	1.143,04	916,00	0,53	485,48
[10;22[		3.908,61	0,51	1.993,39	725,00	0,49	355,25
[0,75;4[	Cooling Compressors	5.051,90	0,60	3.031,14			-
[4;10[		1.890,63	0,65	1.228,91			-
[10;22[		5.066,59	0,70	3.546,61			-
[0,75;4[	Refrigeration				4.200,00	0,70	2.940,00
[4;10[					4.170,00	0,70	2.919,00
[10;22[					4.050,00	0,75	3.037,50
[0,75;4[	Others	3.086,64	0,34	1.049,46	500,00	0,30	150,00
[4;10[		2.859,49	0,39	1.115,20	530,00	0,30	159,00
[10;22[		2.299,44	0,45	1.034,75	570,00	0,30	171,00

2.12.3 Main data to collect

Data needed in calculation for EU values (level 1)	**Examples of corresponding data sources**
Mechanical power	Nameplate data and information from participants
Efficiency of the motors*	
Type of application (pump, fan, compressor, conveyor, other)	

*Before the 1998 (date of the CEMEP-EC efficiency labelling voluntary agreement), most motors had neither the nominal efficiency, not the efficiency class in the nameplate, so we provide the value in Table 19.

Data to be collected National method (level 2)	Examples of corresponding data sources
Market Segmentation (per power range and end-use)	Odyssee Database, EuroDEEM Database, Previous European (e.g. SAVE) and MS Studies (see Bibliography)
Number of EEM sold	
(Average) Number of working hours	
(Average) Load Factor	
(Average) Motor Consumption	

Data to be collected Specific method for motors (level 3, case-specific)	Examples of corresponding data sources
Motor electricity consumption	End-use Metering diagrams
Operating hours	

2.13 Variable speed drives

2.13.1 Formula for unitary gross annual energy savings

For this method on variable speed drives, the unit is an electric motor of a certain mechanical power, on which a VSD is installed.

For motors with a mechanical power < 22 kW:

$$\text{unitary gross annual energy savings} = \left(\frac{P_{mec}}{\eta} * Av.LoadFactor * Av.OperatngHours \right) * Av.DefaultSavings$$

(Equation S1a)

Where:

P_{mec} - Mechanical power taken from nameplate;

η - Motor Efficiency from reference Table 19.

For motors with a mechanical power of 22 kW and higher:

$$\text{unitary gross annual energy savings} = \sum_i \left(\left(P_T^i - P_{VSD}^i \right) * h^i \right)$$

(Equation S1b)

Where:

P_T^i – Electrical Power, with throttle control

P_{VSD}^i – Electrical Power, with VSD

h^i – Number of working hours for each power level

i – Load profile index (Number of hours for each load range).

2.13.2 Indicative default value for unitary gross annual energy savings

Two different approaches are recommended for VSDs. For power levels below 22 kW, the level of effort that the present evaluation method suggests is level 1, 2 or 3 (specific for the facilitating measure), always using equation S1a. On the other hand, for VSDs above 22 kW, inclusive, the level of effort for the evaluation should be level 3 and unit case-specific, using equation S1b.

EU default/harmonised values	
Unitary annual energy	Default values for (a) Motor efficiency (Table 21), as well as, for different

savings Default/harmonised	end uses, (b) Annual operating hours (Table 22), (c) Load factors (Table 22), and (d) percentage of energy savings through VSDs (Table 23) are included in this document (cf. chapter 3 of the detailed report).

Table 21: Efficiency values from motors per power range[15].

P_N(kW)	Efficiency	P_N(kW)	Efficiency
	Standard		**Standard**
0,75	72,1	22	89,9
1,1	75,1	30	90,8
1,5	77,2	37	91,3
2,2	79,7	45	91,7
3	81,5	55	92,2
4	83,1	75	92,7
5,5	84,7	90	93
7,5	86,1	110	93,3
11	87,6	132	93,6
15	88,7	160	93,8
18,5	89,4	200 and above	94

For LEVEL 1 effort, the following values (Table 22) can be used. These values have been estimated based on previous Motors SAVE studies.

Table 22: Estimated values for operating hours and load factor from previous studies[16].

Power ranges	**Type of Applications**	**Industry**			**Tertiary**		
		Hours (h)	**Load factor**	**LFH(Load Factor*Hours)**	**Hours (h)**	**Load factor**	**LFH(Load Factor*Hours)**
[0,75;4[	Pumps	3.861,03	0,55	2.123,57	3.800,00	0,55	2.090,00
[4;10[		4.501,94	0,58	2.611,13	3.050,00	0,60	1.830,00
[10;22[		5.040,47	0,59	2.973,88	3.000,00	0,60	1.800,00
[0,75;4[	Fans	4.910,47	0,53	2.602,55	2.250,00	0,60	1.350,00
[4;10[		4.137,76	0,56	2.317,15	2.500,00	0,65	1.625,00
[10;22[		5.210,64	0,59	3.074,28	2.500,00	0,65	1.625,00
[0,75;4[	Air Compressor	2.177,99	0,63	1.372,13	1.030,00	0,40	412,00
[4;10[		4.057,72	0,60	2.434,63	1.000,00	0,45	450,00
[10;22[							441,00

[15] See Appendix I – Justification and Sources, nº1.

