evaluate energy savings

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

EMEEES bottom-up case application 11:

Office equipment

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Fraunhofer ISI

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evaluate energy savings EU

coordinated by

Wuppertal Institute for Climate, Environment and Energy

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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:

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 11: Office equipment

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Contents

1 Summary

1.1 Title of the method

Harmonised bottom-up evaluation methods for office equipment.

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

1.2 Type of EEI activities covered

End-use (EEI) action	
Sector	Tertiary
Energy end-use	Office equipment: Personal computers (destops, laptops, PDA), computer monitors, printers, copiers, scanner, multifunctional devices (MFD), modems, phones, fax machines, servers, workstations, networks (wired, wireless)
Efficient solution	Best available technology (BAT) (separately for each type of office appliance)
(EEI) Facilitating measure	
Types of EEI facilitating measures	• Regulation (minimum equipment energy performance standards) • Informative and legislative-informative measures (information campaigns, voluntary energy labelling, mandatory energy labelling, training and education, metering) • Financial instruments (subsidies, tax rebates) • Voluntary agreements (with manufacturers) and co-operative instruments (technology and market procurement)

1.3 Detailed definition of EEI activities covered

The EEI activities are listed in section 0 ahead. Additional information includes:

Regulation

Legislative measures to influence the energy consumption of ICT appliances primarily involve maximum consumption or minimum energy efficiency standards. Up to now, most of these regulations mainly apply to large domestic appliances ("white goods"), light sources, air-conditioning appliances, motors or boilers. But on principle, binding energy consumption target values for office equipment (e.g. copiers, computers), as they are already laid down in Japan for instance, are a possible regulative EEI activity. However, if these minimum energy efficiency standards will be set under the European "Framework Directive for the setting of eco-design requirements for **E**nergy **u**sing **P**roducts (EuP)" (2005/32/EC), the impact of this measure may become part of the baseline and not be counted as ESD energy savings. If the ESD Committee

decides to count the impact of EuP minimum energy efficiency standards as ESD energy savings, they will probably be monitored with a top-down indicator method, compared to a baseline trend that would have materialised without the EuP measure. In any case, an EuP minimum energy efficiency standard will influence or even set the baseline for other EEI measures that promote BAT for the same types of office equipment, in order to make the regulation dynamic.

Informative and informative-legislative measures

An important informative instrument with regard to office equipment is the mandatory or voluntary labelling of energy consumption. The most important voluntary label to reduce energy consumption of office equipment is the Energy Star label. These labels do not only fulfil an independent information function for the buyers and users of the appliances, but also serve as an important base for the design of further measures such as joint procurement activities, financial incentives, setting up databases for energy-efficient appliances or carrying out information campaigns. A mandatory labelling of office equipment could possibly be introduced in the course of the planned revision of the European Framework Directive 92/75/EC on Energy consumption labelling.

General information programmes and campaigns have an important concomitant function within the scope of measures to promote the energy efficiency of electrical and electronic appliances. They can both aim at increasing the share of energy-efficient office equipment and at influencing user behaviour. Educational and vocational training programmes are mainly aimed at companies, at both the users of the appliances as well as the planners, buyers and vendors.

Financial instruments

Providing financial incentives to purchase energy-efficient appliances in the form of rebates, grants, bonus-malus systems or tax concessions concentrated up to now on large electrical domestic appliances and lighting and not on ICT appliances. An energy efficiency effect can be achieved in principle using financial incentives if these are temporary and strictly tailored for specific target groups. The main drawbacks of financial incentives can be the comparatively high costs of the programmes for the programme operator. Therefore, financial incentives are most appropriate for stimulating end-use actions with higher unitary annual energy savings, for which the financial incentive can be visible in size but small compared to the total potential energy cost savings. Such cases are not very common for ICT appliances.

Voluntary agreements and co-operative instruments

Voluntary agreements with manufacturers are currently one of the predominant measures to reduce the energy consumption of ICT appliances. Since these usually involve appliances which are traded throughout the EU or worldwide, these agreements are mainly made at the level of the European Union.

