

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

EMEEES bottom-up case application 10: Improvement of central air conditioning (tertiary sector)

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evaluate
energy savings 

coordinated by



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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 la Développement des Méthodes et Processus Industriels (ARMINES)	FR
Electricité de France (EdF)	FR
Enova SF	NO
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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)	GR

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EMEEES bottom-up case application 10: Improvement of central air conditioning

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1 Summary

1.1 Title of the Method

Improvement of central air conditioning by Free cooling or use of BAT cold generating equipment

1.2 Type of EEI activities covered

End-use EEI action	
Sector	Non residential
Energy end-use	Summer air conditioning
Efficient solution	Introduction of free cooling, substitution of BAT cold generating equipment to equipment in place
EEI Facilitating measure	
Types of EEI facilitating measures	Subsidies, White Certificates, building codes following article 6 of EPBD

1.3 Detailed definition of EEI activities covered

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

The end-use action is the retrofit of a non residential building which is being cooled by a central system which also treats primary air (ventilation air). Two retrofit means are considered here : changing the cold generating equipment towards the present BAT (Eurovent-Class A) and introducing Free Cooling in systems using air as a cold distribution means. Why consider these two as priorities? Dealing with equipment the change to better level is clearly feasible when the cost of running the previous equipment becomes too high. The BAT corresponds to present Eurovent-class A equipment which is close to the LLCC. Dealing with air side options, it seems less cost effective to generate the double circuiting of air back to the plant to introduce heat / cold recovery as a retrofit option (if it does not exist) while free cooling (which captures a good part of the same gains) can be introduced with the addition of only one duct and one damper. Heat recovery has thus not been treated as a priority option here.

The retrofit aims at energy savings and should not degrade comfort level and internal air quality. For this reason, any change in ventilation should be treated with other methods (devoted to ventilation, e.g., as part of the method on variable speed drives; other, more complex changes are likely to be covered by

the method on energy audits). **The comfort level assumed here is called TAC- Total Air Conditioning.**

*The following comfort levels **cannot be treated** by the methods hereunder:*

NC- Natural Cooling which is obtained, day or night time, by forced-ventilation, when outdoor conditions permit cooling without any compression energy (there are no gains associated with the retrofits considered in the present method)

PC- Partial Cooling which is obtained with air conditioning equipment that provides partial control of the temperature with undersized systems (there are lower gains than computed here because of lower initial consumption). It is a level 2 estimate that will have to be done if we want to obtain the gains in a partial cooling system, on a national basis.

TC- Total Cooling, wherein the AC system provides full temperature control but no humidity control because the humidity component of energy use is not known (there are lower gains than computed here because of lower initial consumption). It may still be an acceptable assumption to use the TAC default values provided below also for level 1 of TC systems, because a safety coefficient has been introduced, but only until a better method is available for that case.

The following comfort level can be treated by the methods hereunder but the savings will be underestimated :

AAC- Advanced Air Conditioning, with a full control of internal air quality (dust, etc). These systems are particularly applied in hospitals or clean rooms in the electronic industry (there are higher gains than computed here because of higher initial consumption).

Some definitions may be added:

BAT (Best Available Technology) on the market is Eurovent-class A equipment, which is close enough to the LLCC (Lowest Life Cycle Cost) to be assimilated.

Free Cooling in systems using air as a cold distribution means that outside air is used instead of air treated by the AC system

SEC is Summer Electricity Consumption per square meter

SCL is Summer Cooling Load for one square meter

SSEER is system yearly COP, the ratio of SCL to SEC

CDD are the Cooling Degree Days, an imperfect but simple way of correcting SEC for climate

Δ SEC are energy savings estimates expressed in kWh/year/m²

1.4 General specifications

For the calculation of the energy savings, there are some conditions.

The energy savings will become eligible, if equipment performance is really known, which implies Eurovent certification. Level 1 is suitable for average climate of the country and average opening hours of offices and similar.

Special climates (deviating by several degrees from the national average) may require level 2 and 3 evaluation efforts. Comfort levels and occupancy hours differing from base case may also require survey and correction.