[16] See Appendix I of detailed document – Justification and Sources, nº2

		4.625,99	0,68	3.145,67	980,00	0,45	
[0,75;4[	Conveyors	3.060,75	0,42	1.285,52	621,00	0,61	378,81
[4;10[		2.787,90	0,41	1.143,04	916,00	0,53	485,48
[10;22[		3.908,61	0,51	1.993,39	725,00	0,49	355,25
[0,75;4[	Cooling Compressors	5.051,90	0,60	3.031,14			-
[4;10[		1.890,63	0,65	1.228,91			-
[10;22[		5.066,59	0,70	3.546,61			-
[0,75;4[	Refrigeration				4.200,00	0,70	2.940,00
[4;10[					4.170,00	0,70	2.919,00
[10;22[					4.050,00	0,75	3.037,50
[0,75;4[	Others	3.086,64	0,34	1.049,46	500,00	0,30	150,00
[4;10[		2.859,49	0,39	1.115,20	530,00	0,30	159,00
[10;22[		2.299,44	0,45	1.034,75	570,00	0,30	171,00

Table 23: Average percentage VSD Energy Savings, per end-use[17].

End-Use	**Average VSD Savings (%)**
Pumps	28
Fans	28
Air Compressors	12
Cooling compressors	12
Conveyors	12
Other Motors	12

NOTE: the average savings presented in Table 23 are conservative values. Therefore the technical interaction effects are not taken into consideration.

2.13.3 Main data to collect

Data needed in calculation for EU values (level 1)	**Examples of corresponding data sources**
Mechanical power	Nameplate data and information from participants
Type of application (pump, fan, compressor, conveyor, other)	
Number of VSD sold	information from participants

Before the 1998 (date of the CEMEP-EC efficiency labelling voluntary agreement), most motors had neither the nominal efficiency, not the efficiency class

[17] See Appendix I of detailed document – Justification and Sources, nº2

in the nameplate. However before this agreement the motor market was largely dominated by Class 3 motors. After 1998 the efficiency class appears in the nameplate, and the motor market progressively became a Class 2 market. Because motor efficiency can not be collected from nameplates, Table 21 indicates the motor efficiencies to be used.

Data to be collected National or measure-specific method for motors of less than 22 kW (level 2 and 3)	**Examples of corresponding data sources**
Average percentage of energy savings from VSDs (per end-use and possibly power range)	Previous European (e.g. SAVE) and MS Studies (see Bibliography); studies specific for the facilitating measure
(Average) Number of working hours (per end-use and power range)	
(Average) Load Factor (per end-use and power range)	
Mechanical power	Nameplate data and information from participants
Type of application (pump, fan, compressor, conveyor, other)	
Number of VSD sold	information from participants

Data to be collected Specific method for motors of 22kW and higher (level 3, case-specific)	**Examples of corresponding data sources**
Motor electricity consumption	End-use Metering diagrams
Flow Data Requirements	Analysis of Process Time Diagrams Flow Measurement
Number of VSD sold	information from participants

2.14 Vehicle energy efficiency

2.14.1 Formula for unitary gross annual energy savings

For this method, the unit is one vehicle, which may be equipped with fuel-saving motor oil and tyres. The formula for unitary gross annual energy savings is:

$$ES_{uga} = En_{bas} * (1 — En_{eff} / En_{bas} * EV_{lub} * EV_{tyr}) * ADT – (En_{eff} * RE)$$

(Equation 1)

Where:
ES_{uga} Unitary gross annual energy savings [kWh]
En_{bas} Fuel consumption in the baseline case [kWh/km]
En_{eff} Average fuel consumption of efficient vehicle [kWh/km]
EV_{lub} Efficiency value for fuel-saving lubricants [0;1]
EV_{tyr} Efficiency value for fuel-saving tyres [0;1]
ADT Annual distance travelled [km]
RE Direct rebound effect [km]; *inclusion of this effect subject to decision by ESD Committee*

This formula must be separately evaluated for the different types of passenger cars (e.g., mini, compact, vans, etc.). It must not be evaluated across the board of all types of vehicles, since this would grossly overestimate the energy savings.

The European Commission has proposed to set the emission target for passenger cars to 130 g CO_2/km from 2012. An emission target for any commercial vehicle category has not yet been set. The EU emissions targets are taken to define the threshold between efficient and ineffcient vehicles for this case application. The value of the baseline case (En_{bas}) depends not only on the vehicle category, but as well on the facilitating measure under evaluation:

- For all measures promoting the purchase of efficient new passenger cars, the baseline is the average consumption of inefficient new passenger cars, i.e. all new passenger cars emitting more than 130 g CO_2/km.
- For commercial vehicles, the baseline assumptions should be similar to the approach for passenger cars. But a threshold between efficient and inefficient commercial vehicles still needs to be defined. Commercial vehicles should be classified according to the definition of the European Automotive Industry.
- If the purchase of a new passenger car/commercial vehicle is linked to a scrapping rebate for the old vehicle, then the baseline is the average energy

consumption of the vehicle fleet in use five years prior to the year under evaluation.

The conversion factors for the threshold between efficient and inefficient passenger cars are as follows:

Table 24: conversion factors to determine the baseline fuel consumption[18]

energy consumption when emitting 130 g CO_2/km
0,489 kWh/km for regular grade petrol
0,498 kWh/km for super petrol
0,487 kWh/km for diesel fuel
0, 618 kWh/km for natural gas

With respect to facilitating measures promoting the purchase of fuel-saving tyres and lubricants, the baseline/reference case (En_{bas}) shall be the average energy consumption of the current vehicle fleet.

2.14.2 Indicative value for unitary gross annual energy savings

According to Schalleböck et al.[19], there are numerous options to improve vehicle energy efficiency, and a combination of efficient technologies offeres a technical saving potential beyond 50 %.