Procurement is a suitable instrument for the promotion of energy-efficient office appliances because there is a large demand for such appliances and they are replaced quite frequently. Procurement involves the purchasing of energy-efficient appliances by public institutions (public procurement), or joint purchasing by private and public buyers with large market volumes (co-operative procurement), either with the objective of bringing new efficient appliances onto the market (technology procurement), or the objective of increasing the market share of particularly efficient appliances (market procurement). Since the technical possibilities to reduce energy consumption are already known for many ICT appliances and indeed have already been employed for individual appliances, the market procurement, i. e. increasing the market share of these appliances through joint purchasing activities, will probably have greater significance for office equipment.

1.4 General specifications

First of all, the term "office equipment" has to be defined with more detail. Under the term "equipment" are covered "end-use devices" as well as "infrastructure". The calculations of energy savings should be done at the level of devices, and not and not for the whole equipment level. The main ICT end-use devices in offices, to which this methodology could refer, are:

- Personal computers (desktops, laptops, PDA)
- Computer monitors
- Printers
- Copiers
- Scanner
- Multifunctional devices (MFD)
- Modems
- Phones
- Fax machines

The most important ICT infrastructure in offices are:

- Servers and workstations
- Wired and wireless networks

The ICT infrastructure in offices could become an important field for EEI activities in the tertiary sector under the ESD, because there has been enormous growth in server use and related energy consumption in EU-27 during the last years which is expected to continue.

One important characteristic of IT appliances is that the technical specification is very similar all over Europe or even world-wide. This means that with regard to energy data per appliance, European values (level 1) could be sufficient. At the moment, the only policy in place at the European level with regard to office equipment is the Energy Star label, which is a voluntary label. This means that up to now, no special conditions are required for the energy savings to be eligible. In future, this situation will probably change since all office appliances mentioned above are affected by the EuP Directive. As soon as minimum efficiency standards for these appliances will be set under the EuP Directive, these standards could be taken into account as the baseline in the calculation of further energy savings from other measures stimulating market uptake of BAT. The same applies to the planned revision of the Energy Labelling Directive, if a mandatory energy label may be introduced in the course of the revision process. Up to now, the EuP Preparatory Studies on Personal Computers and Computer Monitors (Lot 3) (www.ecocomputer.org), on Standby and Off-mode losses (Lot 6) (www.ecostandby.org) and the study on Imaging equipment (copiers, faxes, printers, scanners, multifunctional devices; Lot 4) (www.ecoimaging.org) are already completed. These studies represent a good data source for level 1 data for ICT end-use devices in offices. For ICT infrastructure, the data situation is more difficult. Recent studies including data on the stock and energy consumption of servers are available for the U.S.[1] and Germany[2] and from an ongoing EU-IEE project on energy-efficient servers (www.efficient-servers.eu).

With regard to the measurement of the power consumption of ICT end-use devices in offices, a distinction between active mode (or on mode) and standby mode is advisable, since the energy savings potentials are different for these modes. Besides, there are EEI activities which only refer to the reduction of standby consumption of office equipment (e.g. standby campaigns or standby labels). However, as yet there is no uniform definition of the operating modes, the term "standby", in particular, is used inconsistently. For the purpose of the ESD Directive, it is proposed to use the standby definition in the EuP Preparatory Study on standby and off-mode losses of EuP's (Lot 6) (www.ecostandby.org), since this definition seems to be most compatible with

1 Koomey, J. G. (2007): Estimating Toal Power Consumption By Servers in The U.S. And the World. LBNL, CA USA. http://www.enterprise.amd.com/Downloads/svrpwrusecompletfinal.pdf.

2 Fichter, K. (2007): Zukunftsmarkt Energieeffiziente Rechenzentren. Borderstep Institute, Berlin, Germany http://www.borderstep.eu/pdf/Studie%20Zukunftsmarkt%20energieeffiziente%20Rechenzentren%20final-2007.pdf

the usual interpretation of standby with regard to EEI activities. In Lot 6, the active mode defines the condition in which the device provides one or more main functions, whereas in standby mode the device draws energy and offers a selection of reactivation and continuity functions (see Figure 1-1). The off-mode both includes soft off (the device is turned off but still connected to the mains and draws energy) and hard off without losses. For ICT infrastructure in offices, this distinction is not necessary since these systems normally only have an active mode.

