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

EMEEES bottom-up case application 1: Building regulations for new residential buildings

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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 la 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	DK
Centre for Renewable Energy Sources (CRES)	EL

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Contents

1 Summary

1.1.1 Title of the method

Building regulations for new residential buildings

1.1.2 Type of EEI activities covered

End-use EEI action	
Sector	(new) residential buildings / households
Energy end-use	heating, cooling, hot water, ventilation
Efficient solution	insulation of the building envelope, energy performance standard (facade, windows, roof, cellar top)
EEI Facilitating measure	
Types of EEI facilitating measures	regulations: e.g. building codes, standards

1.1.3 Detailed definition of EEI activities covered

- Building code involving an overall energy performance standard; or
- Building code involving standards for separate energy efficiency measures

The measures supporting a smooth implementation of a building code, such as control and enforcement, training of building designers and building industry staff, are included.

This method only deals with the building regulations that ensure a minimum energy efficiency performance.

There are often also measures aiming at market introduction and uptake of better building technologies leading to higher performance than the current building code. These are also preparing future revisions of the building code. Such measures can be evaluated using the same method, but with applying the levels required by the current building code as the baseline, since the aim of these measures is to exceed the requirements of the current building code.

1.1.4 General specifications

- Since this case aims at evaluating national or regional buiding codes a level 1 method cannot be applied here
- Conditions requiring level 2 efforts
- Savings are calculated with respect to a baseline reflecting the autonomous development of energy efficiency measures. It is assumed that this autonomous development is flat (zero increase). The baseline is the situation in a MS at moment when the building codes with respect to energy efficiency are implemented for the first time, while this can not be prior to 1995. I.e., in

Member States that already had a building code in 1995, the requirements of this code will form the baseline.

- Energy savings are eligible for the duration of > 25 years for building cohorts for which the building codes are more stringent than the baseline.
- A time-lag must be taken into account for new building codes to take effect in building production of the MS (default value 2 years).
- Non-compliance with the building code should be taken into account. A default value of 10% non-compliance (meaning an 10% increase of the calculated energy use) is proposed in order to compensate for non-compliance with the building code.
- If in a MS building codes with respect to energy efficiency are implemented for the first time and the MS claimes that the building code is more stringent than the building practice before implementation, the MS is required to substantiate this claim. This can be done by providing a documented estimate of the average energy efficiency improvement (or the average improvement of the energetic properties of the individial energy efficiency measures) for the standard type(s) of dwelling(s) since the implementation of the new building regulation regulation.

The main unit for this method can be either m^2 of conditioned floor space, or a flat, a building, dwelling, etc., depending on the data availability. Using m^2 of conditioned floor space as the unit is preferable, since using a dwelling or building as the unit means averaging over the size, which introduces another factor of uncertainty.

In the formula(s) given below an interaction-effect is included to express the fact that the unitary final energy demand is not simply the summation of effects of separate measures (i.e. insulation and efficiency of the heating system). It is assumed that the national models developed for the calculation of the energy performance of buildings take interaction effects into account.

1.1.5 Formula for unitary gross annual energy savings

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

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

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

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

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

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

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

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

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

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

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

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

ie = Interaction effect

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

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

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

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

1.1.7 Formula for total ESD annual energy savings

Level 2: $TNFES = \sum_{i=1}^{c} (UFED_{0i} - nc \times UFED_{1i}) \times n_i \times (1 - re)$

Where: TNFES = Total Net Final Energy Savings

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

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

re = Direct rebound effect (default value is 0)

i = Dwelling class (1 thru c)

nc = non-compliance parameter (1 + percentage higher energy use as a result of non-compliance with the building code; default value is proposed to be 1.1)

n_i = The number of units in class i (total m^2 or total number of dwellings)

Level 3: Method applied on individual buildings or unitary energy savings directly measured

1.1.8 Indicative default values for the lifetime

EU default/harmonised values	
Energy savings Lifetime Default/harmonised	Insulation: building envelope - >25a (harmonized) Windows/glazing - 24a (harmonized) [Small boilers - 17a (harmonized)] [Large boilers - 17a ((default)] Energy performance standard - 25a

Remark: Ventilation system measures are taken into account in the calculation of the energy performance of buildings. In the the CEN workshop agreement, ventilation in residential buildings is not mentioned as a separate EEI measure.