By contrast, the determination of the saving potential of certain facilitating measures proves to be difficult. According to Irrek/Jarczinsky,[20] for passenger transport the net impact achieved by existing policies and measures was not known.

Hence, there is no level 1 default value for En_{eff}/En_{bas}. En_{uga} depends on the fuel consumption values measured and is country-specific. The level 1 default efficiency values of fuel-saving tyres and lubricants are listed in Table 25.

Table 25: Efficiency values for fuel-saving lubricants and tyres, level 1 evaluation[21]

lubricants	**lubricants**	**tyres**	**tyres**
passenger car	**com. vehicle**	**passenger car**	**com. vehicle**
0.973	0.973	0.971	0.950

[18] See Appendix I - Justification and Sources, n°1
[19] See Appendix I - Justification and Sources, n°2
[20] See Appendix I - Justification and Sources, n°3
[21] See Appendix I - Justification and Sources, n°4

2.14.3 Main data to collect

Precision of the data listed below varies strongly. E.g. the vehicle kilometres travelled might in some cases be available for different street categories, while for certain facilitating measures the number of participants might hardly be available at all.

Data needed in calculation for EU values (level 1)	**Examples of corresponding data sources**
Average annual distance travelled (vehicle kilometres). Distinction between passenger cars and commercial vehicles.	Default value: Passenger cars: 12,000 km[22] Commercial vehicles: 18,300 km[23]
Number of participants (level 3)	Monitoring of number of participants Market shares Surveys
Efficiency values for tyres and lubricants	Default values: see Table 25
Fuel consumption to be evaluated on MS-level (level 2)	National statistics or EU monitoring
Data to be collected National method (level 2)	
Average annual distance travelled (vehicle kilometres). Distinction between commercial vehicles and passenger cars. If data available, distinction of street categories as in level 3	National statistics
Average fuel consumption of fleet of inefficient new vehicles, i.e. all vehicles emitting more than baseline levels Average fuel consumption of efficient vehicles, i.e. all vehicles emitting up to baseline levels	National statistics ODYSSEE-indicators statistics from manufacturer's associations
Number of participants	cf. level 1
Efficiency values for tyres and lubricants	cf. level 1
Data to be collected Specific method (level 3)	
Average annual distance travelled (vehicle kilometres) • within urban, built-up areas • in rural areas, out of town and • on motorways. Distinction between commercial vehicles and at least three categories of passenger cars	Advanced governmental/local statistics Manufacturers and their associations Surveys
Average fuel consumption of fleet of inefficient new cars	cf. level 2, but differentiated by street categories
Average fuel consumption of efficient vehicles	own data/assumptions, survey
Number of participants	cf. level 1
Efficiency values for tyres and lubricants	own data, default values from the German Federal Environment Agency (see table 4 of detailed document)

[22] See Appendix I - Justification and Sources, n°5

[23] See Appendix I - Justification and Sources, n°6

2.15 Modal shifts in passenger transport

2.15.1 Formula for unitary gross annual energy savings

The unit is one person. The unitary gross annual energy savings are given by the following formula.

$$ES_{uga} = \sum_{i=1}^{N} \Delta ADT_i * En_i$$

(Equation 1)

Where:

ES_{uga}	Unitary gross annual energy savings [kWh/person/year]
En	Specific energy consumption of a mode of transport [kWh/person-km]
ΔADT	change of annual distance travelled in a transport mode [km/year], baseline case (ADT_{bas}) – new case (ADT_{new})
i	Mode of transport
N	Number of modes of transports concerned

$$\sum_{i=1}^{N} ADT_{bas\ i} = \sum_{i=1}^{N} ADT_{new\ i}$$

2.15.2 Indicative default value for unitary gross annual energy savings

As a matter of fact, many different socio-economic and geographic circumstances determine the choice of the mode of transport of a person. For example, remote regions are not in the position to offer a well-functioning public transport system like urban regions might be able to do. Thus, the quantification of the energy saving potential of one person has to consider such case-specific circumstances and there is no default value for the unitary gross annual energy savings available. However, it is possible to provide default values for the specific energy consumption of the different modes of transport.

EU default values	
Unitary annual energy savings default	Default values for the specific energy consumption of the different modes of transport are included in this document. See Table 26 for details and chapter 3.4.3 of the detailed document for further details. Moreover, chapter 4.1 of the detailed document provides a number of estimates on the total gross annual energy saving potentials of certain transport demand policies and measures.

Table 26: default values for the specific energy consumption of modes of transport[24]

	aero-plane	passen-ger car	long dis-tance train	long dis-tance bus	motor-bike	local public transport	walking, cycling
specific energy consumption (kWh/person-km)	see Table 27	see Table 27	0,11	not considered at level 1 evaluation		0	0

Table 27: default values for the specific energy consumption of aeroplanes and cars

	NL GB, DN (Occupancy level: 1.6)	other EU-15 (Occupancy level: 1.92)	other EU-27 (Occupancy level: 2.4)
specific energy consumption of a passenger car (kwh/pers-km)	0,33	0,28	0,22
	250-499 km (Occupancy level: 75%)	**500-749 km (Occupancy level: 75%)**	**at least 750 km (Occupancy level: 75%)**
specific energy consumption of an aeroplane (kwh/pers-km)	0,46	0,40	0,35

