Methods to assess the attainment of targets in compliance with the Energy End-use Efficiency and Energy Services Directive 2006/32/EC

Bottom-up methods

October 2013

Authors: Heidelinde Adensam
Thomas Bogner
Susanne Geissler
Maike Groß
Marcus Hofmann
Robert Krawinkler
Konstantin Kulterer
Christoph Ploiner
Stephan Renner
Günter Simader
Gregor Thenius
Herbert Tretter

Commissioned by: BMWFJ (Federal Ministry of Economy, Family and Youth)

Vienna, October

AUSTRIAN ENERGY AGENCY

Publishing information

Published by: Österreichische Energieagentur – Austrian Energy Agency,
Mariahilfer Str.136, A-1150 Vienna; Tel. +43 (1) 586 15 24, Fax +43 (1) 586 15 24 - 340;
E-mail: office@energyagency.at, internet: www.energyagency.at | www.monitoringstelle.at

Responsible for the content: DI Peter Traupmann

Overall direction: Mag. Gregor Thenius

Reviewing: Mag. Andrea Jamek

Editing and layout: Dr Margaretha Bannert, Carmen Marksteiner

Manufacturer: Österreichische Energieagentur – Austrian Energy Agency

Place of publication and manufacture: Vienna

Contents

Contents

1 Introduction

The Energy End-use Efficiency and Energy Services Directive (Directive 2006/32/EC) requires that national energy savings be measured as of 2008 and compared to the national indicative energy savings target. Both top-down and bottom-up methods can be used for this, but at least 20% of the final energy demand must be examined using bottom-up methods. With bottom-up methods, the amount of energy savings brought about by individual measures is quantified in units of energy. With top-down methods, national or larger-scale aggregated sectoral levels of energy savings are used as the starting point for calculating the extent of energy savings.

As the harmonised bottom-up model intended to be developed by the Commission by the start of 2008 does not yet exist, the Austrian Energy Agency has suggested bottom-up methods for the monitoring that has to be carried out as of 2008, and has discussed these in workshops with the relevant stakeholders. The methods developed in this way meet the requirements of Directive 2006/32/EC, are as simple as possible to apply, and utilise the available dataset to the greatest possible extent.

This document sets out the bottom-up methods developed thus far, and serves as a basis for the calculation of energy savings in accordance with the Energy End-use Efficiency and Energy Services Directive. On the website of the Austrian monitoring body (Monitoringstelle) www.monitoringstelle.at there is a tool under the 'Datenbank' (database) menu item that calculates final energy savings for individual measures, building on the methods described here. This database is offered by the Austrian monitoring body with the intention of simplifying and systematising the process of data gathering for the calculation of final energy savings in accordance with the Energy End-use Efficiency and Energy Services Directive. Data from existing (and planned) databases (e.g. the measures databases for the regional programmes, the ZEUS database, EBS Manager, FörderManager, etc.) can be integrated, via an interface, into the monitoring database in the form of an Excel file.

2 Description of the model buildings used to calculate expenditure factors

2.1 The model buildings

1) The **single-family house** is a two-storey building whose main axis runs from east to west. Its basic size is 8 x 11 m, giving a gross floor area (GFA) of 176 m². The house's usable floor area (UFA) is 129 m². There is a French window on the ground floor, one large and four small windows on the upper floor facing south, two small east-facing windows and two small west-facing windows, and one large and one small window facing north (window to wall ratio approx. 8%). The gross heated volume is 484 m³, the surface area to volume ratio is 0.85 1/m, and the characteristic length l_c is 1.18 m. A gabled roof with a 45° slope was selected, with an unheated attic. For the sake of simplicity, no basement was included (the impact compared to an unheated basement was deemed to be minor). However, the heat provision system and distribution pipes in these houses are assumed to be located in an unconditioned area.

2) The **small block of flats** is also a two-storey building, but with four dwelling units per floor. Each flat's dimensions are 10.70 x 8 m, giving a UFA of 75 m² each. The flats are linked via a central corridor of 3 m width, giving a GFA of 824.60 m². Each flat has five small windows (window to wall ratio approx. 10%). The gross heated volume amounts to 2 556.30 m³. The surface area to volume ratio is 0.52 1/m, and the characteristic length l_c is 1.92 m. A flat roof was chosen.

