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

EMEEES bottom-up case application 5: Energy-efficient cold appliances and washing machines

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30 April 2009

coordinated by
Wuppertal Institute for Climate, Environment and Energy

supported by
Intelligent Energy Europe

The Project in brief

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

Consortium

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

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

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EMEEES bottom-up case application 5

Energy-efficient cold appliances and washing machines

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1 Summary

1.1 Title of the method

Harmonised bottom-up evaluation method for energy-efficient cold appliances and washing machines (residential sector)

In the following, energy efficiency improvement is abbreviated as EEI.

1.2 Type of EEI activities covered

End-use (EEI) action	
Sector	Residential
Energy end-use	White goods : cold appliances and washing machines
Efficient solution	Best available technology (BAT) among A class appliances: - A++ and A+ for cold appliances – Commission Directive 2003/66/EC - less than 0.17 kWh/kg for washing machines
(EEI) Facilitating measure	
Types of (EEI) facilitating measures	Regulation: ▪ Minimum Equipment Energy Performance Standards Information: ▪ Focused information campaigns ▪ Labelling ▪ Training and Education ▪ Metering and informative billing Financial instruments for energy savings: ▪ Cash rebates ▪ Tax rebates and other taxes reducing energy end-use consumption ▪ Third-party financing ▪ Loans Voluntary agreements: ▪ Industrial companies (appliance manufacturers) ▪ Commercial (appliance trade) or industrial organisations Given the complexity of harmonisation of the method for all types of measures, this document deals with measures most likely to be implemented at national scale: in general, measures facilitating or encouraging the purchase of the most efficient solution. The facilitating measure must target the best available technology: A++ appliances for cold appliances and below 0.17 kWh/kg for washing machines, and should not be restricted to a category of end users. This document may serve as a basis for adaptation to other types of measure or appliance.

1.3 Detailed definition of EEI activities covered

The EEI activities are listed in section 1.2 above. Additional information includes:

Regulation

All member states are under an obligation to comply with the Energy Labelling Directive, which requires that certain household appliances be labelled in shops to inform customers about their energy consumption. The directive targets the following products: cold appliances (refrigerators, freezers and their combination), clothes washing machines, dish washers, tumble dryers, ovens, air conditioners and light sources.

Other legislative measures to influence the energy consumption of cold appliances and washing machines are defined through minimum efficiency standards (MES). These MES are mainly applied at the European level, but with domestic transposition, and concern all family of large domestic appliances, air-conditioning, motors, light sources and boilers.

A new step forward in minimum efficiency standards will be set under the European "Framework Directive for the setting of eco-design requirements for Energy using Products (EuP)" (2005/32/EC), the results of which are scheduled to be available before the end of 2008. The minimum requirements of efficiency improvement achieved within the EuP frame will necessarily be introduced in the baseline discussions for the harmonised methodologies of calculation for energy savings.

Informative and training measures

General information programmes and campaigns have an important function of advertisement to promote all energy efficient electric equipments. They aim at both increasing the share of energy-efficient home equipment rates and influencing consumer's behaviour. Educational and professional training programmes are mainly proposed to retail trade companies and their sales staff in the shops.

Financial instruments

These are mainly financial incentives to purchase energy-efficient appliances in the form of rebates, grants, bonus-malus systems or tax credits.

Voluntary agreements and procurement

Voluntary agreements with manufacturers are currently one of the measures used to reduce the energy consumption of white goods.

Another interesting tool that can be used to promote energy-efficient cold appliances and washing machines is co-operative procurement. Co-operative procurement involves the joint purchasing of energy-efficient appliances by public and/or private buyers with large market volumes. The objective is clearly to create a market for energy efficient appliances, even in case they don't still exist, while launching a competition between manufacturers to deliver these new efficient appliances to a sufficient volume shaped market.