2.15.3 Main data to collect

Data needed in calculation for EU values (level 1)	**Examples of corresponding data sources**
change of average annual distance travelled	Only at level 3
Specific energy consumption, distinguished by mode of transport	Default values: See Table 26 and chapter 3.4.3 of detailed document
Number of participants/customers/passengers	Passenger count, occupancy count, survey, participant monitoring
Data to be collected National method (level 2)	
Average annual distance travelled (vehicle kilometres).	Only at level 3
Specific energy consumption, distinguished by mode of transport	National statistics, ODYSSEE indicators. See chapter 3.4.3 for details
Number of participants/customers/passengers	Passenger count, occupancy count, survey, participant monitoring
Data to be collected Specific method (level 3)	
Average annual distance travelled (vehicle kilometres)	If measure designed for a single line section: distance Local/own statistics (companies and administration): Household survey
Specific energy consumption, distinguished by mode of transport	direct measurement, studies, surveys, otherwise level 1/2 approach

[24] See chapter 3.4.3 for justifications and sources

Number of participants/customers/passengers	Passenger count, occupancy count, survey, participant monitoring

2.16 Ecodriving

2.16.1 Formula for unitary gross annual energy savings

For ecodriving, the unit used in the formula is a **participant in a specific measure** that is part of the ecodriving programme (e.g. one out of the types presented ahead). So the energy savings are, at first, calculated for each type of measure.

The basic formula for calculating the unitary gross annual energy savings is for each specific measure the same:

Unitary gross annual energy savings (PJ) = Effectiveness (E) x Efficiency rate (ER) x average annual energy use per participant

The average energy use is calculated by dividing the total energy use for transport (based on national statistics) divided by the number of drivers. If the number of drivers is not available, the number of cars can be used as a proxy. In the freight-transport sector other units like freight km's may be more suitable in specific situations. The most important aspect is to be consistent in the use of formula with regard to the applied unit for number of participants and average annual energy use.

Effectiveness (E) = % of drivers that changes its behaviour due to the activity or activities conducted for a specific measure

Efficiency rate (ER) = effect of the change of behaviour on energy savings in %

(equation 1)

This formula forms the basis for all the 3 monitoring levels. Level 1 and 2 focus on the ecodriving measures, which allow both for a reliable estimate of participants and a relatively direct relation between the measures and the effects on energy use. These are:

- Specific driver trainings
- Integrating ecodriving in driver license training
- Simulators/ virtual trainers
- Stimulating fuel-saving in-car devices

In level 3 the effects of the remaining measures (communication, stakeholder consultation and long term agreements) are also taken into account.

If new measures with regard to ecodriving are implemented, which also fit the criteria of having reliable estimates of participants and a relatively direct relation between the measure and the effects on energy use, these measures can be treated the same way.

2.16.2 Indicative default value for unitary gross annual energy savings

At level 1 the monitoring activities should focus on acquiring the following data:

- Average annual energy use per participant (GJ/year) (as described in the text box)
- The number of driver trainings that has been given
- The number of drivers having passed a driver license training with integrated ecodriving training
- Number of participants in simulators/virtual trainings
- The number of fuel saving devices in cars per type of device

These data can be used in equation 1. For the effectiveness and efficiency standard values can be used, indicating the minimum amount of energy savings that can be expected as a result of the measure.

Ideally these standard values should be based on the range of effectivenesses and efficiencies found in all EU countries. For now, due to lack of data for other countries, we have based these values on the Dutch situation with a correction factor of 75% for both efficiency and effectiveness. The correction for effectiveness and efficiency together implies a decrease of the estimated effect of about 50%. This decrease is probably too strong compared to reality, however we want to reduce the risk of overestimating the savings at level 1.

Right now the parameters are mainly based on Dutch information. In the coming years the database at ecodrive.org is expected to grow, when the monitoring data from various countries become available and are added to this database. For now we propose to use the following default values for the efficiency (E) and the effectiveness (ER). From the evaluation of the Dutch ecodriving programme the following values for participation effectiveness and efficiency have been derived, multiplied with 0.75[25]:

	Effectiveness (E)	Efficiency Rate (ER)
1. Specific training	26 %	7.5 %
2. Driver licenses	26 %	7.5 %
3. Virtual trainer/simulator	10 %	7.5 %
4. In-car devices	67.5%	3.8 %

[25] These effects are assumed to be independent of other parameters like volume (km/driver) or car efficiency. If more information on this becomes available, this can be incorporated in the formula.

These values shall be maintained in Ecodrive.org. As stated at the beginning of this pargraph, the monitoring of the effects of the supporting measures is not incorporated separately at level 1.

2.16.3 Main data to collect

Data needed in calculation for values (level 1)	Corresponding data sources
Average energy use per driver	National statistics
Number of participants per measure	National monitoring data per measure
Efficiency and effectiveness per measure	Database (e.g. www.ecodrive.org)

Data to be collected (level 2)	Corresponding data sources
Average energy use per driver	National statistics
Number of participants per measure	National monitoring data per measure
Effectiveness and efficiency per measure	National monitoring data/research per measure

Data to be collected (level 3) additional to data collected at level 1 and 2	Corresponding data sources
Average energy use per driver	National statistics
Number of participants per measure	National monitoring data per measure
Effectiveness and efficiency per measure	National monitoring data/research per measure
Questionnaire on reported behaviour to incorporate effect of supporting measures	Annual survey (licenced drivers)
Effects of communication campaign	National survey(s)
Test results	Field tests. These are also used as contribution to the databank, see annex 1

2.17 Energy Performance Contracting

2.17.1 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.

Unitary gross annual energy savings = 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), %
η_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.

2.17.2 Indicative default value for unitary gross annual energy savings

EU wide default values are not recommended for EPC.

2.17.3 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	Data gathered according to level 3 (see level 3 below)

Reported data	
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.

Data to be collected <u>measure-specific</u> (or participants-specific) (level 3)	**Corresponding data sources**
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 wit 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.