A non-heated basement has been included for the small block of flats. The heating system is located in the basement and is therefore outside of the conditioned area. Hot water generation also takes place centrally. Here too, there are no alternative energy sources available. Here too, non-insulated pipes are assumed BEFORE a boiler replacement, while insulated pipes are assumed AFTER a boiler replacement.

3) The **large-scale residential building** is a three-storey building with eight dwelling units per floor. Each flat's dimensions are 10.70 x 8 m, giving a UFA of 75 m² each. The flats are linked via a central corridor of 3 m width, giving a GFA of 2 445.30 m². Each flat has 3–5 small windows (window to wall ratio approx. 10%). The gross heated volume amounts to 7 825 m³. The surface area to volume ratio is 0.36 1/m, and the characteristic length l_c is 2.78 m. A flat roof was chosen.

The large-scale residential building has a non-heated basement for general connections. The heating system is located in the basement and is therefore outside of the conditioned area. Hot water generation takes place centrally. Here too, there are no alternative energy sources available. Here too, non-insulated pipes are assumed BEFORE a boiler replacement, while insulated pipes are assumed AFTER a boiler replacement.

2.2 U-values pursuant to the ‘Energy Performance of Buildings Guideline’ OIB-300.6-039/07

Table 2-1: U-values pursuant to the ‘Energy Performance of Buildings Guideline’ OIB-300.6-039/07

	KD	OD	AW	FE	g
NÖ 1960:	0.90	0.52	1.25	2.50	0.67
NÖ 1969:	0.63	0.48	0.80	2.50	0.67
NÖ 1976:	0.56	0.44	0.60	2.50	0.67
Average:	**0.70**	**0.48**	**0.88**	**2.50**	**0.67**

2.3 Calculated[1] heating requirement values[2] for the aforementioned buildings

‘Old envelope’ (existing buildings, not renovated)

Single-family house heating requirement ref: 156.07 kWh/m²/year
Small block of flats heating requirement ref: 107.00 kWh/m²/year
Large-scale residential building heating requirement ref: 80.24 kWh/m²/year

Special case: Large-scale residential building heating requirement ref., old buildings (ca. 1900): 140.69 kWh/m²/year

‘New envelope’ (new buildings)

Single-family house heating requirement ref: 65.78 kWh/m²/year
Small block of flats heating requirement ref: 49.38 kWh/m²/year
Large-scale residential building heating requirement ref: 37.82 kWh/m²/year

‘New envelope’ (existing buildings, renovated[3])

Single-family house heating requirement ref: 82.76 kWh/m²/year

Small block of flats heating requirement ref: 69.02 kWh/m²/year

Large-scale residential building heating requirement ref: 50.37 kWh/m²/year

[1] Using the Excel tool 2008-07-11 V 08 b of Dr Pöhn, MA 39

[2] The heating requirement values listed here apply for the specified average buildings and are used in the calculation of expenditure factors. To calculate the final energy savings resulting from renovation of the thermal building envelope, a heating requirement of 200 kWh/m^2/year or 90 kWh/m^2/year is reverted to, as specified in the ‘Reporting template of the Federal Ministry of Agriculture, Forestry, Environment and Water Management (Lebensministerium) for meeting the reporting requirements according to Art. 10 of the agreement under Art. 15a of the Federal Constitutional Law (B-VG) between the federal government and the federal states concerning joint quality standards to subsidise the construction and renovation of residential buildings in order to reduce greenhouse gas emissions (BGBl (Federal Law Gazette) II No 19/2006)’.

[3] In accordance with Austrian Institute of Construction Engineering (Österreichisches Institut für Bautechnik – OIB) Guideline 6 ‘extensive renovation’ values up to 31/12/ 2009: HWB_{max} = 34 x (1 + 2.0/ l_c); achieved through window replacement (new U-value: 1.4) and insulation of the outer walls (new U-value: 0.30).