Figure 1-1: Definition of operation modes in the EuP Preparatory Study on Standby (Lot 6)

Report for Tender No. TREN/D1/40 Lot 6 -2005 EuP Lot 6 - Task 1 2nd of October 2007

Table 1-1: Main Lot 6 modes and allocation to most relevant IEC standards

Lot 6 Modes	Active Modes	Transition to standby and off-mode	Lot 6 standby (Passive or Networked)	Off-Mode losses	Off-Mode 0 Watt	Disconnected
Functions	At least one main function continuously on / active Time limited function cycle, programmable job	One or more main functions are off (typical energy save or ready modes) Active Network Download	Reactivation Function: Remote Control, Sensor, Timer, Switches Continuity Function: Display, Memory, Safety Network (→Networked standby) Wake-up and status only	No function (except reactivation switch)		

For the measurement of power consumption, test standards have to be taken into account which provide common rules for the measurement and are approved by a recognized standardization body. However, a single test standard or procedure for measuring power consumption (on mode and standby mode) of office equipment as well as for calculation of daily or annual consumption does not exist up to now.

Country-specific data (level 2) for office equipment are mainly important to determine the activity factors (number of office appliances) and maybe behavioural factors (time of use, usage habits) for the calculation of total annual energy savings. With regard to the power input, country specific data can be used, if available, but the technical specification of office equipment should be very similar in Europe, so that level 1 values can be used, too.

1.5 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:

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

(equation S1a)

The resulting formula for the standby mode is:

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

(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.

1.6 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 1.2** 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 1-1 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 1-1).

Table 1-1 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 1-2 shows the corresponding unitary gross annual energy savings for computers and monitors which are calculated based on the default values in Table 1-1 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 1-2 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 1-1 and using equations S1a and S1b (original calculation without safety factor of 0.8)

1.7 Formula for total ESD annual energy savings

In order to calculate the total ESD (net) annual energy savings, first of all the total gross annual energy savings have to be calculated by summing up the number of EEI actions which have been carried out under a specific EEI facilitating measure. In this case, this means the substitution of less efficient office appliances (all types, active mode and/or standby mode) by BAT technologies (mainly normal replacement, possibly also early replacement). In a second step, if all correction factors are included, the formula for the total ESD (net) annual energy savings will read:

Total ESD annual energy savings =
*total gross annual energy savings of all office equipment * (1-free-rider coefficient + multiplier coefficient) * double-counting factor*

(equation S2)

1.8 Indicative default value for energy savings lifetime

The following value is suggested as a default or a harmonised value.

Energy savings lifetime: **EU default/harmonised values**	
EU default	According to final CWA draft of 15 Febr. 2007 (CEN WS 27): • Value for all energy efficient office appliances: **3 years** According to EuP Preparatory Studies (Lot 3 and 4): • PC desktop office: 6.6 years[1] (without 2nd life: 6 years) • PC laptop office: 5.6 years[1] (without 2nd life: 5 years) • Computer monitor office: 6.6 years[1] (without 2nd life: 6 years) • Electro Photography (EP) printer and EP copier: 6 years • Inkjet (IJ) printer, IJ MFD, scanner: 4 years • Fax: 8 years

[1] Average economic lifetime including second life

Office equipment belongs to a group of EEI actions with an energy savings lifetime "< 10 years". EEI measures aiming at these actions will not always contribute to the ESD target in 2016. For instance a measure implemented in 2010 with a saving lifetime of 5 years will have disappeared by 2016. Earlier implemented measures with a short lifetime will have disappeared anyway in 2016.

In the CEN Workshop agreement (CEN WS 27), the preliminary energy savings lifetime for all office appliances is settled at 3 years. Compared to the 9-year period of the ESD Directive, this lifetime is very short and means that many measures aiming at the energy efficiency improvement of office equipment will not contribute to the ESD target in 2016. In the EuP Preparatory Studies on PCs, computer monitors and imaging equipment, the average economic lifetime of these appliances is assumed to be longer, in general between 4 and 6 years. These values are based on literature data and opinions of the suppliers. Since the very short lifetime of 3 years for office equipment could be a clear obstacle to carry out EEI measure aiming at office appliances, the lifetimes assumed in the EuP Preparatory Studies are suggested in this case study.