1.4 General specifications

The EU labelling policy is usually considered as a success in that it helped shape the market by informing the consumers and raising their awareness to efficiency issues. However, although the market shares of A class appliances have significantly increased since the implementation

of the Labelling Directive throughout the EU, in many countries the share of the most efficient ones (A++ or A+ for cold appliances and BAT, below 0.17 kWh/kg, within A for washing machines respectively) struggle to take off. Financial measures such as the Dutch rebate on topmost classes have proved effective in this regard.

Since all member states are under an obligation to comply with Energy Labelling Directive, the present method therefore refers constantly to the energy label. It is assumed that information concerning the energy consumption of these appliances can rely on the label. This information is the basis for the calculation of savings.

However the labelling scheme may be revised during the ESD assessment period. This method would need to be reworked accordingly.

Dishwashers are not targeted by this method since most appliances sold in the EU are already A labelled and no higher energy class exists. A revision of the energy label will define classes for most efficient appliances and the method may then be applied after adapting to the new labelling scheme.

Given the variety of situations of national markets, MS where national sales data are available are strongly encouraged to use level 2 evaluation.

1.5 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

=

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

Where:

- BL stands for the baseline, depending on the level of effort; for methods counting participants:
  - normal replacement:
    - a) if the objective is to calculate only additional energy savings[1]: 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 A++)
- F: correction factor reflecting the ratio of the consumption under the standard test conditions and the measured consumption in real life

[1] 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)

* 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 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.

- **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.

1.6 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	Cold appliances Default annual unitary gain between A+ and A++ =

additional energy savings in normal replacement cases. No EU default value is possible for the stock baseline, which is highly country-specific.	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.

1.7 Formula for total ESD annual energy savings

The unit of action in the case of white appliances is a unit of sold equipment. The total energy savings is therefore

(Equation S2)

Total ESD annual energy savings per type of appliance =

Average unitary gross annual energy savings of one appliance

*

number of sold appliances *

(1 – free-rider coefficient + multiplier coefficient)* (1- double-counting factor)

1.8 Indicative default value for energy savings lifetime

The following value is suggested as a harmonised value.

Energy savings lifetime: **EU harmonised values**	
EU harmonised	Efficient cold appliances : 15 years Efficient wet appliances : 12 years

These values are based on the report CWA 15693 of the CEN Workshop 27: saving lifetimes of energy efficient improvement measures in bottom up calculations and Annex A: Preliminary list of saving lifetimes commonly applied EEI measure types – 16 Efficient cold appliances – 17 Efficient wet appliances (April 2007).

1.9 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 national values (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 measure-specific (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 Introduction

2.1 Twenty bottom-up case applications of methods

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

This report deals with case application 5 "Energy-efficient cold appliances and washing machines" developed by ADEME.