2.4 Technical specifications for heating

2.4.1 Centralised heat provision (single-family houses, small blocks of flats, large-scale residential buildings)

The following table sets out specifications with regard to heating i.e. how it should be treated before and after a measure has been carried out (e.g. boiler replacement, connection to district heating). The specifications apply to existing buildings (single-family houses, small blocks of flats, large-scale residential buildings) in which there is centralised heat provision with combined hot water provision. It is of course acceptable to modify this if other system specifications apply (for instance, if with district heating there is no hot-water heat storage; or to take buffer storage into account with solid fuel combustion systems).

Table 2-2: Specifications with regard to heating: centralised heat provision

	Before enacting the measure	**After enacting the measure**
Hot water worksheet		
Property details	Hot water (HW) and space heating (SH) heat provision combined HW heat provision, centralised	Hot water (HW) and space heating (SH) heat provision combined HW heat provision, centralised
HW heat distribution	Distribution pipes in a non-conditioned area; 0/3 insulated; valves not insulated Rising mains in a conditioned area; 1/3 insulated; valves not insulated No circulation	Distribution pipes in a non-conditioned area; 3/3 insulated; valves not insulated Rising mains in a conditioned area; 1/3 insulated; valves not insulated No circulation
HW heat provision	No heat provision	No heat provision
HW heat storage	Indirectly heated storage (depending on year of manufacture of boiler, SH) Connecting parts not insulated No electric heating element Not conditioned	Indirectly heated storage (depending on year of manufacture of boiler, SH) Connecting parts insulated No electric heating element Not conditioned
Space heating worksheet		
SH heat emission	Radiator control valve operated by hand Small-area heat emission, as with radiators System temperatures (70/55°C)	Radiator control valve operated by hand Small-area heat emission, as with radiators System temperatures (70/55°C)
SH heat distribution	Distribution pipes in a non-conditioned area; 0/3 insulated; valves not insulated Rising mains in a conditioned area; 1/3 insulated; valves not insulated Connecting pipes: 1/3 insulated; valves not insulated	Distribution pipes in a non-conditioned area; 3/3 insulated; valves not insulated Rising mains in a conditioned area; 1/3 insulated; valves not insulated Connecting pipes: 1/3 insulated, valves not insulated
SH heat provision	Standard boiler (1978–1993); in a non-conditioned area Operational mode: non-modulating, constant	Condensing boiler; in a non-conditioned area Operational mode: modulating, variable

SH heat storage	No storage	No storage
Property details	HW + SH heat provision, centralised Capacity of the SH boiler (PRH, KN): oversizing	HW + SH heat provision, centralised Capacity of the SH boiler (PRH, KN): adjusted

These details should be used as default settings. If comparisons with other reference systems are desired for the evaluation of the expenditure factors (e.g. combi boiler in a single-family house), then one can deviate from these specifications, but justification must be provided for the changes. As a starting point for the further consideration of other systems, the Excel files were produced initially with an oil-fired boiler as the heat provision system.

For measures aimed at new buildings with a centralised heating supply, the same assumptions apply in principle as those given in the 'After' column, although certain settings can of course be adapted in this regard (e.g. the type of heat emission, system temperatures, etc.).

In the event of centralised heat provision replacing decentralised heat provision, the specifications in the following table should be used for the reference system ('Before enacting the measure').

2.4.2 Decentralised heat provision (small block of flats, large-scale residential building)

The following table sets out specifications with regard to heating when decentralised heat provision is present and a measure is implemented in connection with this (e.g. replacement of combi boilers). The specifications apply to existing multi-storey residential buildings (small blocks of flats, large-scale residential buildings). It is of course acceptable to modify this if other system specifications apply (for instance, if storage combi boilers are used).