1.9 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 EI 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 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 11 "Office equipment" developed by Fraunhofer-ISI.

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:

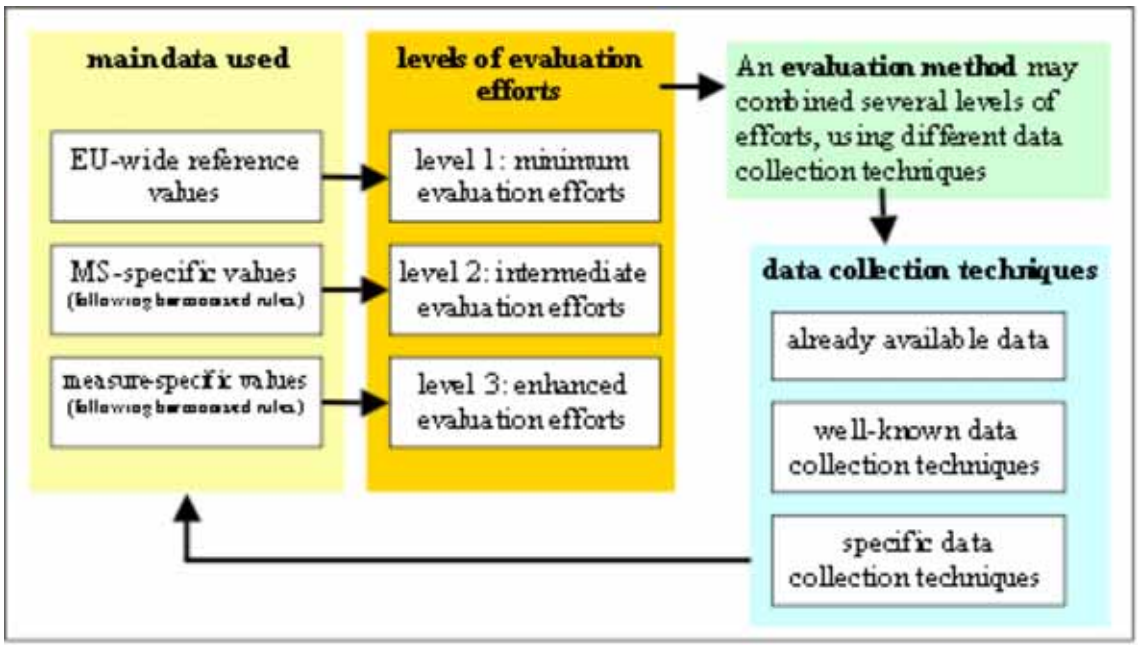
N°	End-use or end-use action, technology, or facilitating measure	Sector	Responsible organisation
1	Building regulations for new residential buildings	Residential	SenterNovem
2	Improvement of the building envelope of residential buildings	Residential	AEA
3	Biomass boilers	Residential	AGH-UST
4	Residential 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