It is always possible to use well-documented country-specific energy data. For this method, new simulations taking into account the specific climate, if any, should be performed.

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 the square meter of non residential building being cooled, and the deemed energy savings estimates are expressed in kWh/year/m². They are called here Δ SEC.

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

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

unitary gross annual energy savings = Δ SEC given in the following table

(equation S1)

1.6 Indicative default value for unitary gross annual energy savings (when relevant)

The following values are suggested as default values. Values are in kWh/year/m². They have been obtained by simulation with the DOE 2 software. The limitation of the universe of simulations (three climates, with a building

adapted to local regulations) is the weakness of the method. However, this is only a default value. The default value of unitary savings per square meter Δ SEC is given in table 1 for moving cold generating equipment to Eurovent-class A, or for introducing free cooling in an air distribution system. Reversible (i.e. Winter) behaviour of the system is not included. It could both decrease or increase net energy savings, depending on the choices made by the MS (cf. chapter 3.4.2 on the rebound effect). It is recommended to analyse this for level 2 and 3 calculations.

Table 1: default values of unitary gross annual energy savings

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

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

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

¹ Based on last column of table 2 and default % gains of table 4 of detailed document

1.7 Formula for total ESD annual energy savings

If all correction factors are included, the formula for the total ESD (net) annual energy savings will read, as presented in section 5:

$$\text{ESD annual energy savings} = (\text{total gross annual energy savings} - \text{double-counted savings}) * (1 - \text{technical interaction factor} - \text{free-rider fraction} + \text{multiplier fraction})$$

(equation S2)

The technical interaction factor can be taken as zero, as long as we consider only cooling and do not integrate cooling gains with actions dealing with ventilation and heating.

1.8 Indicative default value for energy savings lifetime

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

Unitary annual energy savings: EU harmonised values	
Equipment	17 years
Free cooling	15 years

This value is based on CWA27.

1.9 Main data to collect

Data needed in calculation for EU values (level 1)	Corresponding data sources
Data 1 Area with introduction free cooling in an air distribution system	Field indication for instance in a White Certificate system, in a subsidy scheme, in an energy audit scheme with a follow up
Data 2 Area with upgrade of a chiller to Eurovent-class A	Field indication for instance in a White Certificate system, in a subsidy scheme, in an energy audit scheme with a follow up
Data 3 Area with upgrade of a large package or split to Eurovent-class A	Field indication for instance in a White Certificate system, in a subsidy scheme, in an energy audit scheme with a follow up
Data 4 Area with upgrade of a small split equipment to Eurovent-class A	Field indication for instance in a White Certificate system, in a subsidy scheme, in an energy audit scheme with a follow up
Data 5 Area with upgrade of an unknown cold generating equipment to Eurovent-class A	Field indication for instance in a White Certificate system, in a subsidy scheme, in an energy audit scheme with a follow up

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

Data 2 Comfort levels	Simulation on meteorological files and building data
Data 3 Special occupancy hours	Simulation on meteorological files and building data

2 Introduction

2.1 Twenty bottom-up case applications of methods

Within EMEES, 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 EMEES partners within task 4.2, and reference values were to be specified within task 4.3.

This report deals with case application 10 “Improvement of central airconditioning” developed by Armines.

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:

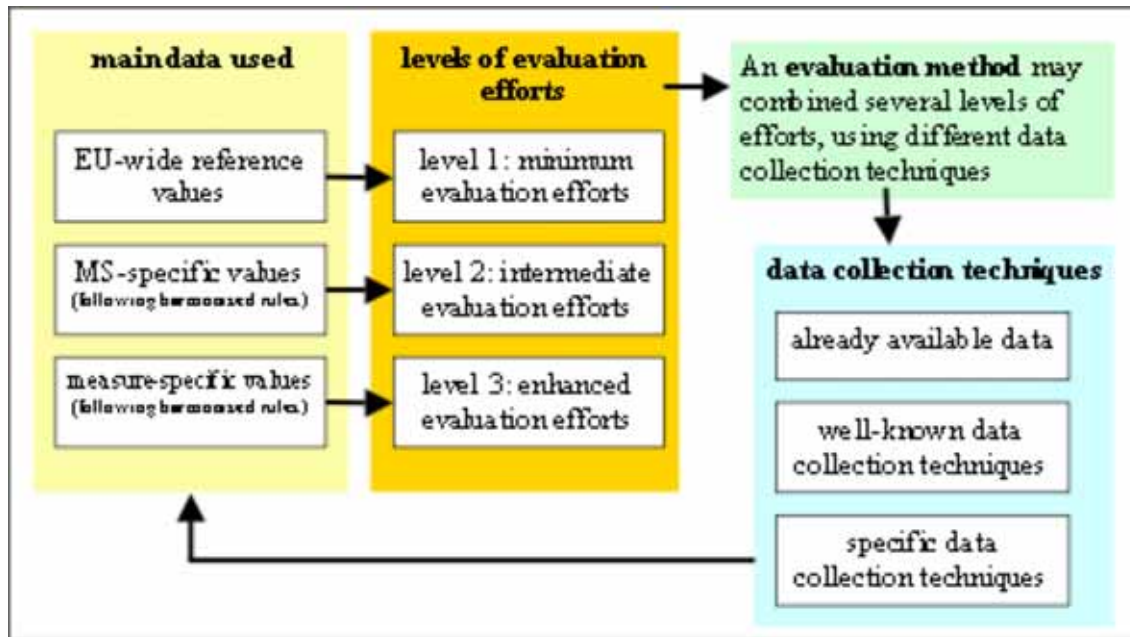
N°	End-use or end-use action, technology, or facilitating measure	Sector	Responsible organisation
1	Building regulations for new residential buildings	Residential	SenterNovem
2	Improvement of the building envelope of residential buildings	Residential	AEA
3	Biomass boilers	Residential	AGH-UST
4	Residential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



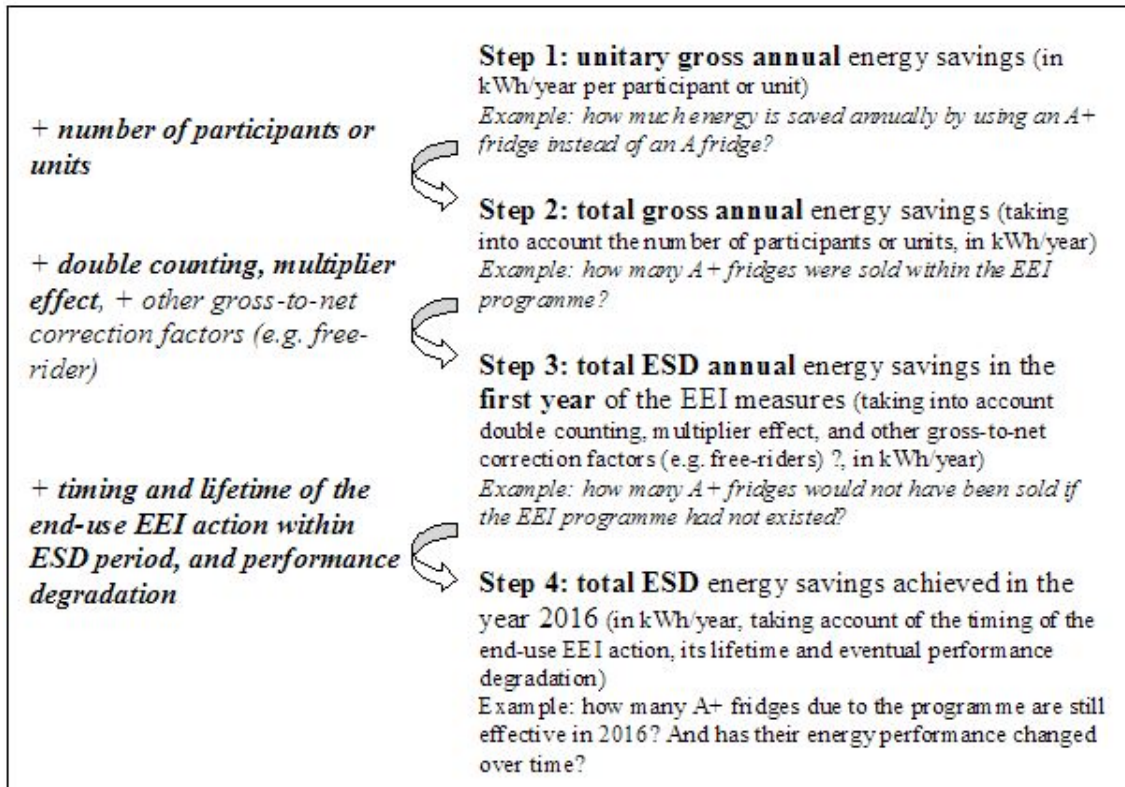
As a consequence, the EMEES case applications for bottom-up evaluation methods present:

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

2.3 Four steps in the calculation process

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

Figure 2: Four steps in the calculation process



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

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

2.4 Pilot tests

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

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

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

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

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

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

3 Step 1: Unitary gross annual energy savings

3.1 Step 1.1: General formula and calculation model

The “unitary” action is the retrofit of one square meter of non residential building which is being cooled by a central system which also treats primary air (ventilation air). Two retrofit means are considered here : **changing the cold generating equipment** towards the present BAT (Eurovent-Class A) and introducing **Free Cooling** in systems using air as a cold distribution means.

The retrofit aims at energy savings and should not degradate comfort level and internal air quality. For this reason any change in ventilation should be treated with other methods (devoted to ventilation, e.g., as part of the method on variable speed drives; other, more complex changes are likely to be covered by the method on energy audits). **The comfort level assumed here is**

*“**TAC- Total Air Conditioning**, which includes full control of temperature and humidity as well as provision of the minimum ventilation rate required for hygienic purposes but is not capable of attaining air purity conditions for specific IAQ (Indoor Air Quality) levels.”* (EECCAC definition, see also standard EN 12792)

The following comfort levels **cannot be treated** by the methods hereunder:

***NC- Natural Cooling** which is obtained, day or night time, by forced-ventilation, when outdoor conditions permit cooling without any compression energy (there are no gains associated with the retrofits considered in the present method)*

***PC- Partial Cooling** which is obtained with air conditioning equipment that provides partial control of the temperature with undersized systems (there are lower gains than computed here because of lower initial consumption). It is a level 2 estimate that has to be done if we want to obtain the gains in a partial cooling system, on a national basis.*

***TC- Total Cooling**, wherein the AC system provides full temperature control but no humidity control because the humidity component of energy use is not known (there are lower gains than computed here because of lower initial consumption). It may still be an acceptable assumption to use the TAC default values provided below also for level 1 of TC systems, because a safety coefficient has been introduced, but only until a better method is available for that case.*

The following comfort level **can be treated** by the methods hereunder **but the savings will be underestimated** :

AAC- Advanced Air Conditioning, with a full control of IAQ (dust,etc). These systems are particularly applied in hospitals or clean rooms in the electronic industry (there are higher gains than computed here because of higher initial consumption).

General Computation

The SEC (Summer Electricity Consumption per square meter), the SSEER (system yearly efficiency) and the yearly cooling demand SCL (Summer Cooling Load for one square meter) are computed by hourly simulation. For instance, before retrofit, SEC_{before} (Summer Electricity Consumption) equals $SCL_{before}/SSEER_{before}$. Here a default value of SEC to be used without simulation will be given on the basis of the simulations described in the report "Energy Efficiency and Certification of Central Air Conditioners (EECCAC) for the Directorate General Transportation-Energy of the Commission of the European Union, May 2003 ".

Both SCL and SSEER (and consequently SEC) are different between system types. For the sake of simplicity we have grouped system types in three categories :

- Water distribution : a fan coil unit in each room, with injection of prepared primary air
- Air distribution : Air Handling Units in technical rooms, only air inlets in the rooms
- Direct expansion : no carrier from a cold generating unit; the refrigerant is present in the room like in split air conditioners, with injection of prepared primary air.