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

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

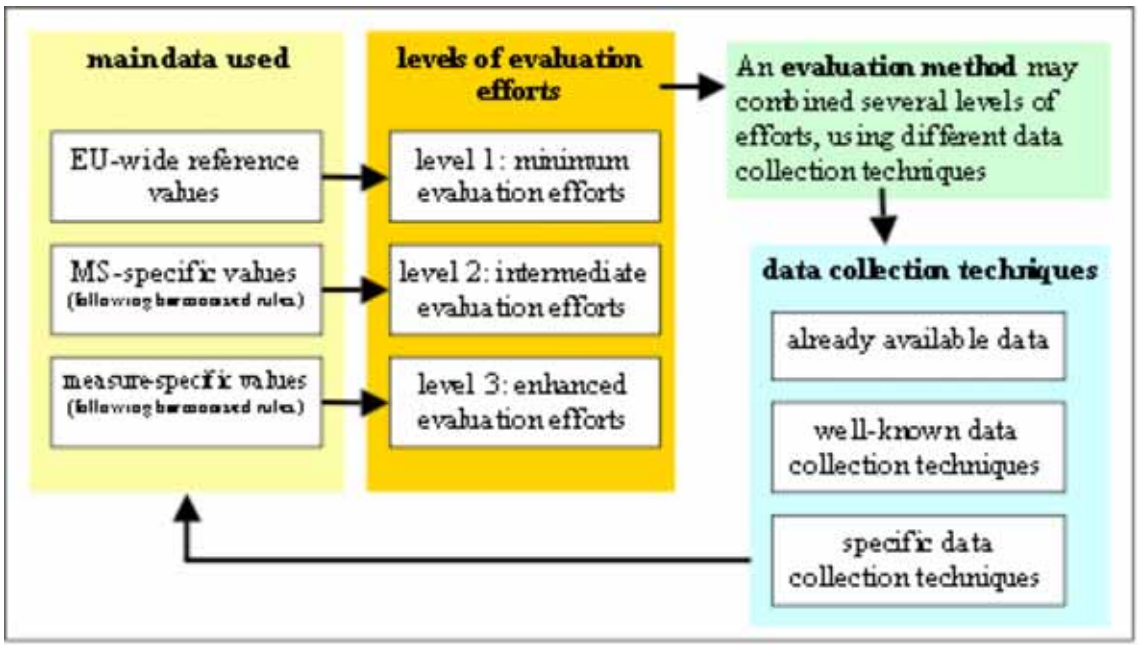
N°	End-use or end-use action, technology, or facilitating measure	Sector	Responsible organisation
1	Building regulations for new residential buildings	Residential	SenterNovem
2	Improvement of the building envelope of residential buildings	Residential	AEA
3	Biomass boilers	Residential	AGH-UST
4	Residential condensing boilers in space heating	Residential	Armines
5	Energy efficient cold appliances and washing machines	Residential	ADEME
6	Domestic Hot Water – Solar water heaters	Residential	AGH-UST
7	Domestic Hot Water - Heat Pumps	Residential	AGH-UST
8	Non residential space heating improvement in case of heating distribution by a water loop	Tertiary	eERG
9	Improvement of lighting systems	Tertiary (industry)	eERG
10	Improvement of central air conditioning	Tertiary	Armines

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

2.2 Three levels of harmonisation

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

Figure 1: Three levels of harmonisation



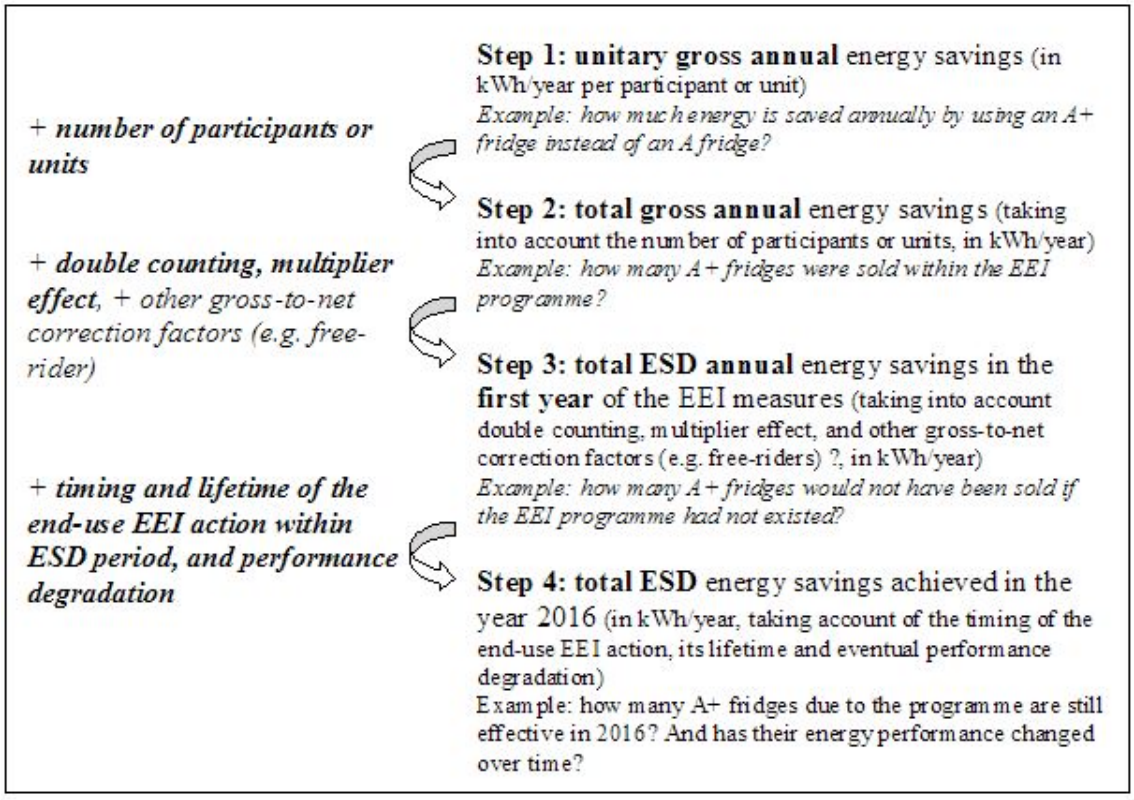
As a consequence, the EMEEES case applications for bottom-up evaluation methods present:

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

2.3 Four steps in the calculation process

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

Figure 2: Four steps in the calculation process



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

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

2.4 Pilot tests

Additional to the development of the 20 bottom-up case applications, some of these cases were tested in practice in Work Package 8.
Pilot tests of the following case applications were performed by EMEEES partners in Italy, France, Denmark, and Sweden:

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

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

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

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

3 Step 1: Unitary gross annual energy savings

3.1 Step 1.1: General formula and calculation model

For this method, the unit 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

=

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

Where:

- BL stands for the baseline, depending on the level of effort; for methods counting participants:
  - normal replacement:
    - a) if the objective is to calculate only additional energy savings[2]: 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 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 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.

[2] 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)

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.

3.2 Step 1.2: Baseline

- before/after EEI: current market inefficient average for additional energy savings; stock average for all energy savings (see also chapter 3.1).

level 1	**Market inefficient appliances baseline for EU Default value:** **<u>Cold appliances</u>** Average of A+ to C appliances on the EU market **<u>Washing machines</u>** Average of appliances with 0.17 kWh/kg or higher on the EU market No EU average stock baseline applicable
level 2	**<u>Cold appliances</u>** guidelines: *every MS should prove that its market situation differs from the average calculated as above – National value by national market analysis* **<u>Washing machines</u>** guidelines: *every MS should prove that its market situation differs from the average calculated as above* Stock baseline: based on stock model and past market data or consumer survey
level 3	If definition of BAT appliance is different in a measure, the market inefficient baseline needs to be calculated based on appliances that are not BAT of the measure

3.3 Step 1.3: Requirements for normalisation factors

Cold appliances:

A normalisation factor accounting for the influence of temperature on the consumption of cold appliances may be used only for level 3. Since level 2 efforts apply only at a national level, and hence with a limited geographical coverage, the influence of climate on the consumption of cold appliances may be considered as not significant for most countries.
However it is known that during summer higher temperatures might increase the consumption of cold appliances w.r.t. winter. Measurement campaigns may provide satisfying data on this topic, but it would be meaningful to apply such a normalisation factor only if the correction factor for real use conditions were known.

Washing Machine:

(new) normalisation factor 1:	
level 1	default coefficient. The normalisation today is based on those requirements: present normalisation; Washing temperature of 60°C/cotton/ full load/ number of cycle Future normalisation based on: Water temperature between 40-60°C/ mixed textiles/ Full charge-Medium Charge/number of cycle
level 2	guidelines: *if there is a specific water feed channel for solar heating water, the resulting energy saving could be higher.* *it is possible to document the number of washing machines concerned with this thank to market data.* data required: national survey
level 3	guidelines:as level 2 data required: as level 2