When the building codes refer to an integral EP-measure, in effect this means a package of separate EEI measures. These measures have a savings lifetime in the range from 10 to >25 years. The most important components, insulation and glazing have a very long savings lifetime. For heating and cooling systems the savings lifetime is less than 25 years. We propose to use a long savings lifetime of 25a for the energy performance standard, since we expect future replacement of heating and cooling equipment to involve more energy efficient installations than the present generation.

1.1.9 Main data to collect

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

2 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 1 “Building regulations for new residential buildings” developed by SenterNovem.

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:

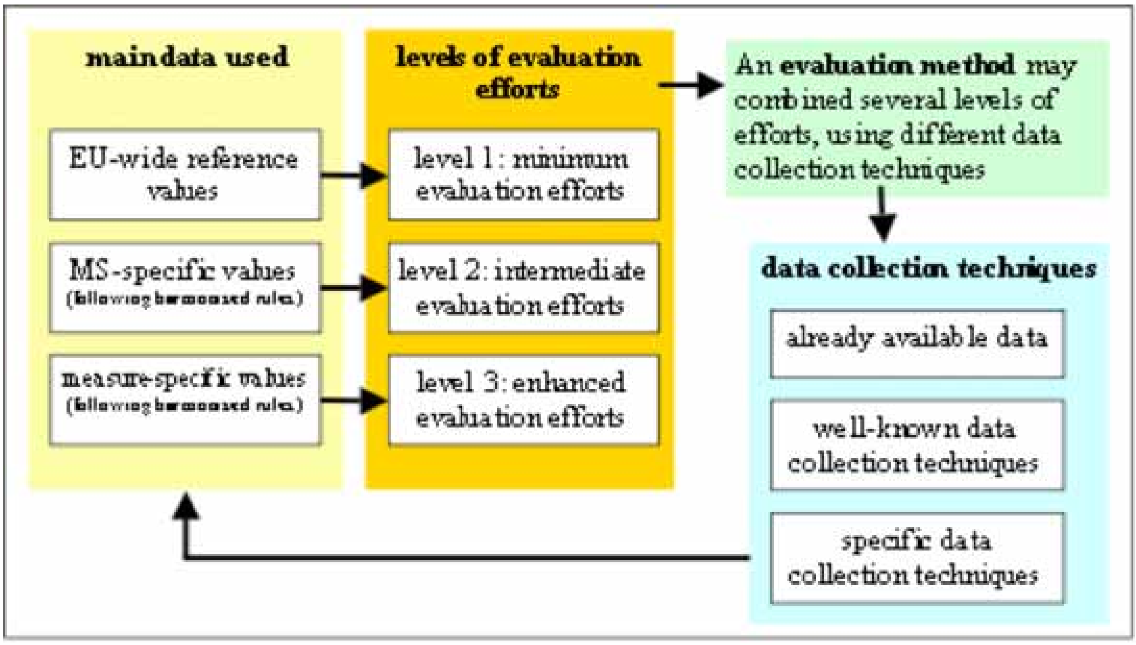
N°	End-use or end-use action, technology, or facilitating measure	Sector	Responsible organisation
1	Building regulations for new residential buildings	Residential	SenterNovem
2	Improvement of the building envelope of residential buildings	Residential	AEA
3	Biomass boilers	Residential	AGH-UST
4	Residential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