Table 2-3: Specifications with regard to heating: decentralised heat provision

	Before enacting the measure	After enacting the measure
Hot water worksheet		
Property details	Hot water (HW) and space heating (SH) heat provision combined HW heat provision, decentralised Number of flats 8 or 24 GFA = 85.6 m^2	Hot water (HW) and space heating (SH) heat provision combined HW heat provision, decentralised Number of flats 8 or 24 GFA = 85.6 m^2
HW heat distribution	No circulation	No circulation
HW heat provision	No heat provision	No heat provision
HW heat storage	No hot water storage	No hot water storage

Space heating worksheet		
SH heat emission	Radiator control valve operated by hand Small-area heat emission, as with radiators System temperatures (70/55°C)	Radiator control valve operated by hand Small-area heat emission, as with radiators System temperatures (70/55°C)
SH heat distribution	Connecting pipes: 1/3 insulated; valves not insulated	Connecting pipes: 1/3 insulated, valves not insulated
SH heat provision	Combi boiler with no storage (–1987); in a conditioned area Operational mode: non-modulating, constant	Combi boiler with no storage (>1994), in a conditioned area Operational mode: modulating, variable
SH heat storage	No storage	No storage
Property details	HW + SH heat provision, decentralised Number of flats 8 or 24 GFA = 85.6 m^2 Capacity of the boiler (PRH, KN): oversizing	HW + SH heat provision, decentralised Number of flats 8 or 24 GFA = 85.6 m^2 Capacity of the boiler (PRH, KN): adjusted

These details should be used as default settings. If comparisons with other reference systems are desired for the evaluation of the expenditure factors, then one can deviate from these specifications, but justification must be provided for the changes. As a starting point for the further consideration of other systems, the Excel files were based initially on decentralised heat provision with combined hot water provision (combi boilers).

2.5 Reference cases

At this point it is worth restating which reference scenarios can be considered before and after a measure when making a comparison. It was agreed that the affected parties, when evaluating the expenditure factor, would select the most commonly used reference system or systems (and could generate an average if necessary). The following table is intended to highlight these considerations for the measures 'boiler replacement' and 'connection to district heating'.

Table 2-4 and Table 2-5: Reference cases, boiler replacement and connection to district heating

	Öl		Gas				
	EFH	MFH	EFH	MFH		MG WB	
				zentr.	dez.	zentr.	dez.
Kessel alt	Öl alt	- ?	Öl/Gas/ FB alt?	Öl/Gas/ FB alt?	Gas (KoTh) alt?	Öl/Gas/ FB alt?	Gas (KoTh) alt?
Kessel neu	Öl neu	- ?	Gas neu	Gas neu	Gas neu	Gas neu	Gas neu

	Anschluss an Fernwärme									
	Bestand					Neubau				
	EFH	MFH		MG WB		EFH	MFH		MG WB	
		zentr.	dez.	zentr.	dez.		zentr.	dez.	zentr.	dez.
Referenz system	Öl/Gas/ FB alt?	Öl/Gas/ FB alt?	Gas (KoTh) alt?	Öl/Gas/ FB alt?	Gas (KoTh) alt?	Öl/Gas/ FB neu ?	Öl/Gas/ FB neu?	Gas (KoTh) neu?	Öl/Gas/ FB neu?	Gas (KoTh) neu?
Fernwärme	FW	FW (sek./tert.)		FW (sek./tert.)		FW	FW (sek./tert.)		FW (sek./tert.)	

Öl	Gas	EFH	MFH	MG WB	Zentr.
Oil	Gas	Single-family house	Small block of flats	Multi-storey residential building	Centr.
Dez.	Kessel alt	Öl alt	Öl/Gas/FB alt?	Gas (KoTh) alt?	Kessel neu
Decentr.	Boiler, old	Oil, old	Oil/gas/solid fuel, old?	Gas (combi), old?	Boiler, new
Öl neu	Gas neu				
Oil, new	Gas, new				

Anschluss an Fernwärme					
connection to district heating					
Bestand	Neubau	Referenz system	Öl/Gas/FB neu?	Gas (KoTh) neu?	Fernwärme
Existing building	New building	Reference system	Oil/gas/solid fuel, new?	Gas (combi), new?	District heating (DH)
FW	FW (sek./tert.)				

In order to achieve transparency and consistency in the calculations of the various interest groups, we recommend evaluating the expenditure factor using the Excel files that have already been created.

3 Lighting

3.1 Efficient street lighting

Description of measure

Street lighting is converted to a more efficient technology (lamp and ballast); reduction of the illuminance at night is also an option.

The requirements for street lighting systems vary considerably depending on the type of transportation route being illuminated. There is a great deal of variation in the technology used and how densely the light sources are positioned. Therefore, the default formula below can only produce a rough approximation.