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

level 1	Deemed savings based on EU market surveys: average energy consumption of energy-efficient vs. not energy-efficient (sub-)classes of the EU energy label, weighted by market shares of energy efficiency (sub-)classes
level 2	Deemed savings based on MS market surveys: average energy consumption of energy-efficient vs. not energy-efficient (sub-)classes of the EU energy label, weighted by market shares of energy efficiency (sub-)classes
level 3	Mix of deemed savings and ex-post: Deemed unitary gross annual energy sacings based on average energy consumption of (measure-specific) energy-efficient vs. not energy-efficient (sub-)classes of the EU energy label, weighted by market shares of energy efficiency (sub-)classes ratio and length of advancement period of early replacements based on consumer survey

3.4.1 **Conversion factors** (when relevant)

- no conversion factors if energy savings are calculated as final energy
- If it they are calculated in primary energy, take into consideration the electricity production mix.

3.4.2 Considering the direct rebound effect

The direct rebound effect is not explicitly mentioned in the ESD. It is created by final energy consumers who increase the intensity of the use of energy-efficient equipment after an EEI measure, e.g., when the internal temperature of a building is increased after insulation. This reduces the energy savings achieved in comparison to the baseline of autonomous consumption changes. Consequently, including energy savings “eaten up” by the direct rebound effect in the total ESD annual energy savings would mean to include too high energy savings compared to the autonomous energy consumption changes. It has not yet been decided by the

European Commission and the ESD committee, whether this effect shall be included in the total ESD annual energy savings or eliminated from them. In the latter case, the following requirements apply.

Measurement campaigns (ex: REMODECE) have shown that despite of the use of very efficient equipments, they are often replaced with larger sized appliances, and the potential energy savings may be lower than it was estimated. The biggest part of this change is probably due to an ongoing growth trend happening anyway, but it may be enhanced by a rebate scheme for energy-efficient appliances. In the latter case, this would be a direct rebound effect. This is difficult to measure, which could be done either by surveys or by monitoring purchases of a participant group and a control group.
The same is the case for the question whether consumers are washing more often, when and because they know that they purchased an energy-efficient washing machine.
One direct rebound effect could be linked to the fact that it is easier for larger washing machines (6, 7 or more kg of capacity) to achieve the threshold of 0.17 kWh/kg. So an EEI measure to promote energy-efficient washing machines could accelerate the shift towards bigger machines.

3.4.3 From EMEEES tasks 4.2 to 4.3: defining values and requirements

3.4.3.1 Default values for energy consumption and/or related parameters

Parameters affecting the evaluation of the energy consumption are: Unit consumption provided by the label, which is the annual consumption under standard test conditions. Real consumption depends on a multitude of parameters such as the type and volume of food stored in the refrigerator/freezer, the storing temperature, the external temperature, the frequency of door opening, etc.
Past measurement campaigns in a number of countries of EU15 might provide an average correction factor, which may be applied for each energy class. Ongoing measurement campaigns such as Remodece can provide updated data for a number of member states.

- **cold appliances:**

The following benchmarks are identified for the purpose of Annex I of Directive 2005/32/EC. At the time of adoption of this regulation, the following values can be considered as BAT benchmarks for the products concerned in terms of their Energy Efficiency Index and Noise.

Refrigerator- compressor-type:

EEI=29,7 and an annual energy consumption of 115 kWh/year for a total storage volume of 300 l of resh food compartment

Refrigerators, absorption-type:

EEI: 97.2 and and an annual energy consumption of 245 kWh/year for a total storage volume of 28 l of fresh food compartment

Refrigerator-freezers, compressor type:

EEI: 28 and and an annual energy consumption of 157 kWh/year for a total storage volume of 255 l of fresh food compartment

The default value: default annual unitary gain between A+ and A++ = 61 kWh/year

- **washing machines:**

Parameters affecting the evaluation of the energy consumption: the energy label rating stands for wash performance, energy efficiency and spin-drying efficiency. The energy consumption is valid for standard test conditions: a 60°C cotton wash cycle at full load. The actual cycle energy consumption varies according to the selected programme, the washing temperature, the amount of load, etc.