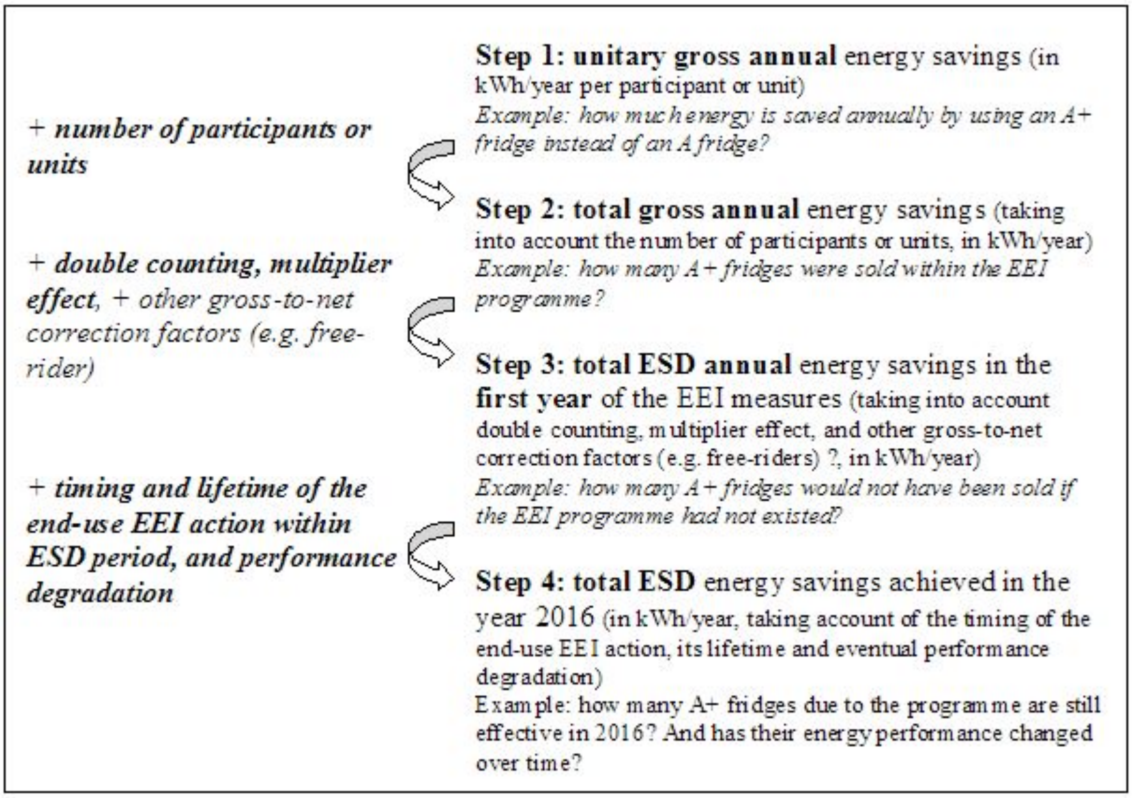
As a consequence, the EMEEES case applications for bottom-up evaluation methods present:

- 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 Six pilot projects

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

Building codes of EU member states formulate the requirements with respect to the energy performance of buildings either at the level of **separate efficiency measures**, i.e. standards for insulation of windows, floor and walls, standards for heating systems energy losses (9 MS), or they use an integrated measure of **overall energy performance** (18 MS)[1]. The EU Directive on the overall energy performance of buildings EPBD requires such a performance calculation for existing buildings.
As energy savings as a result of building codes are by definition calculated using some model (there is no prior energy consumption to refer to), a higher level of measurement can only be achieved for the properties of the buildings. If the properties of individual dwellings (as opposed to are known by type of dwelling) are known, this can be regarded as a level 3 measurement.

The main unit for this method can be either m^2 of conditioned floor space, or a flat, a building, dwelling, etc., depending on the data availability. Using m^2 of conditioned floor space as the unit is preferable, since using a dwelling or building as the unit means averaging over the size, which introduces another factor of uncertainty.

Implementation of the EPBD in the MS ensures that MS can evaluate the energy performance of a dwelling. The different methods used for this in the MS are also harmonized to a considerable extent.

In the formula(s) given below an interaction-effect is included to express the fact that the unitary final energy demand is not simply the summation of effects of separate measures (i.e. insulation and efficiency of the heating system). It is assumed that the national models developed for the calculation of the energy performance of buildings take interaction effects into account.

level 1: Calculation is irrelevant here, since we want to evaluate national building codes.

level 2: Calculation using **classes** of residential dwellings.

Note that level 2 calculations can (and preferably should) be made for different types of dwellings. The latter will take more effort to report, but will most likely also decrease uncertainty and inaccuracy. When different types of dwellings are reported upon, a shift in the composition of the building production over time will be monitored more accurately. It is preferred to do the calculation for at least three types of dwellings. Even better is a calculation for m^2 of conditioned floor space by at least three types of dwellings.

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1 **Separate efficiency measures:** Austria, Belgium, Czech Republic, Hungary, Latvia, Lithuania, Poland, Spain, Sweden; **Overall energy peroformance:** Bulgaria, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Romania, Slovakia, Slovenia, United Kingdom.