2.18 Energy audits

2.18.1 Calculation formulas for the three levels

The following general calculation formula is used for estimating energy savings by energy audits:

total gross annual energy savings =

$$\sum_{i=1}^{n}[\text{annual energy savings of industrial participant i}]+$$

$$\sum_{i=1}^{n}[\text{annual energy savings of tertiary participant i}]$$

The total gross annual energy savings are the sum of energy savings of all participants (energy audits) in a given year. The "elementary unit of action" is one energy audit which corresponds to one participant with its energy savings arising from several improvement actions. Separate calculation formulas have been formulated for estimating the annual energy savings by one participant at levels 1, 2 (two approaches) and 3.

Level 1

The annual energy savings (GWh/a) to be realised by one energy audit (participant) are calculated as follows at level 1:

Annual energy savings of one participant [GWh/a] =

$= DV_{h,f}(heat+fuels)*AC(heat+fuels) + DV_e(electricity)*AC(electricity)$

where:

- DV_e = EU default value for electricity savings, %
- $DV_{h,f}$ = EU default value for heat and fuel savings, %
- AC = annual energy consumption (GWh/a)

Note: Making evaluations at Level 1 is **not recommended**: However, use of Level 1 may be necessary, for example, if a Member State is in the process of introducing an audit policy and therefore does not possess any experience or data of their own. In such a case, the annual energy consumption of the participants in the audit scheme must be collected or calculated from audited building volumes.

Level 2, Approach A – Survey

At level 2 two different approaches – A and B – are possible. The choice will depend on whether the information on the realised savings is collected by a survey or can be found in the audit report data.

The energy savings (GWh/a) to be realised by one energy audit (participant) are calculated as follows at level 2 in Approach A:

Annual energy savings of one participant [GWh/a] = AS(heat+fuels) + AS(electricity)

where:
- AS = annual energy savings of the participant realised as a consequence of the energy audit and collected through a survey of participants (GWh/a)

Note: A survey among the recipients of the audits concerning the realised savings will be based on the saving potential estimates in the audit report, since only in very few cases the savings are actually metered. Furthermore, there may be lack of monitoring of measures taken, participants may lack expertise and there is a risk of survey biases. We therefore propose that method A should **only be allowed** for past but recent energy audit schemes where a Level 2, Approach B or Level 3 is not possible, i.e., no database of energy savings potentials identified in audit reports exists yet, so that the data have to be collected from the participants through the survey. For all future participants from the time of application of level 2A, a database of energy savings potentials identified in audit reports should be created, so that level 3 or at least level 2B calculation becomes possible.

Level 2, Approach B – Audit report data

The annual energy savings (GWh/a) to be realised by one energy audit (participant) are calculated as follows at level 2 in Approach B:

Annual energy savings of one participant [GWh/a] =
*= $DV_{h,f}$ (heat+fuels)*TSP(heat+fuels) + DV_e (electricity)*TSP(electricity)*

where:
- DV_e = EU default value for the share of the electricity savings potential implemented, %

- $DV_{h,\ f}$ = EU default value for the share of the heat and fuel savings potential implemented, %
- TSP = total annual energy savings potential of the participant identified in the energy audit (GWh/a)

Note: We recommend that this approach should only be used if follow-up implementation data for each participant (see level 3) cannot be collected, e.g., if this is too costly for small customers. Replacing the EU default values by national or programme-specific default values based on a sample of participants analysed with follow-up (level 3) is recommended.

<u>Level 3</u>

The annual energy savings (GWh/a) to be realised by one energy audit (participant) are calculated as follows:

where:
The annual energy savings (GWh/a) to be realised by one energy audit (participant) are calculated as follows:

Annual energy savings of one participant [GWh/a] =
*= DI(heat+fuels)*TSP(heat+fuels) + DI(electricity)*TSP(electricity)*

where:
- DI = degree of implementation of the TSP by the participant, %
- TSP = total annual energy savings potential of the participant identified in the energy audit (GWh/a)

The degree of implementation (DI) by one participant in the above formula is calculated as follows:

*Degree of implementation DI [%] = I + D + a*C*

where:
- I = proportion of implemented actions in all actions proposed in the audit report, D = proportion of actions decided to be implemented, C = proportion of actions under consideration (%)
- a = 0.05 for actions in industry
- a = 0.3 for actions in the service sector

Alternatively, the estimates of energy savings from the implemented, planned, or considered end-use actions could be added up directly for each participant:

Annual energy savings of one participant [GWh/a] =

$= TSP_I(heat+fuels) + TSP_D(heat+fuels) + a*TSP_C(heat+fuels) +$

$TSP_I(electricity) + TSP_D(electricity) + a*TSP_C(electricity)$

where:
- TSP_I = the participant's total annual energy savings potential of the implemented actions (GWh/a)
- TSP_D = the participant's total annual energy savings potential of the actions decided to be implemented (GWh/a)
- TSP_C = the participant's total annual energy savings potential of the actions under consideration for implementation (GWh/a)
- a=0.05 for actions in industry
- a=0.3 for actions in the service sector

Follow-up implementation data (I, D, C or the implemented, planned, and considered actions for the alternative approach) have to be collected for the calculations of the degree of implementation e.g. via questionnaires after the audit (see chapter 3.4.3.5 of detailed document). In the alternative approach, the TSP values are taken from the database of energy audit results for the actions implemented, planned, or considered.

2.18.2 Indicative default value for annual unitary energy savings

Energy audits are not one single energy efficiency improvement action. Instead, as a consequence of energy audits, several improvement actions are proposed and some of them are implemented. In EMEEES terminology, an energy audit is an (EEI) facilitating measure which consists of numerous end-use (EEI) actions.