Past measurement campaigns in a number of countries of EU15 might provide an average correction factor, which may be applied for each energy class. Ongoing measurement campaigns such as Remodece provide updated data for a number of member states. An average number of cycles per year must then be applied to work out the gross annual unit consumption. This data must be obtained from a consumer survey

The following benchmarks are identified for the purpose of Annex I, part 3 of Directive 2005/32/EC. At the time of adoption of this regulation, the following values can be considered as BAT benchmarks for the products concerned in terms of their Energy Efficiency Index and water consumption for the standard 60° cotton programme at full load.
Number of cycles: this parameter should be defined at level 2. As a default value, 1 cycle per week may be used, but this is very conservative. It is strongly advised to investigate the data with a consumer survey.

Washing machines with a rated capacity of 5kg:

Energy consumption of 0.830 kWh/cycle (or 0.166 kWh/kg)

Water consumption of 35 l/cycle

E.g., corresponding to an annual energy consumption of 183 kWh without considering the energy consumption of low power modes, and water consumption of 7.700 litres for 220 standard (or equivalent) cycles at full load.

Washing machines with a rated capacity of 8kg:

Energy consumption of 1.200 kWh/cycle (or 0.15 kWh/kg)

Water consumption of 52 l/cycle

Corresponding to an annual energy consumption of 264 kWh without considering the energy consumption of low power modes, and water consumption of 11.440 litre for 220 standard (or equivalent) cycles at full load.

The default unitary gain per cycle between A and energy-efficient appliances= 0.06 kWh/cycle

3.4.3.2 Requirements to define level 2 and level 3 values

Given the variety of situations of national market in the EU, with very strong differences in market shares and consumer behaviours, it is recommended to carry out the estimation of energy savings at least at level 2.

Efforts should be pushed to level 3 when the EEI measure uses financial incentives to promote most efficient appliances, such as rebates, tax credits, etc. In this case member states need to estimate the share of "best" and "early" replacements to evaluate the efficiency of the measure and its cost: this requires stock modelling and corresponds to level 3 of efforts.

For level 2 and 3, washing machine:

Washing machine temperature, load use and type of cycle are parameters that can affect the evaluated energy consumption. Surveys on users behaviour have to be done.

It is also important to know the market regarding the load of the washing machine (5kg/7kg).

For level 2 and 3, cold appliances:

Only the volume of the refrigerator can affect the evaluated energy consumption. Behaviour of the users regarding the way of use for the appliance can give some information on the consumption too. But it would be irrealistic to expect Member States implementing many of those surveys .

4 Step 2: Total gross annual energy savings

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

The unit of action in the case of white appliance is a unit of sold equipment. The total energy savings is therefore

Total gross annual energy savings

=

Average unitary gross annual energy savings per sold BAT appliance

*****

Number of sold appliances

Levels	**Cold appliance**	**Washing machine**
Level 1: Average annual energy saving/sold BAT applliance; Number of sold appliances	61 kWh/y/BAT appliance sold national value given by retailers (GFK, e.g., GIFAM)	0.06 kWh/cycle/ BAT appliance sold national value given by retailers (GFK, e.g., GIFAM)
Level 2 Average annual energy saving/sold BAT appliance; Number of sold appliances	National deemed average unitary gross annual energy savings value; Users consumption behaviour thanks to measurement campaigns Appliances sold / category (e.g., GIFAM)	
Level 3 Average annual energy saving/sold BAT appliance; Number of sold appliances due to measure(s) evaluated	Measure-specific deemed or monitored average unitary gross annual energy savings value; National representative measurement campaign all along the year to take into account the users habits and consumption with the climate Appliances sold / category (measure-specific monitoring or national association, e.g., GIFAM)	

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

Market surveys must be available on market shares of energy labels, whatever the type of measure implemented.
For measures with a financial incentive, the sold energy-efficient units can be counted directly. For measures with a personal advice (either direct, or by phone, or by internet), a survey of

contacts can identify the rate at which they purchased energy-efficient appliances after – and due to – the advice. For all other types of facilitating measures, the number of sold equipment must be evaluated from market surveys.