Source: MURE II database (http://www.isis-it.com/mure/; "Ongoing mandatory standards for new buildings")

Another issue is **non-compliance**. The World Energy Council (WEC) writes in a recent report[2]: "Relatively few countries have carried out evaluations of their building codes. According to the few studies available, it seems that the actual energy performance of new buildings is below what could be expected from the building regulations. This can be explained by behavioural factors (such as higher indoor temperatures, more rooms heated, or longer heating period over the year) and by a non-compliance with the building regulation".
In order to address this problem, the level 2 calculation of energy efficiency should contain a parameter for non-compliance (nc) in practice with the building code. This parameter can be specific for each MS. However, if no national data on non-compliance are available, this parameter will be set at the default value. Studies[3] indicate that this effect can be as high as 50% (southern China), but more likely for new dwellings in the EU it will be in the range of 5 to 15%. The non-compliance will be included as a parameter in the formulas for level 2. We propose to apply a **conservative default value in the calculation of $UFED_{1i}$ of 1.10** (meaning a 10% higher energy use).

Furthermore we should address the timelag between the moment the new building code comes into force and the actual energy savings resulting from building production under the new regime. It is proposed to use a default timelag of two years before energy savings may be attributed to the new building code. So if the buiding code comes into force on january 1st 2009, the building production from 2011 onwards is used for the calcualtion of the resulting energy savings (see figure on baseline below).

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

$$UFES_i = UFED_{0i} - nc \times UFED1_i$$

The $UFED_{.i}$ is calculated as a function of in the characteristics of the standard dwelling in class i and the properties of the materials and installations used. This function can be specific for a MS, but must be in conformity with the EPBD methodology.

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

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

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

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

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

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2 Energy Efficiency Policies around the World: Review and Evaluation (WEC: London, 2007)
3 Chair report IEA workshop meeting energy efficiency goals february 2008. http://www.iea.org/Textbase/work/2008/meeting_goals/chair_report.pdf

nc	=	Non-compliance paramater (1 + percentage higher energy use as a result of non-compliance with the building code)
$UEL._{im}$	=	Unitary energy loss for a standard dwelling in class i, for measure m, under a specific building code, per annum
$dp_{i(1..p)}$	=	Other relevant dimensional parameters for standard residental dwelling in class i (conditioned floor space, sqm glass surface, s sqm insulation, energy efficiency of the heating system, etc.)
ie	=	Interaction effect
m	=	Energy efficiency measure (1 thru m) referenced in building code

Level 2a: Building code involves **an overall energy performance** standard; (use of a specific model for new residential dwelllings).

- Per class (type) of dwelling the 'normalized' energy consumption for heating, cooling and hot water is determined (averages, reference dwellings).
- For this a MS will apply the method in it's building code for the calculated energy performance index and the associated annual energy consumption.
- The norm, the relation between the energy performance index and the standardized energy consumption, must be documented (for example by national normalization institute) and legally embedded in the building code.
- It is assumed that normalization factors (indoor temperature, behaviour, climate, etc.) are incorporated in the calculation method to determine the annual energy consumption associated with the energy perfomance index of the standard dwelling of that type of residential building.
- The number of categories (types of dwellings) may be 1 or more. However, it is preferred that the typology of dwellings contains at least 3 classes.

Level 2b: Building code involves standards for **separate efficiency measures**; (use a model in line with EPBD)

- Per category (type) of dwelling a standard quantity for each energy efficiency measure (insulation materials, glazing) in the building code is determined (averages, reference dwellings).
- Using the appropate (legally embedded) specifications of the energy efficiency measure, the annual energy losses are calculated
- The norm, the relation between the technical specifications of the relevant material and the annual energy losses, must be legally embedded in the building code.
- It is assumed that normalization factors (indoor temperature, behaviour, climate, etc.) are incorporated in the calculation method to determine the annual energy losses associated with the energy efficiency measure for a standard dwelling in a specific type of residence.
- The number of categories (types of dwellings) may be 1 or more. However, it is preferred that the typology of dwellings contains at least 3 classes.

Level 3: Method applied on individual buildings or unitary energy savings directly measured

- Formulas are identical to those in level 2, but now the unit is an individual dwelling (the unit is its own class).