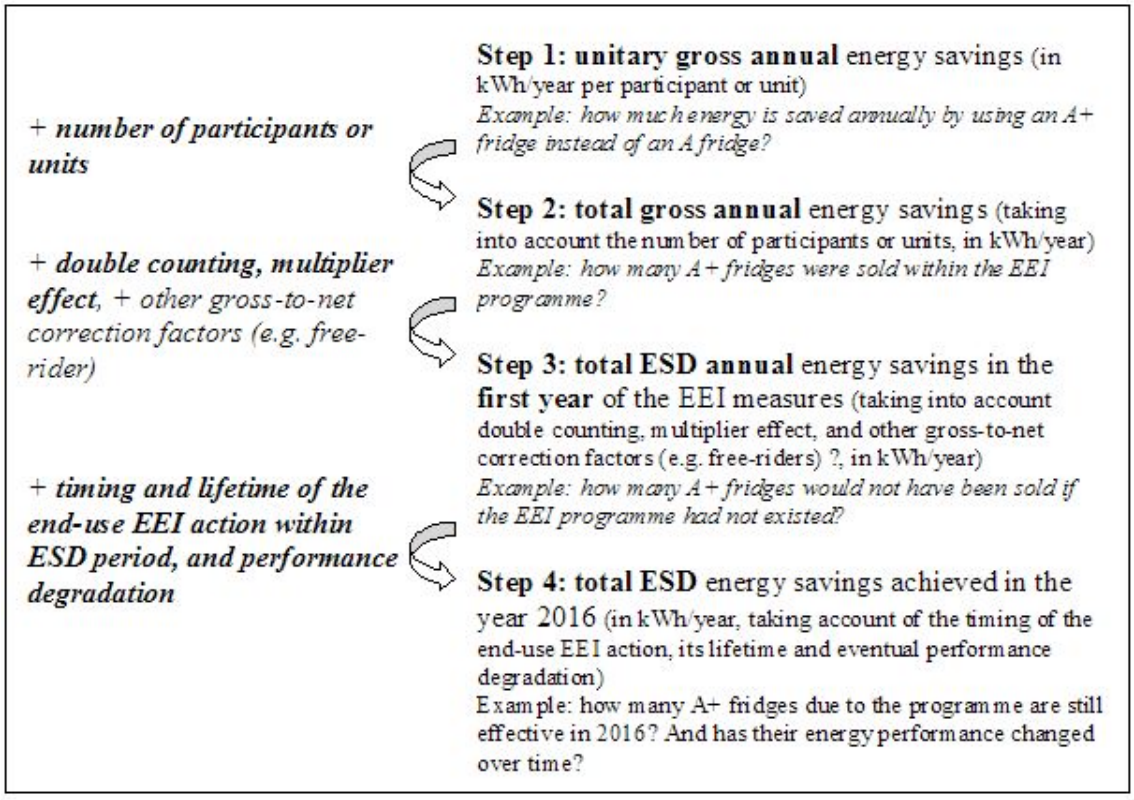
As a consequence, the EMEEES case applications for bottom-up evaluation methods present:

- 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 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:

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

(equation 1a)

The resulting formula for the standby mode is:

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

(equation 1b)

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, depending on whether future minimum energy efficiency standards under the EuP Directive are taken into account or not:

1) Without minimum efficiency standard: BL = market average of appliances excluding BAT
2) With minimum efficiency standard: BL = standard set under EuP Directive; Note: 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.

3.2 Step 1.2: Baseline

For office equipment, the standard baseline should represent average annual working hours and the energy efficiency of the market average of office appliances excluding BAT, distinguishing between active mode and standby mode.

In principle, the method will thus calculate energy savings additional to this baseline. If the objective is to calculate all energy savings in the case of the replacement of an existing piece of equipment, in principle the baseline should be the average energy consumption of the stock. However, this will in most cases not be known and will also be similar to the market average of the same type of office appliances excluding BAT, due to the short lifetime of office equipment. We therefore propose to always use the market average of office appliances excluding BAT as the baseline.

However, 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.

level 1	**Default:** European average working hours and power input (active mode, standby mode) of the market average by type of office equipment. **Data source:** Relevant EuP studies for office equipment (Lot 3, Lot 4, Lot 6)
level 2	**Guidelines:** Baseline should be based on MS national data, in any case for working hours. Since the technical specification of IT appliances is very similar all over Europe or even world-wide, for the power input European values (level 1) could be sufficient at level 2, too. **Data needed:** National working hours and perhaps national data on power input for the market average. **Data source:** National statistics, surveys, samples.
level 3	**Guidelines:** Baseline should be based on data specific for the EEI measure. **Data needed:** Target-group specific average working hours and power input. **Data source**: New measurements or previous data collections.

3.3 Step 1.3: Requirements for normalisation factors

For office equipment, normalisation factors are less important, since both the technical specification and the usage of these appliances are relatively independent from the country. The average working hours are a potential normalization factor, but they are difficult to monitor. Therefore, no normalisation should be required.

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

level 1 and 2	Deemed estimates based on previous EU studies or national studies. Statistically adjusted engineering analyses could be an instrument to improve the default values.
level 3	Direct measurements: end-use load data metering, billing analysis

3.4.1 Conversion factors (when relevant)

n.a.