For level 3, a survey must take place at the retailers and/or participants. The type of replacement (better or early) and the role played by the EEI measure must be investigated when the appliance is purchased:

- which appliance would the customer have chosen if the EEI measure had not been in place (cf. step 3.5)?
- would the customer have replaced their old appliance?
- is it a purchase for replacement or multi-equipment?

5 Step 3: Total ESD annual energy savings

5.1 Step 3.1: Formula for ESD annual savings

Total ESD annual energy savings =

Total gross annual energy savings of cold appliances and washing machines

*

(1 – free-rider coefficient + multiplier coefficient)

*

(1 – Double-counting factor

5.2 Step 3.2: Requirements for avoiding double counting

White goods are already included in the EU energy labelling scheme, and there is a minimum energy performance standard for cold appliances. Furthermore, the EcoDesign Directive is expected to lead to a new minimum energy performance standards for cold and wet appliances, and possibly a revision of the EU energy label.

Therefore, double-couting with these measures is likely to be an issue. It will be smaller, if the method presented here is only applied to facilitating measures that promote A++ cold appliances and very energy-efficient washing machines. As noted above, energy savings from EuP requirements would and could be evaluated separately from those of (packages of) facilitating measures targeting BAT appliances.
In any case, two general recommendations can be made:

- Try to evaluate the effect of the whole package of facilitating measures that promote energy-efficient cold appliances and washing machines;
- Try to cross-check the results with a top-down evaluation using regression analysis of the diffusion indicators for the overall market share of the A++ cold appliances and the very energy-efficient washing machines, and/or for the average unit consumption of all appliances sold in a Member State market.

5.3 Step 3.3: Requirements for taking account of technical interactions

Washing machine:

We can find on the market washing machine equiped with two water feed channels. This device can be powered both by hot water from solar water supply and "normal" cool water. The heat replacement by a solar heating storage can have an effect on the energy savings as less energy is needed to heat washing water. The electricity consumption decreases and energy savings results become more interesting.

5.4 Step 3.4: Requirements for multiplier energy savings

Multiplier is a result of accelerated market penetration of the very energy-efficient appliances. This can either be evaluated through a market data (diffusion indicator) analysis, after the end

of a temporary facilitating measure, or through surveys of market actors (retail, manufacturers) and non-participants.

5.5 Step 3.5: Requirements for the free-rider effect

The free-rider effect is not explicitly mentioned in the ESD . Free riders are final energy users who are counted when monitoring the effects of facilitating measures but would have taken the end-use actions promoted also without the facilitating measure. Consequently, including energy savings achieved by free riders in the total ESD annual energy savings would mean to include a part of the autonomous energy efficiency improvements. It has not yet been decided by the European Commission and the ESD committee, whether this effect shall be included in the total ESD annual energy savings or eliminated from them. In the latter case, the following requirements apply.

Concerning this study, a partial free-rider effect occurs for white appliances as a consequence of the self-sustained evolution of the market: higher demand for energy-efficient appliances (recognised by the consumer through a higher energy class) contributes to a larger and more competitive offer of best technologies, thus attracting more consumers towards higher energy classes. It is assumed that consumers don't purchase appliances of an energy class lower than that of their previous appliance. Free-rider effect is therefore due to those consumers who would have purchased the most efficient appliances, even if the measure were not implemented. A survey of participants will be needed to evaluate the share of free riders. It can be complemented by an analysis of the market share of the most efficient appliances: has it increased faster with the measure than would have been expected in the trend? As the free-rider effect and the multiplier effect work into the opposite direction, they partly cancel out each other. Furthermore, even with extensive surveys and evaluation efforts, the uncertainty for these effects can remain high. For EEI measures or measure packages that have limited total gross annual energy savings (e.g., below 20 million kWh/year), it may therefore be considered to neglect both correction factors.