Level 3 measurement requires relevant data on **individual dwellings**. Most MS will not have these data available and the report will therefore most likely be some variant of level 2. However, level 3 measurement can also be performed in studies on a sample of new buildings in order to

a) validate the calculation method for level 2, using the parameters of the individual dwellings in the model (e.g. instead of average conditioned floorspace of the relevant class)
b) monitor compliance with the building code. In that case the parameter for non compliance will be 0, as the real situation is evaluated.
c) To compare the calculated energy demand using the model with actual directly metered/measured energy use.

3.2 Step 1.2: Baseline

We have as yet not encountered any data or dedicated studies on the subject of autonomous development of energy efficiency measures in the building envelope. Therefore we lack a sound basis in the literature for such an autonomous development. However, there are studies that touch upon the subject that suggest that there is little or no reason to assume that indeed there is an autonomous development with respect to energy efficiency options.

Although sharply rising energy prices (1973, 1979, 2007/08) may be of influence on the technical development of energy efficiency options, we propose to **regard all energy efficiency in the new housing sector as policy induced**. The most important arguments for this position are briefly explained below.

- Since the 1970's many governments have implemented policies to stimulate energy efficiency in the residental housing sector. It can therefore be argued that it is not very well possible to determine how much (if any) of the developments in economically viable energy efficiency techniques, materials or designs should be regarded as autonomous or as induced by policy. Therefore an attempt to model such an autonomous development is largely arbitrary.
- Because investments in energy efficiency tend to not or insufficiently translate into the property value, the market failes to provide energy efficient buildings without help from the government (see for example Pett et al, *Asset Value Implications of Low Energy Offices*[4] and *Building Energy Efficiency*[5]).

In light of these arguments, we propose that every increase in the energy efficiency of newly build dwellings conforming to the building codes is to be regarded as induced by policy.

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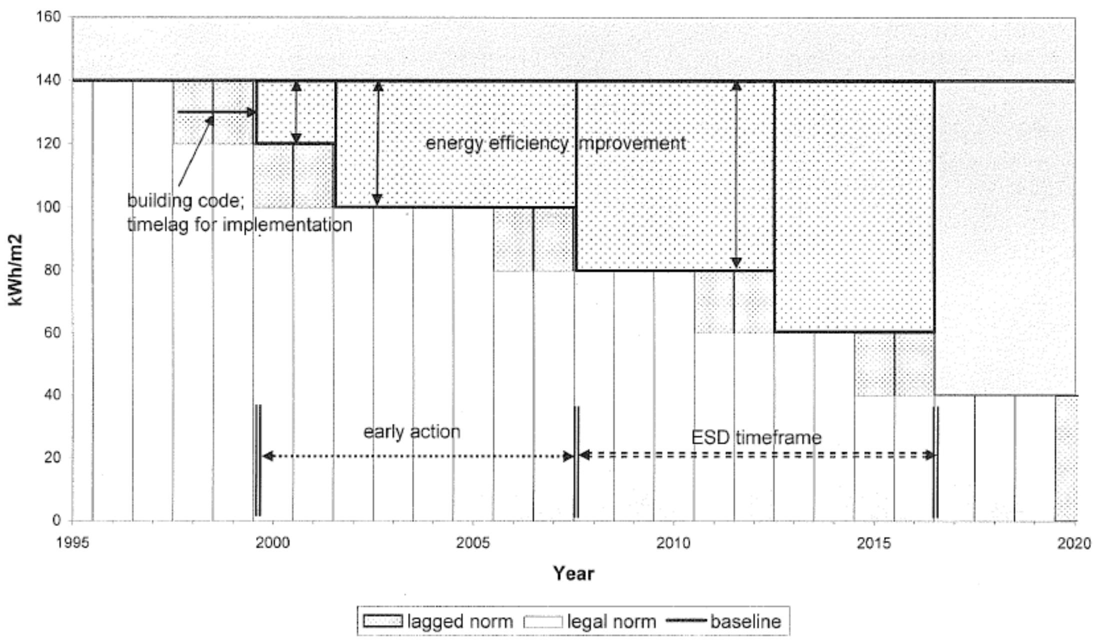
[4] Pett, J, Guertler, P, Hugh, M and Kaplan, Z (2004), *Asset Value Implications of Low Energy Offices,* Association for the Conservation of Energy, London

[5] U.S. Congress, Office of Technology Assessment, *Building Energy Efficiency, OTA-E-518* (Washington, DC: U.S. Government Printing Office, May 1992).