After the retrofit both SCL (due to the introduction of free cooling) and SSEER (due to equipment improvement) may be changed. The new values enter into the equation $SEC_{after}=SCL_{after}/SSEER_{after}$. For one square meter the gain is $\Delta SEC = SEC_{before}-SEC_{after}$. We have directly obtained ΔSEC values from the tables in the EECCAC report. We may also express the savings as $SEC_{before} * Gain\%$, a percentage that has to be computed by hourly simulation or taken as a default for one country and sector.

The baseline SEC_{before} used in the calculations for table 1 represents the market average of new equipment without the efficient ones.

The list of normalisation factors to take into account (for unitary gross annual energy savings) is the following : detailed geographic information, schedule of use, comfort levels.

For this method, the unit is a square meter of non residential building which is cooled and on which certain specific actions have been applied.

unitary gross annual energy savings = Δ SEC in kWh/year and square meter to be read from a table, or computed in case of more combined changes

to be multiplied later by the area to which the action is applied, in square meter

A proposal for default values for Δ SEC based on the EECCAC study is presented in section 3.4.3.1.

3.2 Step 1.2: Baseline

level 1	<p>default baseline: <i>average EU market of cold generating equipment excluding best available technology (BAT, i.e., Eurovent-class A) defined in chapter 3.4 of EECCAC report; no free cooling in baseline</i></p> <p><i>After introduction of an EuP minimum energy efficiency requirement, the above or the level 2 and 3 baselines defined below and calculated for the year before the entry into force of the EuP requirement will be the baseline to calculate the energy savings due to the EuP requirement. After its entry into force, the EuP requirement will become the baseline for calculation of additional energy savings due to Eurovent-class A or whatever will be BAT equipment then.</i></p>
level 2	<p>guidelines: <i>to define a MS-specific baseline and savings values for national building types, possibly by economic sector, and/or for distinct national climates, a survey should be made to obtain the necessary data and then a simulation with DOE2 or TRNSYS should be performed; if the national building code has been tuned on simulations, it can be used in lieu of actual simulation;</i></p> <p>data required: <i>statistics of EER of equipment being sold, statistics on building envelopes features and equipment types and sizing, climatic data (or correction for altitude if it's a problem)</i></p>
level 3	<p>guidelines: <i>to define a measure-specific baseline, the participant buildings and equipment under consideration will be simulated with DOE2 or TRNSYS</i></p> <p>data required: <i>EER of equipment in place, exact building envelopes features and equipment types and sizing, specific climatic data (or closest station); if the national building code has been tuned on</i></p>

	<p><i>simulations, it can be used in lieu of actual simulation;</i></p> <p><i>We have not considered here the possibility of monitoring SEC before the improvement to generate a baseline because this would require more than one year of monitoring and the installation of meters on a large number of small equipment (fans, pumps, etc)</i></p>
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The baseline as defined would be a dynamic baseline. However, after EuP is in force, the former inefficient models on the market will vanish. Therefore, a hypothetical dynamic baseline without EuP may be set and adapted from time to time. Building individual baselines (level 3) will automatically be dynamic.

We consider that the average of the inefficient market is similar to the existing stock, so there is no systematic difference between the level 1, 2, and 3 calculations and between the baselines for all and additional energy savings in this case application.

3.3 Step 1.3: Requirements for normalisation factors

normalisation factor 1 detailed geographic information	
level 1	default coefficient: <i>Cooling degree days of the capital city of the country or the national average</i>
level 2	guidelines: <i>Cooling degree days of the capital city of the country and then of the exact location of buildings; proportional correction</i> data required:
level 3	guidelines: <i>to include the normalisation factor in calculation model or how to calculate a level 2 coefficient of normalisation, a simulation with a specific meteorological file or a computation with building codes data is possible</i> data required:

normalisation factor 2 schedule of use	
level 1	default coefficient:: <i>number of hours of occupation, 60 hours a week in the ΔSEC values in table 1</i>
level 2	guidelines: <i>the default correction would be proportional to number of hours of occupation, which is 60 hours a week in the ΔSEC values in table 1</i> data required:
level 3	guidelines: <i>simulation</i> data required:

normalisation factor 3 comfort levels	
level 1	default <i>coefficient</i> : TAC
level 2	guidelines: 50% of SEC, and hence 50% of ΔSEC in case of level TC data required:
level 3	guidelines: data required:

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

level 1	deemed savings obtained by simulation of typical situations
level 2	direct measurement ; billing analysis are not feasible simulation is recommended or use of the national building code if validated by a simulation, i.e., detailed engineering analysis
level 3	direct measurement ; billing analysis are not feasible simulation is recommended or use of the national building code if validated by a simulation

3.4.1 Conversion factors (when relevant)

n.a.

3.4.2 Considering the direct rebound effect

This section does not apply here because the decision process is split: somebody owns the equipment, somebody operates the system, somebody occupies the room. There is no possibility for the occupant to take into account the cost of the service in changing its behaviour.

The effects of using reversible units for heating in winter are not accounted in this calculation.

If the “before” situation already includes that a reversible unit is used for heating in winter, or a direct electrical resistance heating, there will certainly be additional energy savings for the heating from the energy-efficient system.

If the “before” situation does **not** include that a reversible unit is used for heating in winter, but the new, energy-efficient system will be used for heating, the result will depend on the choices made by the MS about the ESD conversion factor of electricity. If the MS decides to use a coefficient distinct from 1.00 like the one in annex 2 note 3 (2.50), there may be a gain or a loss depending on the climate, the reference heating system, and the value chosen for the conversion factor for electricity. If there is a higher energy consumption

compared to another, energy-efficient heating system, this will constitute a rebound effect.

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

After making all calculations, the default value of unitary savings per square meter Δ SEC is given in table 1:

- for moving all cold generating equipment to Eurovent-class A, whatever the equipment is
- for moving the generating equipment to Eurovent-class A, when we know what type of equipment it is
- for introducing free cooling in an air distribution system, if we know that we have retrofitted such a system

Reversible (i.e. Winter) behaviour of the system is not considered here. It could both decrease or increase net energy savings, depending on the choices made by the MS (cf. chapter 3.4.2 on the rebound effect). It is recommended to analyse this for level 2 and 3 calculations, at least for samples of buildings. Due to lack of data, no indication on trends is possible here.

Table 1: Level 1 unitary gross annual energy savings Δ SEC in KWh/year/m²

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

² Based on last array of table 2 and default %gains of table 4 of detailed document

Por	2,2	2,2	2,6	4,4	6,6
Spa	3,6	3,6	4,2	7,2	4,9
Swe	0,6	0,6	0,8	1,4	11,0
UK	0,9	0,9	1,0	1,8	11,8
Other	1,1	1,1	1,4	2,3	17,3

Such values are conservative with safety factor 0.8 applied, as compared with higher level methods described in detailed document. It has been calculated with 60 hours/week, which is conservative for offices, and needs correction for other sectors as explained in detailed document.

Retrofit BAT equipment is compared here to new market average **excluding** BAT. Since one default building per country is considered the list of normalisation factors may take into account more detailed geographical information, schedules of use of buildings which may differ from the typical one, comfort levels under the present one (TAC). For more complex changes in factors of use, the national building codes may give useful indications.

3.4.3.2 Requirements to define level 2 and level 3 values

More accurate default values of equipment performance and envelope characteristics, default SEC values are given in table 2; default values for % gains from tables 3 and 4 (values were obtained by simulation with DOE2 program and extrapolation based on CDD, as well as market statistics about equipment performance). To apply all these values to one m², one has to extract SEC from table 2, to compute gains by free cooling (if applicable) by multiplying SEC by the percentual gain of table 4, and then the gain due to equipment replacement by multiplying the remaining SEC (which is initial SEC minus free cooling gains) by the percentual gain of table 3. If there is no free cooling, table 3 will directly apply to SEC. The conservative coefficient of 0.8 will not be needed if we are using these levels.