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

The ESD text is interpreted so that only for those EEI measures that have not reached the end of their energy saving lifetime in the years of the intermediate (2010) and final (2016) targets, energy savings will be counted towards a Member State's intermediate or final energy savings target under the ESD.

6.1 Requirements for the energy saving lifetime

The following value is suggested as a harmonised value.

Energy savings lifetime: **EU default/harmonised values**	
EU harmonised	Efficient cold appliances : 15 years Efficient wet appliances : 12 years

These values are based on the report CWA 15693 of the CEN Workshop 27: saving lifetimes of energy efficient improvement measures in bottom up calculations and Annex A: Preliminary list of saving lifetimes commonly applied EEI measure types – 16 Efficient cold appliances – 17 Efficient wet appliances (April 2007).

6.2 Special requirements for early actions

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

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

OR

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

Note:

If early energy savings are accepted, a contribution to the target in 2016 can only be counted if the energy saving lifetime is greater than 8 years plus the time between installation and 2008. This needs to be proven. The same holds, respectively, for the intermediate target in 2010.

Therefore, early energy savings could only be counted for the 2016 target for cold appliances from 2002, and for washing machines from 2005.

A proposal has been made to only count energy savings relative to the 2008 baseline for early energy savings. In the case of white goods, this would mean that only energy savings relative to the average energy consumption of A+ to D cold appliances and A to D washing machines on

offer or sold in 2008 could be counted towards the target. Hence, only a part of the energy savings from EEI measures that targeted A++ and A+ cold appliances, or washing machines of class A or better would count.

6.3 Reminder to treat uncertainties

Any value/result should be presented with at least a range of magnitude (min-max).

For each parameter included in the calculation model, it should be considered if uncertainties can be addressed through:

Cold appliance:

- level 1 effort: range of magnitude (min-max)

Annex III from a working document on directive 2005/32/EC “household refrigeration applainces” says:

“ the value measured on the first refrigeration appliance tested shall not be less than the rated value by more than 10%. If the results of the test carried out on the first refrigeration appliance is less than the rated value minus 10%, the test shall be carried out on a further three randomly selected refrigerating appliances. The arithmetical mean of the values of these three refrigeration appliances shall not be less than rated value by more than 10%”.

So we can assume that the range of magnitude for level 1 effort is 10%.

- level 2 effort: sensitivity analysis (pessimistic/optimistic scenarios)

The level 2 uncertainties is defined by the instrumentation of the measurement campaigns for actual energy consumption relative to standard energy consumption. It is also important to know the behaviour of the targeted panel; if it is above or below the average behaviour.

- level 3 effort: quantified uncertainties (confidence intervals)

Appendix I: Justifications and sources

General overview of EMEEES bottom-up methodology:

Vreuls, H., Thomas, S., Broc, J.-S., 2009. *General bottom-up data collection, monitoring, and calculation methods, Summary report.* SenterNovem, Sittard, Wuppertal Institute, Wuppertal, ARMINES, Nantes

Default values for annual unitary energy savings :
Unit consumption of A+ cold appliances and A and A+ washing machines is based on the online catalogue (2006) of French retailer Darty: www.darty.com, taken as the average of appliances of that class on offer.
Unit consumption of A++ cold appliances is obtained from the average of unit consumption of appliances from the TopTen website (http://www.topten.info/).
The energy efficiency index does not vary much from one appliance to another and is assumed to remain stable until a new labelling scheme is set up, since it aims the upper boundary of the efficiency class. What may change is the size and functionalities of appliances on offer, which has an impact on the unit consumption. Therefore it is recommended to work it out when the measure is to be implemented.

Default values for energy consumption and/or related parameters:
Sales unit consumptions by efficiency class are based on the same source as above. The same precaution applies to the evolution of other characteristics such as the size, and the values should be worked out again if possible.

Requirements for savings lifetime
Report CWA 15693 of the CEN Workshop Agreement (CWA) 27: saving lifetimes of energy efficient improvement measures in bottom up calculations, April 2007