Baseline (autonomous development = 0)



Base year:

It is proposed that the MS shall take the first year that building codes for energy efficiency were implemented as their base year. It is assumed that the building code reflects a state of market conformity and therefore no savings can be attributed to this legislation.

The earliest possible base-year is 1995, since early measures on energy efficiency may be reported from 1995 onwards and most of the efficiency measures have a savings lifetime of over 20 years. The important issue is what efficiency effects may be attributed to policy since the base year. Therefore the building code has had to be tightened at least once since the base year. Also a reasonable period has to be taken into account for the new code to be implemented before the resulting energy efficiency may be attributed to the new code. It is proposed to use a two year time-lag for the calculation of energy savings.

At Level 2 (or if applicable level 3), the baseline should be calculated using the same formula (model) as is used to calculate the 'normal' annual energy consumption or 'normal' annual energy loss per efficiency measure, but using the 1995 parameters (building code, HDD-correction, etc.).

This baseline will be the same for calculation of all and additional energy savings, and it is not dynamic. It could be analysed in the future, whether it should be adapted to a higher efficiency baseline in a step harmonised between Member States.

3.3 Step 1.3: Requirements for normalisation factors

(new) normalisation factor 1: interaction effect between building shell and heating system	
level 1	n.a.
level 2	Interaction effect already incorporated in the calculation method (i.e., the MS model to calculate the overall energy performance of a dwelling).
level 3	Interaction effect already incorporated in the calculation method (i.e., the MS model to calculate the overall energy performance of a dwelling).

(new) normalisation factor 2: standardizing weather and other conditions	
level 1	n.a.
level 2	Normalization factors already incorporated in the calculation method
level 3	Normalization factors already incorporated in the calculation method; Further guidelines: For measured energy performance data normalisation should be applied with respect to weather conditions (HDD's and CDD's), occupancy levels, internal temperature levels. data required: HDD's, CDD's, survey data (internal temperature, occupancy) Levels of these variables for a standardized dwelling / year.

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

level 1	Level 1 is not possible
level 2	mix of deemed and ex-post estimates calculated for classes of dwellings; deemed values based on enhanced engineering estimates
level 3	enhanced engineering estimates or mix of deemed and ex-post estimates calculated for individual dwellings or direct measurement

3.4.1 Step 1.5 Conversion factors

Member states are expected to use conversion factors (when relevant) as specified in their national Energy Erfficiency Action Plan.

3.4.2 Step 1.6 Considering the direct rebound effect

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

In the literature the rebound effect is estimated to be between 10 and 30%[6] for space heating. However, as Geller and Attali point out: “The rebound effect is a dynamic phenomenon. It tends to decline over time as the saturation and quality of energy services increase.”[7] In a study on rebound effects associated with refurbishment of residential buildings in Austria Biermayr et al.[8] report that the direct rebound effect depends on the initial state of the building. For buildings that were already in a good condition and a lower than average energy consumption, a rebound effect of up to 5% was reported.

Unitary gross annual energy savings for a dwelling in class i, including a rebound effect

$$UFES_i = (UFED_{0i} - nc \times UFED_{1i}) \times (1 - re) \qquad \text{(equation 2)}$$

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

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

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

re = Direct rebound effect (default value is 0)

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

Considering the findings in the literature it is plausible that rebound effects do occur. However, based on the findings of Biermayr et al., these effects are likely to be relatively small in **new** residential dwellings. For this reason we do not take the rebound effect into account.

[6] Gottron, F., 2001: Energy efficiency and the rebound effect: Does increasing efficiency decrease demand? Congressional Research Service. Report for Congress (RS20981). The Library of Congress. July 30, 2001.

[7] Howard Geller and Sophie Attali; The experience with energy efficiency policies and programmes in IEA countries. : IEA information paper, august 2005.