Table 2: Default SEC values weighted over climates and sectors for countries of EUR 15

Country	(1)Direct expansion systems default SEC ³ (kWh/m ²), also used as a general default if system type is not known	(2)Water distribution systems default SEC ⁴ (kWh/m ²),	(3)Air Distribution systems default SEC ⁵ (kWh/m ²),
Aus	13,1	26,1	39,2
Bel	9,8	19,5	29,3
Den	7,1	14,1	21,2
Fin	7,5	15	22,5
Fra	16,3	32,6	48,9
Ger	11,4	22,8	34,2
Gre	24,2	48,3	72,5
Ire	9,8	19,5	29,3
Ita	25,1	50,1	75,2
Lux	9,6	19,1	28,7
Neth	8,9	17,7	26,6
Por	24,9	49,7	74,6
Spa	40,8	81,5	122,3
Swe	7,5	14,9	22,4
UK	9,9	19,7	29,6
Other	13,1	26,1	39,2

Note: We left here the original footnotes allowing the reader to confer to the EECCAC report .

Table 3: Default values of SEC gains in % as a function of cold generator type (from part 7.5 of EECCAC report)

End use measure taken	Gain% = factor to be applied to SEC _{before} (baseline) to obtain savings
Moving a chiller from average to Eurovent-class A ⁶	11%
Moving a large packaged or split equipment (not	13%

³ A factor 0.5 resulting from tables 5.5 a, b and c has been applied to the SEC of table 5.5d

⁴ equal to the SEC of table 5.5d

⁵ A factor 1.5 resulting from tables 5.5 a, b and c has been applied to the SEC of table 5.5d

⁶ This is an EER rating, not yet an SEER; however note that there is a check by Eurovent that equipment rated A is really A.

chiller) from average to Eurovent-class A	
Moving a small split equipment from average to Eurovent-class A	22%
Default value for moving unknown cold generating equipment to Eurovent-class A (to be used as a default if specific equipment type is not known)	11%
Default value for moving a mix of cold generating equipment to Eurovent-class A (a weighted average, to be used as a default for large programmes if specific equipment type is not known but is representative of market)	13%

Table 4: Gain due to free cooling for an air distribution system

Country	Gain% = factor to be applied to SEC _{before} to obtain savings
AU	55%
BE	53%
DE	53%
FI	61%
FR	27%
GE	52%
GR	12%
IR	50%
IT	12%
LU	56%
NE	56%
PO	11%
SP	5%
SW	61%
UK	50%
Other	55%

3.4.3.3 One example

Let's imagine we want to compute the savings realised by introducing a new chiller (Eurovent class A) and free cooling in an existing AC plant where distribution is done by Air Handling Units (with moisture control : TAC) in Italy.

Initially the SEC was 75.2 kWh/(year.m²). The SEC is reduced to 66.2 kWh/(year.m²) by introduction of free cooling and further down to 58.9 kWh/(year.m²) by the new chiller. So DSEC is 16.3 kWh/(year.m²).

4 Step 2: Total gross annual energy savings

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

- unit is square meter being conditioned
- for summing actions, the number of square meters of each type (system type, improvement performed) has to be determined

Total gross annual energy savings = Δ SEC (unitary savings) * number of relevant square meters

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

The number of actions (square meters) will always be known. The area actually conditioned may be ambiguous: the total cooled area **connected to the equipment** under consideration has to be known if we want to compute the savings associated with the purchase of **new cold generating equipment**, preferably by system type; the **exact cooled area of the air cooled zones** have to be known if we want to compute the savings associated with **free cooling**; as a default a percentage of 80% of the total constructed area of a building reported as “totally cooled” is actually cooled (due to the existence of lobbies, halls, etc); as a default, the “standing” zones of the buildings and meeting rooms may be considered as cooled through air distribution.