The results achieved through energy audits vary significantly by country depending on the starting level of energy efficiency, the type of energy audit used, the type of audited facility and interaction with other (EEI) facilitating measures. Saving potentials reported by some individual Member Countries range from 3% to 20–30% of the audited facility's energy consumption depending on, e.g. the type of energy concerned (electricity or heat and fuels) and the sector (industry or tertiary). The degree of implementation of the proposed improvement actions (end-use (EEI) actions) varies as well.

Despite the above difficulties, very conservative European default values for level 1 calculation (see Table 28) have been proposed in this report as a percentage of energy consumption of the audited facilities (to be applied only for the energy consumption of the audited processes in the case of a System-Specific Energy Audit/Partial Audit). The default values are based on the results achieved in the Finnish Energy Audit Programme. The proposed default values amount to approximately one third of the actual savings achieved in Finland.

*Table 28: Proposed **level 1** default values for average energy savings achieved by energy audits (% of annual energy consumption)*

Sector	Savings % of annual consumption	
	Electricity	Heat and fuels
Buildings in the municipal services sector (residential buildings not included)	2%	3%
Buildings in the private services sector (residential buildings not included)	1.5%	4%
Industry (energy-intensive process industry not included)	1%	2%

In level 2 calculations, two different approaches are possible. One (approach A) does not require the use of any default values because data on implemented actions is collected nationally. In another approach (B) at level 2, default values can be used to estimate how much of the potential savings identified in the energy audits have been realised (see Table 29).

*Table 29: Proposed percentages for realised savings out of potential savings to be used as default value in **level 2B** energy saving calculations*

Sector	Proportion of realised savings compared to potential savings %			
	Finnish Energy Audit Programme[1]		Percentages to be used as default value in level 2B calculations	
	Electricity	Heat and fuels	Electricity	Heat and fuels
Buildings in the municipal services sector (residential buildings not included)	76%[2]	73%[2]	25%	25%
Buildings in the private services sector (residential buildings not included)	71%[2]	79%[2]	25%	25%
Industry (energy-intensive process industry not included)	59%[3]	52%[3]	20%	15%

[1] Source: Motiva Oy, 2006.

[2] Includes all implemented improvement actions (I), all decided ones (D) and one third of those under consideration (C).

[3] Includes all implemented improvement actions (I), all decided ones (D) and 5% of those under consideration (C).

2.18.3 Main data to collect

The resources required for the evaluation consist of two components: establishing and operating the monitoring system and the evaluation itself.

If less than 100 audits are conducted per year, the monitoring resources needed are negligible. If the number exceeds 100 per year, a rough estimate for the operating costs at level 2 ranges from a week to one person-month per year. At level 3, the operating costs of the monitoring system are in the range of 4 person-months per year. The cost of establishing the database needed for level 3 calculations and in some cases also level 2 calculations is approximately 6 person-months.

Data needed in calculation for EU values (level 1)	**Examples of corresponding data sources**
EU default values for annual energy savings (% of annual energy consumption of the audited facility)	This report
Audit volumes (annual energy consumption of the audited facilities or building volumes or floor area by building type in the service sector) in existing audit schemes	Audit or investment subsidy decisions, number of vouchers issued for energy audits in existing schemes
Average specific consumption by building type in the service sector and by energy type (electricity and heat). This information is needed if calculations are based on building volumes or floor area.	National statistics or other sources

Data to be collected National method (level 2)	**Examples of corresponding data sources**
<u>Approach A – participant survey</u>	
Audit programme participants	Audit or investment subsidy decisions, vouchers issued for energy audits, audit reports filed
Realised savings from implemented actions	Survey questionnaires/interviews
<u>Approach B – audit reports</u>	
Potential savings of all proposed actions from energy audit reports	Monitoring database with national data on energy efficiency potential. For each proposed improvement action the following data is needed: o short description/name (technical/ operational actions) o savings of heat and electricity in energy units (kWh/a)
Degree of implementation	Default values given in this report for the degree of realisation

Data to be collected Specific method (level 3)	**Examples of corresponding data sources**

Proposed improvement actions and their saving potential	Monitoring database of energy audit results (as for level 2)
Implemented actions and actions decided to be implemented	Annual reports or periodical question-naires/interviews to collect follow-up data on the implementation rate
Savings from actions under consideration for implementation	Default vales given in this report for degree of realisation

Furthermore, on levels 2 and 3, national average values or values specific to an energy audit scheme or a type of end-use actions proposed by energy audits can be developed to replace the EU default values, based on samples of participants analysed with follow-up at level 3.

2.19 Voluntary agreements - billing analysis method

2.19.1 Formula for unitary gross annual energy savings

For this case application, the unit is one final consumer (participant in the voluntary agreement scheme).

<u>Level 3a calculation</u>

Unitary gross annual energy savings =
[annual energy consumption]$_{t-1}$ – [annual energy consumption]$_t$

<u>Level 3b calculation</u>

Unitary gross annual energy savings =
[annual energy consumption- delivered energy in year]$_{t-1}$ – [annual energy consumption - delivered energy in year]$_t$

<u>Level 3c calculation</u>

Unitary gross annual energy savings =
[annual energy consumption- delivered energy in year]$_{t-1}$ – [annual energy consumption - delivered energy in year]$_t$ +
$\Sigma_{actions}$ *([annual energy consumption in the product chain]$_{t-1}$ – [annual energy consumption in the product chain]$_t$)*

(Exploring the possibilities for) calculating energy efficiency throughout the chain (level 3c) is optional and thus not in any case obligatory.