3.4.2 Considering the direct rebound effect

There is no evidence that a rebound effect is important in the case of office equipment.

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

The parameters which can affect the evaluated energy consumption in the case of office equipment are (see equations 1a and 1b):

- power input (active mode, standby mode) by type of appliance
- annual working hours

As an example, Table 3-1 shows European default levels for level 1 from previous EuP Preparatory studies.

3.4.3.2 Requirements to define level 2 and level 3 values

Country-specific data (level 2) for office equipment are mainly important to determine the activity factors (number of office appliances) and maybe behavioural factors (time of use, usage habits) for the calculation of total annual energy savings. With regard to the power input, country-specific data can be used, if available, but the technical specification of office equipment should be very similar in Europe, so that level 1 values could be used, too.

For the measurement of power consumption of more complex ICT equipment (server stations etc.) (level 3), test standards have to be taken into account which provide common rules for the measurement and are approved by a recognized standardization body. However, a single test standard or procedure for measuring power consumption (on mode and standby mode) of office equipment as well as for calculation of daily or annual consumption does not exist up to now. At least a suitable measurement equipment should be used, which also gives reliable values for low power consumption (especially in the case of standby).

Table 3-1 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).

4 Step 2: Total gross annual energy savings

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

The total gross annual energy savings have to be calculated by summing up the number of EEI actions which have been carried out under a specific EEI facilitating measure. In case of office equipment, this means the replacement of less efficient office appliances (all types, active mode and/or standby mode) by BAT technologies (mainly normal replacement, possibly also early replacement).

$$Total\_gross\_annual\_energy\_savings = \sum_{i}^{n} [energy\_savings\_of\_OE\_i]$$

(equation 2)

Where:
OE = Office Equipment (unit)
i = Number of replaced office equipment.

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

The number of actions always has to be defined for the evaluated EEI measure (level 3 effort). The methods proposed for monitoring the number of actions are related to the EEI facilitating measures chosen (see Table 4-1).

Table 4-1 Proposed methods for monitoring the number of actions (level 3)

Direct accounting measures are particularly important in the case of • Financial measures • Energy Audits • White Certificate Schemes	**Possible methods** • Collection of accounting documents (e.g. invoices, vouchers) • registry/database to collect information about participants and end-use actions taken
Indirect accounting methods are particularly important in the case of • Minimum energy performance standards • Informative measures	**Possible methods** • surveys

5 Step 3: Total ESD annual energy savings

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

5.1 Step 3.1: Formula for ESD annual savings

The total ESD annual energy savings are calculated from the gross annual energy savings (equation 3). If all necessary correction factors are included, the formula for the total ESD (net) annual energy savings will read:

Total ESD annual energy savings =
*total gross annual energy savings of all office equipment * (1-free-rider coefficient + multiplier coefficient) * double-counting factor*

(equation 4)

5.2 Step 3.2: Requirements for avoiding double counting

The problem of double-counting occurs when different (EEI) facilitating measures are directed at the same end-use, in this case office equipment. Overlaps can occur only at the national level or between local, national and EU activities. In case of overlap, the decision to allocate the corresponding energy saving to the relevant EEI measure is up to the Member States.

There are several possibilities to address double counting when reporting the energy savings:

- The facilitating measures targeting the same end-use (here: office equipment) can be aggregated in a measure package, and only the savings of the total package are counted.
- Each targeted end-use is only associated with one specific facilitating measure. This is, however, difficult, since many EEI measures need accompanying measures in order to become effective (e. g. information programmes to promote financial programmes or standards).
- In the case of overlaps between national and EU measures (e.g. minimum efficiency standards under the EuP Directive), the EU standards could be taken into account in the baseline for the national measures. These national measures will then have the objective to promote BAT that is much more energy-efficient than the EuP standards (see Chapter 3.2).

5.3 Step 3.3: Requirements for taking account of technical interactions

Negligible in case of ICT equipment.