Default formula

$$EE_{ges} = (L - Lfr) \times (EK_{d} - EK_{esl} \times na) \times rb \times so \times cz$$

EE_{ges}	Total energy savings [kWh per year]
L	Length of the route along which the street lighting was modernised [m]
Lfr	Length of the route along which the street lighting was modernised independently of the measure (free riders) (= 0)
EK_{d}	Average energy indicator, inefficient system (mercury vapour lamps) [kWh/m/year]
EK_{esl}	Average energy indicator, efficient system (sodium vapour lamps) [kWh/m/year]
na	Effect of the night-time reduction
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Average energy indicator, inefficient system (mercury vapour lamps) [kWh/m/year][4]	15
Average energy indicator, efficient system (sodium vapour lamps) [kWh/m/year][5]	8
Reduction factor for night-time reduction (partial night-time switching)[6] … no night-time reduction … 50% performance reduction for period 23:00–6:00 … 100% performance reduction for period 1:00–5:00	 1 0.72 0.65
Lifetime [years] (Harmonised value in accordance with 'Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations – Final CWA draft (CEN WS 27)', 2007)	13

Formula for project-specific information

$$EE_{ges,k} = \frac{\left(\sum_{i=1}^{n} P_{alt\ i} - \left(\sum_{j=1}^{m} P_{neu\ j} \right) \times na \right) \times t_{a\ k} \times rb \times so \times cz}{1000}$$

$EE_{ges,\ k}$	Total energy savings [kWh per year] in project k
n	Number of light sources in the existing system
m	Number of light sources in the new system
$P_{alt\ i}$	Power of inefficient (old) technology with light source i [W]
$P_{neu\ j}$	Power of efficient (new) technology with light source j [W]
$t_{a\ k}$	Annual runtime in project k (average daily runtime x 365) [h]
na	Reduction factor for night-time reduction
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

×

[4] www.topten.ch, 2008

[5] www.topten.ch, 2008

[6] www.topten.ch, 2008

Determining na (reduction factor for night-time reduction)

$$na = \frac{\sum_{i=1}^{n} t_{Pi} \times pr_{i}}{t_{ges}}$$

t_{Pi}	Runtime per power setting
pr_i	Power reduction factor (0 … 100%)
t_{ges}	Total system runtime (evening until morning, Σ_n i=1 t_{Pi})

3.2 Efficient lighting in households

Description of measure

Household consumers use energy-saving lamps or light-emitting diodes (LEDs) instead of conventional incandescent bulbs, for lights used often to moderately often. The production of conventional 60 W incandescent bulbs has ceased with the coming into force of Stage 3 of the Eco-design requirements, Commission Regulation (EC) No 244/2009. For this reason, halogen lamps are to be used for the reference value from 2012 onward instead of incandescent bulbs.

Default formula

$$\mathbf{EE_{ges} = (n - fr) \times (p_d - p_{eff}) \times t_a \times rb \times so \times cz / 1000}$$

EE_{ges}	Total energy savings [kWh per year]
n	Number of energy-saving lamps or LEDs put in place due to the measure
fr	Number of energy-saving lamps or LEDs that would have been purchased anyway regardless of the measure (free riders) (= 0)
p_d	Power of the incandescent bulb [W]
p_{eff}	Power of the efficient energy-saving lamp or LED [W]
t_a	Annual runtime in the household [h]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Average power, incandescent bulb [W]	60
From 2012: Average power, halogen lamp [W]	42
Average power, energy-saving lamp [W]	12
Average power, LED [W]	11
Luminous efficacy of an incandescent bulb [lm/W]	12
Luminous efficacy of a halogen lamp [lm/W]	17.1
Luminous efficacy of an energy-saving lamp [lm/W]	60
Luminous efficacy of an LED [lm/W]	65.5
Annual runtime [h][7]	1000
Lifetime of an energy-saving lamp [years][8]	8
Lifetime of an LED [years][9]	20

Formula for project-specific information

$$EE_{ges,k} = \frac{\sum_{i=1}^{n} P_{eff\ i} \times (\frac{\eta_{EFF}}{\eta_R} - 1) \times t_{a\,i} \times rb \times so \times cz}{1000}$$