Recommended application example:
Since the early nineties, the Netherlands uses the Direct Energy Efficiency Index (DEEI) as good practice. This index encompasses all three normalisation factors discussed here. It also relates the energy savings to energy efficiency improvements. Furthermore, the use of such a DEEI results straightforwardly in the estimation of the total ESD-savings for year y (for detailed information on DEEI, see Appendix II).

2.19.2 Indicative default value for annual unitary energy savings

No default values are available and possible.

2.19.3 Main data to collect (for level 3a to 3c evaluation efforts)

Data needed in calculation for (level 3a)	**Corresponding data sources**
Data 1	Actual energy consumption (in fact purchased energy): registry/databases to collect details about participants
Data 2	Conversion values as provided for by the Energy Service Directive (ESD, 2006/32/EC) or national values
Data 3	Normalisation factors to exclude changes in actual energy consumption not related to energy efficiency improvement; calculating a DEEI as in the Dutch example
Data 4	An estimate of energy savings due to autonomous progress and actions by participants (only if the aim is to calculate additional energy savings), e.g., from Bottom-up modelling based on surveys; registry/databases to collect details about end-use actions taken by participants and other facilitating measures that influenced them; statistical analysis of participant vs. non-participant data of energy consumption
Data to be collected (level 3b)	**Corresponding data sources**
Data 1 to 4	As for level 3a
Data 5	Information on energy delivered to other facilities: registry/databases to collect details about participants
Data to be collected (level 3c)	**Corresponding data sources**
Data 1 to 5	As for level 3b

Data 6	Additional information on (deemed) energy savings (estimation, calculation) in the supply chain or the products:
	➢ Installed energy efficient equipment;
	➢ Transport & logistics;
	➢ Generation of renewable energy only insofar this concerns discounting energy purchased and energy delivered;
	➢ Side-effects within the production facility; positive spill-over effects from newly installed energy efficient devices leading to higher efficiency values;
	➢ assessment of sales data of products manufactured by industrial facilities (may include the use of control groups) (ONLY if not calculated elsewhere, avoid double counting)
	    ➢ surveys among the participants to assess the portion/number of implemented end users actions;
	    ➢ surveys among industries, for assessing the participant rate.

Concerning the end-use actions taken and the possible other facilitating measures that influence them, several options to enhance energy efficiency in industry, such as audit programmes, inplementation of an Energy Management Systems or Long Term Agreements, Energy Performance Contracting (ESCOs), third-party financing options, etc., can be taken into account. Krarup and Ramesohl developed the following table (included in Vreuls 2005), being a systematic and comprehensive coverage of energy efficiency end use actions that may be taken by participants to a VA scheme, and the likely influence the scheme may have.

Options	**Requirements**	**Timeframe**	**Impact of agreement schemes**
Change in product design, composition of processed materials and resource use (e.g. thinner and lighter bottles, better recycling, etc.).	Strategic commitment and long-term decisions with regard to a change of technical paradigms, process technologies and resource structures.	Long term.	Minor effects.
Change in energy supply structure (e.g. introduction of CHP	Strategic commitment and long-term decisions with regard to energy	Medium/long term.	Some effects, depending on policy mix (e.g. CHP policy in the Netherlands).

Options	Requirements	Timeframe	Impact of agreement schemes
appliances or domestic generation of renewables)	infrastructure and fuel imput.		
Increased technology innovation.	Strategic commitment and long-term investment into R&D.	Long term.	Minor effects.
Enhanced investment.	Change in strategic and operative business goals as well as altered decision criteria and procurement procedures.	Short/medium term.	Some effects, depending on policy mix (e.g. subsidies) and mandatory requirements (e.g. in Denmark)
Enhanced technology diffusion.	Increased communication, exchange of practical experience and generation of new network links, and even energy-related cooperation of competitors.	Medium Term.	Some effects, depending on existing cooperation and competition.
Improved energy management.	Integrated approach and systematic search for improvement options, changes in organisational routines, staff empowerment.	Medium term.	Some effects depending on design of scheme (e.g. integration of audits in Denmark and Finland).
Awareness and motivation.	Mobilisation of company stakeholders, provision of information, know-how and expertise, and continious discussion of the issue.	Short/medium term	Some effects.

The use of energy services such as energy audits could be added to this table.

2.20 Voluntary agreements with individual industrial companies – engineering method

2.20.1 Formula for unitary gross annual energy savings

For this method, the unit used in the formula for the unitary gross annual energy savings is an industrial participant (a plant or several plants within a company). The definition (equation S1) is differentiated according to the level of evaluation effort (1, 2 or 3).

Unitary gross annual energy savings = Energy savings of one participant

(equation S1)

The total gross annual energy savings is then calculated as the sum of the savings for all N participants at all possible levels (1-3).

$$\text{Total gross annual energy savings} = \sum_{i=1}^{3} \sum_{j=1}^{N} (\text{savings of level i participant j})$$

<u>Level 1 calculation</u>
Only if an energy audit is an integral part of the VA scheme, the conservative default values established in the EMEEES case application 18 on energy audits can be used for level 1 calculation.

$$\text{Unitary gross annual energy savings} = (DV1_{h,f} * AC_{h,f}) + (DV1_{e} * AC_{e})$$

(equation S1a)

Where:
$DV1_{h,f}$ = default value for heat and fuel savings [%] from the energy audit case application
$AC_{h,f}$ = annual consumption of heat and fuel
$DV1_{e}$ = default value for electricity savings [%] from the energy audit case application
AC_{e} = annual consumption of electricity

Annual consumption values may be based on the average consumption over 3-5 years or estimated if there is no record due to e.g., major changes in production. Calculated electricity savings may be kept separate and converted to primary energy savings at different levels of aggregation.