5.4 Step 3.4: Requirements for multiplier energy savings

In the case of office equipment, the main target of all EEI facilitating measures will be to achieve a higher market penetration of energy efficient office appliances and office infrastructure. In order to achieve this target, multiplier effects are important. Possible methods to assess the multiplier effect are surveys of participants, non-participants, retail trade, and manufacturers as well as sales data analysis.

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.

The main method to analyse free rider effects are surveys, using a sample of participants and non-participants in a specific EEI action. This is, however, a relatively costly measure and there will still remain doubts in the reliability of the answers of the respondents. The same is true for the multiplier effect.

In light of the difficulties of determining the free-rider effect and the multiplier effect, we propose that it should only be attempted to quantify them for EEI measures or measure packages that deliver more than 50 million kWh of total annual energy savings or, if that is not the case, more than 10 % of the national ESD target (cf. Vreuls et al, 2009). However, the two effects should in any case be commented on in qualitative terms in the reporting.

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

Office equipment belongs to a group of EEI actions with an energy savings lifetime "< 10 years". EEI measures aiming at these actions will not always contribute to the ESD target in 2016. For instance a measure implemented in 2010 with a saving lifetime of 5 years will have disappeared by 2016. Earlier implemented measures with a short lifetime will have disappeared anyway in 2016.

In the CEN Workshop agreement (CEN WS 27), the preliminary energy savings lifetime for all office appliances is settled at 3 years. Compared to the 9-year period of the ESD Directive, this lifetime is very short and means that many measures aiming at the energy efficiency improvement of office equipment will not contribute to the ESD target in 2016. In the EuP Preparatory Studies on PCs, computer monitors and imaging equipment, the average economic lifetime of these appliances is assumed to be longer, in general between 4 and 6 years (see Table 6-1). These values are based on literature data and opinions of the suppliers. Since the very short lifetime of 3 years for office equipment could be a clear obstacle to carry out EEI measure aiming at office appliances, the lifetimes assumed in the EuP Preparatory Studies are suggested in this case study.

Table 6-1: Proposed lifetimes for office equipment

Energy savings lifetime: **EU default/harmonised values**	
EU default	According to final CWA draft of 15 Febr. 2007 (CEN WS 27): • Value for all energy efficient office appliances: **3 years** According to EuP Preparatory Studies (Lot 3 and 4): • PC desktop office: 6.6 years[1] (without 2nd life: 6 years) • PC laptop office: 5.6 years[1] (without 2nd life: 5 years) • Computer monitor office: 6.6 years[1] (without 2nd life: 6 years) • Electro Photography (EP) printer and EP copier: 6 years • Inkjet (IJ) printer, IJ MFD, scanner: 4 years • Fax: 8 years

[1] Average economic lifetime including second life

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).

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.

Since the lifetime of office equipment only ranges between 3 and 6 years, early actions will not be important for this end-use. There is rather the opposite problem that even measures undertaken within the 9-year-period of the ESD cannot be counted as ESD savings due to the short lifetime of office equipment. This could prevent countries from undertaking measures in this field, though the BAT solutions in the case of office equipment are often cost neutral compared to less efficient appliances.

6.3 How to treat uncertainties

There is a certain degree of uncertainty in the data which are used for the calculation of energy savings at the level 1 and 2, which is mainly due to the fact that these figures represent average values. At level 3, if measurements are used, the rate of uncertainty depends on the quality of the measurement equipment, but should not be too big. Another problem is the technical development, which is very fast in the case of office equipment. The default values proposed here are based on previous studies and have to be adapted to the technical progress after some time.

If using the qualification of data sources from the Odyssee project (see Table 6-2), the data used in this method belong to the category B and the quality can be assessed as ranging from 1 to 2.

Table 6-2 Qualification of data sources used in the ODYSSEE project[3]

Category of source	Details
A	Official statistics: official statistics/surveys (national statistical office, Eurostat/AIE, Ministries statistics), model estimations used as official statistics, data "stamped" by Ministries
B	Surveys/ modelling estimates: consulting, research centres, universities, industrial associations
C	Estimations made by national teams

Quality grades for data
1 Good: low uncertainty
2 Medium: medium uncertainty
3 Poor: large uncertainty

3 www.odyssee-indicators.org

Appendix I: Justifications and sources

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