$EE_{ges,\,k}$	Total energy savings [kWh per year] in project k
n	Number of lamps replaced in project k
$P_{esl\ i}$	Power of efficient lamps in project k [W]
η_{ESL}	Luminous efficacy of the efficient lamps (default values given above)
η_R	Luminous efficacy of a reference light source (incandescent bulb or halogen lamp) (default values given above)
$t_{a\ i}$	Annual runtime in project k [h]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

[7] Annual runtime for lamps in households according to the industry-standard guideline value (particularly in the conversion of the stated lifetime in operating hours into years)

[8] Topprodukte.at, 2008: Standard for lifetimes of industry-standard compact energy-saving lamps. The default value according to the CEN proposal ('Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations – Final CWA draft (CEN WS 27)', 2007), at 6000 h (corresponding to 6 years with an average annual runtime of 1000 h), appears to have been set too low.

[9] Topprodukte.at, 2012: Top-Produkte minimum requirements

3.3 Efficient lighting in office buildings

Description of measure

Inefficient lighting systems commonly used in the existing building stock (lamp: T8; conventional ballast) are replaced with new efficient lighting systems (lamp: T5; electronic ballast).

Default formula

$$EE_{ges} = (m - fr) \times (p_{alt} - p_{neu} \times ls) \times t_a \times rb \times so \times cz / 1000$$

EE_{ges}	Total energy savings [kWh per year]
m	Office floor area covered by the lighting system updated in connection with the measure [m^2]
fr	Office floor area that would have been updated anyway regardless of the measure (free rider) (= 0)
p_{alt}	Installed power (lamp and ballast) per office floor area of the inefficient (old) system [W/m²]
p_{neu}	Installed power (lamp and ballast) per office floor area of the efficient (new) system [W/m²]
ls	Reduction factor through additional lighting control measures
t_a	Annual runtime [h]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Average installed power per office floor area for inefficient (old) systems [W/m²][10]	14 (11–17)
Average installed power per office floor area for efficient (new) systems [W/m²]	11.5 (9–14)
Annual runtime [h][11]	2580
Reduction factors for lighting control measures ƒ Partial shutdowns[12]	0.9

[10] Information from Andreas Danler, Bartenbach LichtLabor GmbH, 2008

[11] Proposed value corresponds to the default value for office buildings of public and private institutions according to the report 'Task 4.2: harmonised bottom-up evaluation methods: Method 9, Improvement of Lighting Systems (Tertiary Sector) – Final draft for consultation: EU Project EMEEES'

[12] Values according to the report 'Task 4.2: harmonised bottom-up evaluation methods: Method 9, Improvement of Lighting Systems (Tertiary Sector) – Final draft for consultation: EU Project EMEEES'

• Timer switches • Occupancy sensors • Daylight harvesting	0.9 0.8 0.8
Lifetime [years] (Harmonised value in accordance with 'Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations – Final CWA draft (CEN WS 27)', 2007)	15

Formula for project-specific information

$$EE_{ges,k} = \frac{\left(\left(\sum_{i=1}^{n} P_{alt\ i}\right) \times t_{a,alt} - \left(\sum_{j=1}^{m} P_{neu\ j}\right) \times t_{a,neu} \times ls\right) \times rb \times so \times cz}{1000}$$

$EE_{ges,k}$	Total energy savings [kWh per year] in project k
n	Number of light sources in the existing system in project k
m	Number of light sources in the new system in project k
$P_{alt\ i}$	Installed power of light source i (lamp and ballast) of the existing lighting system in project k [W]
$P_{neu\ j}$	Installed power of light source j (lamp and ballast) of the new lighting system in project k [W]
$t_{a,\ alt}$	Annual runtime of the existing system in project k [h]
$t_{a,\ neu}$	Annual runtime of the new system in project k [h] (including consideration of lighting control systems)
ls	Reduction factor through additional lighting control measures
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

3.4 Efficient lighting in the hotel and food service industries

3.4.1 Energy-saving lamps or LEDs

Description of measure

The conventional incandescent bulbs used frequently in the hotel and food service industries are replaced with energy-saving lamps or light-emitting diodes (LEDs). The production of conventional 60 W incandescent bulbs has ceased with the coming into force of Stage 3 of the Eco-design requirements, Commission Regulation (EC) No 244/2009. For this reason, halogen lamps are to be used for the reference value from 2012 onward instead of incandescent bulbs.