Level 2 calculation

Unitary gross annual energy savings =
$RS_{h,f} + RS_e + (DV2_{h,f} * AC_{h,f}) + (DV2_e * AC_e)$

(equation S1b)

Where:
$RS_{h,f}$ = reported heat and fuel savings from actions identified in an energy audit and actually realised
RS_e = reported electricity savings from actions identified in an energy audit and actually realised
$DV2_{h,f}$ = default value for savings from changes in routines and O&M [%]
$DV2_e$ = default value for savings from changes in routines and O&M [%]

RS covers only reported savings that result from investments or actions that are clearly identifiable (e.g., retrofitting and reducing leakage in a compressed air system). Changes in Operation & Maintenance (O&M) result from the use of an energy management system which ensures, for example, continuous maintenance and adjustments in the operation of the compressed air system in order to maintain low leakage rates and identify additional savings. DV2 values can be EU country- and, or, subsector-specific. The member state needs to develop and motivate the default values through surveys and samples.

Level 3 calculation

Unitary gross annual energy savings =
$RS_{h,f} + RS_e + (RV3_{h,f} * AC_{h,f}) + (RV3_e * AC_e)$

(equation S1c)

Where:
$RS_{h,f}$ = reported heat and fuel savings from actions identified in an energy audit and actually realised
RS_e = reported electricity savings from actions identified in an energy audit and actually realised
$RV3_{h,f}$ = reported value for savings from changes in routines and O&M [%]
$RV3_e$ = reported value for savings from changes in routines and O&M [%]

RS covers only reported savings that result from investments or actions that are clearly identifiable (e.g., retrofitting and reducing leakage in a compressed air system). Changes in O&M result from the use of an energy management system which ensures high standards in the operation and maintenance of energy using equipment. RV3 values can be based on self-reported estimates but should be corroborated through surveys and samples, or verified by EMS auditors.

2.20.2 Indicative default value for unitary gross annual energy savings

The default values for unitary annual energy savings that are suggested below can only be accounted for once, i.e. when a participant enters a voluntary agreement. Energy savings are in this sense not cumulative.

Level 1 calculation default values

Only if an energy audit is an integral part of the VA scheme, the conservative default values established in the EMEEES case application 18 on energy audits can be used for level 1 calculation.

Table 30: Proposed level 1 default values for average energy savings achieved by energy audits (% of the annual energy consumption covered by the audit), from EMEEES case application 18

Sector	Savings % of annual consumption	
	Electricity	Heat and fuels
Buildings in the municipal services sector (residential buildings not included)	2%	3%
Buildings in the private services sector (residential buildings not included)	1.5%	4%
Industry (energy-intensive process industry not included)	1%	2%

It is not possible to define clear cut default values with evidential support. Foremost, there are only a few examples of VA's targeting industrial companies. Those existing are characterized by heterogeneity, and there are also decisive variations in the evaluations practices aiming at assessing their impacts. Appendix II provides a compilation of electricity savings that has been reported by the companies participating in PFE. These figures are of course unfit as EU default values, but anyway give some indications on what various end-use EEI actions, within different industrial sectors, can achieve in terms of electricity savings.

Level 2 calculation default values

When developing national default values for $DV2_{h,f}$ and $DV2_e$, it is important that care is taken so that values are based on savings that are additional to the reported savings (RS) from specific actions. This can only be done at national level, as it also depends on the concrete national VA schemes and its role in the context of other measures targeting industrial energy consumers. It is important that national program administrators put an effort into developing country specific default values.

2.20.3 Main data to collect

Data needed in calculation for <u>EU</u> values (level 1)	Corresponding data sources
Annual fuel, heat, and electricity consumption of each participant	Monitoring of participant data
Default values for energy savings (% of annual energy consumption)	Conservative default values, preferably the ones suggested in this report but only if an energy audit is part of the agreement
Free-rider and multiplier coefficient, double-counting factor	Surveys of participants and their end-use EEI actions taken; monitoring of end-use actions vs. facilitating measures to avoid double-counting the impacts of end-use actions

Data to be collected <u>national values</u> (level 2)	Corresponding data sources
Default values for savings resulting from the use of an energy management system, as well as procurement and planning routines	The literature appears to have very little information, anecdotal at best, on the savings that result from energy management in industry. Default values must be developed at national level. Savings may depend strongly on quality of the EMS, country, and industrial branch.
Reported savings from individual technical actions	It is assumed that participants are obliged to report both implemented investment options and saving actions with a payback period of less than 3 years as part of the voluntary agreement.
Annual fuel, heat, and electricity consumption of each participant	Monitoring of participant data
Free-rider and multiplier coefficient, double-counting factor	Surveys of participants and their end-use actions taken; monitoring of end-use actions vs. facilitating measures to avoid double-counting the impacts of end-use actions

Data to be collected participants-specific (level 3)	Corresponding data sources
Reported values for savings resulting from changes in routines, O&M, and energy management system	Self reported from participating companies corroborated by surveys and samples, or verified by EMS auditors
Reported savings from individual technical actions	It is assumed that participants are obliged to report as well as implement investment options and saving actions with a payback period of less than 3 years as part of the voluntary agreement.
Annual fuel, heat, and electricity consumption of each participant	Monitoring of participant data
Free-rider and multiplier coefficient, double-counting factor	Surveys of participants and their end-use actions taken; monitoring of end-use actions vs. facilitating measures to avoid double-counting the impacts of end-use actions