[8] Biermayr, P., Schriefel, E., Baumann, B., 2004: Maßnahmen zur Minimierung van Reboundeffekten bei der Sanierung von Wohngebäuden (MARESI). Berichte aus Energie- und Umweltforschung; 6/2005. Bundesministerium gür Verkehr, Innovation und Technologie. Vienna, Austria.

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

Since a level 1 method is not possible for new buildings, there are no EU level default values for unitary annual energy savings possible either.

The effect on the unitary gross annul energy savings is observed with some timelag from the date of implementation of a building code. The default time-lag is 2 years.

The increased energy demand resulting from non-compliance with the building code is set at 10% (proposed default value).

3.4.3.2 Requirements to define level 2 and level 3 values

Level 2 is always the minimum required for this method.

A level 3 measurement can be performed on a sample of new buildings to validate the calculation method for level 2, to validate and monitor compliance with the building code or to evaluate the rebound effect.

The calculation of the energy efficiency must comply with the methodological framework presented in the EPBD. To do this, the relevant data for this calculation must be gathered (depending on the MS definitions and building codes).

4. Step 2: Total gross annual energy savings

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

- The main unit for this method can be either m^2 of conditioned floor space (preferred), or a flat, a building, dwelling, etc., depending on the data availability.
- For both type of building codes the UFED.i are calculated in accordance with EPBD methodology. The total gross annual energy savings are calculated as:

$$TGFES = \sum_{i=1}^{c} (UFED_{0i} - nc \times UFED_{1i}) \times n_i \times (1 - re) \qquad \text{(equation 3)}$$

Where: TGFES = Total Gross Final Energy Savings

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

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

re = Direct rebound effect (default value is 0)

i = Dwelling class (1 thru c)

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

n_i = The number of units (dwellings or m^2) in class i

Level 3: Method applied on individual buildings or unitary energy savings directly measured

- Formula as in level 2; now each unit is it's own class

For efforts on every level the MS should provide an adequate definition for a new dwelling. Also a factor for time between the moment the building permit is granted under the new building code and the moment the building is actually built should be taken into account. For the EU-wide reference value a delay period of two years is suggested, based on a study for the Dutch situation concluding that within 2 years most dwellings are built.

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

The number of actions, i.e. the number of newly built residential dwellings in each class of dwellings in a specific year shall be taken from official national statistics of the MS

The calculation of the unitary final energy demand for a standard dwelling in each class, both under baseline conditions and under the current buiding code must be in conformity with the methodological framework presented in the EPBD.

5. Step 3: Total ESD annual energy savings

5.1 Step 3.1: Formula for ESD savings

The main unit for this method can be either m^2 of conditioned floor space, or a flat, a building, dwelling, etc., depending on the data availability.

$$TNFES = \sum_{i=1}^{c} (UFED_{0i} - nc \times UFED_{1i}) \times n_i \times (1 - re) \qquad \text{(equation 4)}$$

Since there are no additional corrections to be made, the formula for the total net savings is the same as for the gross savings.

Where: TNFES = Total Net Final Energy Savings

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

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

re = Direct rebound effect (default value is 0)

i = Dwelling class (1 thru c)

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

n_i = The number of units (dwellings or m^2) in class i

Level 3: Method applied on individual buildings or unitary energy savings directly measured

- Formula as in level 2; now each unit is its own class

5.2 Step 3.2: Requirements for double counting

Not applicable here: there is no competing measure, the building code is reaching 100 % of the market and the potential up to the performance level required.

However, the issue of double-counting will need to be analysed, if the formulas from this method are used to evalaute measures aiming at market introduction and uptake of better building technologies leading to higher performance than the current building code (cf. chapter 1.1.3).

5.3 Step 3.3: Requirements for technical interactions

Applicable when the building code involves standards for separate efficiency measures. The calculation method (equation 1b) assumes a model in conformity with the EPBD methodological framework. Therefore interaction effects are already incorporated and need no additional attention.

5.4 Step 3.4: Requirements for multiplier energy savings

Not applicable here, since the building code is reaching 100 % of the market and the potential up to the performance level required.

However, if the formulas from this method are used to evalaute measures aiming at market introduction and uptake of better building technologies leading to higher performance than the current building code (cf. chapter 1.1.3), and if such measures exceed a certain size of total gross annual energy savings (e.g., 100 million kWh/year), it is also recommended to analyse correction factors such as for multiplier and free-rider effects.