Such data can come from **declarations of field actors**, from a **white certificate scheme**, from a regulatory data base if the MS traces the implementation of **Article 6 of EPBD: Existing buildings** *“Member States shall take the necessary measures to ensure that when buildings with a total useful floor area over 1 000 m² undergo major renovation, their energy performance is upgraded in order to meet minimum requirements in so far as this is technically, functionally and economically feasible. Member States shall derive these minimum energy performance requirements on the basis of the energy performance requirements set for buildings in accordance with Article 4. The requirements may be set either for the renovated building as a whole or for the renovated systems or components when these are part of a renovation to be carried out within a limited time period, with the abovementioned objective of improving the overall energy performance of the building.”*

Some consistency could be generated here between the two directives. There is a risk of double counting: in the EPBD and through specific accounting. In case of reversible cooling, there is a specific risk of double counting the same equipment that we have suppressed by giving here only values for the gains in Summer.

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 total ESD annual energy savings

If all correction factors are included, the formula for the total ESD (net) annual energy savings will read:

$$\text{ESD annual energy savings} = (\text{total gross annual energy savings} - \text{double-counted savings}) * (1 - \text{technical interaction factor} - \text{free-rider fraction} - \text{multiplier fraction})$$

5.2 Step 3.2: Requirements for avoiding double counting

With the definitions made here (air conditioning gains only), there is less risk of double counting. For avoiding double counting, the effects of article 6 of EPBD on cooling, all gains resulting from air conditioners market transformation as well as all gains related with energy audits of air conditioning systems have to be tracked separately from the rest of national accounting.

As soon as an EuP minimum energy efficiency requirement enters into force, the energy savings from it will have to be calculated separately from the energy savings obtained by the use of BAT. This can be done by adapting the baseline as presented in chapter 3.2.

5.3 Step 3.3: Requirements for taking account of technical interactions

In case ventilation issues or heating benefits/rebounds of improved air conditioning are taken into account in some other methods, the interactions should be treated.

Technical interaction inside cooling is zero for the time being because some has been integrated in the previous step.

In the frame of the present method, the interaction between the two techniques considered is treated in the following way. First, SEC from table 2 is reduced for free cooling (which indeed reduces SCL) according to table 4 (or corresponding level 2 or level 3 simulations), then it is further reduced for the selection of BAT

equipment by applying table 3 values (or corresponding level 2 or level 3 simulations) to the reduced SEC, not the original ones. This avoids the problem.

5.4 Step 3.4: Requirements for multiplier energy savings

Unfortunately, there seems to be no multiplier effect in the retrofitting of air conditioning plants, one by one. For large facilitating measures specifically targeting BAT in air conditioning, it is recommended to conduct surveys and market analysis to find out, whether market uptake of BAT will be accelerated through the facilitating measures, leading to multiplier energy savings.

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.

There is no indication that the owners would implement spontaneously an improvement of Energy Efficiency of existing air conditioning plants, or would purchase replacement equipment better than the market average. However, for facilitating measures with a larger effect or as part of an overall national evaluation study, this should be analysed through surveys of samples of participants and non-participants and the end-use actions they have taken.

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

level 1	Harmonised values of CWA 27: 17 years for cold generating equipment replacement, 15 years for free cooling, assimilated to a ventilation option
level 2	Survey on renovated plants to determine their age
level 3	Best estimate of lifetime of new plant would be the age of the individual replaced plant

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.

Due to the very high harmonised values of CWA 27 (17 years for cold generating equipment replacement, 15 years for free cooling, assimilated to a ventilation option) there is a real possibility that MS claim savings realised before the 2008 to 2016 period. The performance of the market has been stable and there is no specific reason to lower those unitary gains.

6.3 How to treat uncertainties

The range of magnitude (min-max) can be estimated from the EECCAC report in some countries for which detailed simulation results are available in the report. Furthermore, the fact of using simulations and not field measurements increases the uncertainty.

In the qualification of data sources used in Odyssee project our data is B1. Anyway, EMEEES results will only be indicative. Then the Art. 16 Committee and/or the European Commission will decide what should be recommended and/or required, and what remains only advice.

Appendix I: Justifications and sources

“Energy Efficiency and Certification of Central Air Conditioners (EECCAC) for the Directorate General Transportation-Energy of the Commission of the European Union, May 2003 “.