5.5 Step 3.5: Requirements for the free-rider effect

Not applicable here, as it is assumed that all the market share of buildings better than the baseline is due to previous EEI measures.

6. Step 4: total ESD energy savings for year "t"

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

EU default/harmonised values	
Savings Lifetime Default/harmonised	Insulation: building envelope - >25a (harmonized) Windows/glazing - 24a (harmonized) [Small boilers - 17a (harmonized)] [Large boilers - 17a ((default)] Energy performance index – 25a

Remark: Ventilation system measures are taken into account in the calculation of the energy performance of buildings. In the the CEN workshop agreement[9] ventilation in residential buildings is not mentioned as a separate EEI measure.

When the building codes refer to an integral EP-measure, in effect this means a package of separate EEI measures. These measures have a savings lifetime in the range from 10 to >25 years. The most important components, insulation and glazing have a very long savings lifetime. For heating and cooling systems the savings lifetime is less. **We propose to use a default savings lifetime of 25 years**. We expect future replacement of heating and cooling equipment to involve more energy efficient installations than the present generation.

Note that this should not result in double counting as a result of future refurbishment or replacement of installations, because the reference situation for such measures is already a quite energy-efficient situation. Therefore, a replacement with even more energy-efficient solutions will only generate *new* savings. However, it is recommended to analyse this in future evaluations, when these heating and cooling installations of the buildings that are now new but then existing buildings will be replaced for the first time.

[9] CWA27, 2007: Lifetimes in Energy Efficiency Calculations. CEN Workshop Agreement 27. CWA 15693:2007. CEN, Paris, France.

5.2 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.

Early energy savings from end-use actions initiated between 1995 and 2008, with the end-use actions having a lasting effect in 2016 (for the overall target). For a new building code installed from jan 1st 1995 and using a time lag of 2 years allowing for the new building code to take effect, the required minimal savings lifetime is 20 years (i.e. lasting energy savings effects in the years 1997 thru 2016).

The base-line is the situation in a MS at moment when the building codes with respect to energy efficiency are implemented for the first time, while this can not be prior to 1995.

6.3 How to treat uncertainties

Note that level 2 calculations preferably should be made for different classes of dwellings. The latter will take more effort to report, but will most likely also decrease uncertainty and inaccuracy. When different types of dwellings are reported upon, a shift in the composition of the building production over time will be monitored more accurately. It is preferred to do the calculation for at least three types of dwellings. It is therefore important to assess the degree of uncertainty as realistically as possible.

If a dwelling, building, or flat is used as the unit, there will be an additional source of uncertainty compared to the use of m^2 of conditioned floor area as the unit. The uncertainty results from the averaging of the floor area per dwelling etc. This is, why using m^2 of conditioned floor area as the unit is preferable.

Appendix I: Justifications and sources

1. Source: MURE II database (http://www.isis-it.com/mure/; "Ongoing mandatory standards for new buildings").

2. Energy Efficiency Policies around the World: Review and Evaluation (WEC: London, 2007).

3. Chair report IEA workshop meeting energy efficiency goals february 2008.

4. Pett, J, Guertler, P, Hugh, M and Kaplan, Z (2004), Asset Value Implications of Low Energy Offices, Association for the Conservation of Energy, London.

5. U.S. Congress, Office of Technology Assessment, Building Energy Efficiency, OTA-E-518 (Washington, DC: U.S. Government Printing Office, May 1992).

6. Gottron, F., 2001: Eenergy efficiency and the rebound effect: Does increasing efficiency decrease demand? Congressional Research Service. Report for Congress (RS20981). The Library of Congress. July 30, 2001.

7. Howard Geller and Sophie Attali; The experience with energy efficiency policies and programmes in IEA countries. : IEA information paper, august 2005.

8. Biermayr, P., Schriefel, E., Baumann, B., 2004: Maßnahmen zur Minimierung van Reboundeffekten bei der Sanierung von Wohngebäuden (MARESI). Berichte aus Energie- und Umweltforschung; 6/2005. Bundesministerium gür Verkehr, Innovation und Technologie. Vienna, Austria.

9. CWA27, 2007: Lifetimes in Energy Efficiency Calculations. CEN Workshop Agreement 27. CWA 15693:2007. CEN, Paris, France.