Default formula

$$EE_{ges} = (n - fr) \times (p_d - p_{eff}) \times t_a \times rb \times so \times cz / 1000$$

EE_{ges}	Total energy savings [kWh per year]
n	Number of energy-saving lamps or LEDs purchased due to the measure
fr	Number of energy-saving lamps or LEDs that would have been purchased anyway regardless of the measure (free riders) (= 0)
p_d	Power of the incandescent bulb [W]
p_{esl}	Power of the energy-saving lamp or ELD [W]
t_a	Annual runtime [h]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Until 2011: Average power, incandescent bulb [W]	60
From 2012: Average power, halogen lamp [W]	42
Average power, energy-saving lamp [W]	12
Average power, LED [W]	11
Luminous efficacy of an incandescent bulb [lm/W]	12
Luminous efficacy of a halogen lamp [lm/W]	17.1
Luminous efficacy of an energy-saving lamp [lm/W]	60

Luminous efficacy of an LED [lm/W]	65.5
Annual runtime [h][13]	2900
Lifetime of an energy-saving lamp [years][14]	2.8
Lifetime of an LED [years][15]	6.9

Formula for project-specific information

$$EE_{ges,k} = \frac{\sum_{i=1}^{n} P_{eff,i} \times (\frac{\eta_{EFF}}{\eta_R} - 1) \times t_{a,k} \times rb \times so \times cz}{1000}$$

EE_{ges}	Total energy savings [kWh per year]
n	Number of lamps replaced in project k
$P_{esl,i}$	Power of the energy-efficient lighting in project k [W]
$t_{a,k}$	Annual runtime in project k [h]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

[13] Proposed value corresponds to the default value for businesses according to the report 'Task 4.2: harmonised bottom-up evaluation methods: Method 9, Improvement of Lighting Systems (Tertiary Sector) – Final draft for consultation: EU Project EMEEES'

[14] Average lifetime of industry-standard compact energy-saving lamps 8000 h (Topprodukte.at, 2008) and with an average annual runtime of 2900 h

[15] Average lifetime of industry-standard LEDs 20 000 h (Topprodukte.at, 2012) and with an average annual runtime of 2900 h

3.4.2 IRC halogen lamps and other innovative lamps

Description of measure

Conventional halogen lamps with a power of 35 W (or 50 W), used frequently in the hotel and food service industries, are replaced with more efficient IRC[16] halogen lamps with a power rating of 20 W (or 35 W), or with other innovative lamps.

Default formula

$$EE_{ges} = (n - fr) \times (P_{St} - P_{IRC}) \times t_a \times rb \times so \times cz / 1000$$

EE_{ges}	Total energy savings [kWh per year]
n	Number of IRC halogen lamps purchased in connection with the measure
fr	Number of IRC halogen lamps that would have been purchased anyway regardless of the measure (free riders) (= 0)
P_{St}	Power of the conventional halogen spotlight [W]
P_{IRC}	Power of the IRC halogen spotlight [W]
t_a	Annual runtime [h]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Average power of the conventional halogen spotlight [W]	35
Average power of an IRC halogen spotlight [W] with almost the same luminous flux as the original conventional halogen spotlight[17]	20
Annual runtime [h][18]	2900
Lifetime [years] (Average lifetime 4000–5000 h according to manufacturer's information (cf. Philips, Osram) and with an average annual runtime of 2900 h)	1.55

[16] IRC stands for infra-red coated

[17] According to information from OSRAM: max. savings in the region of 48–65 %

[18] Proposed value corresponds to the default value for businesses according to the report 'Task 4.2: harmonised bottom-up evaluation methods: Method 9, Improvement of Lighting Systems (Tertiary Sector) – Final draft for consultation: EU Project EMEEES'

Formula for project-specific information

$$EE_{ges,k} = \frac{\left(\sum_{i=1}^{n} P_{alt\ i} - \sum_{j=1}^{m} P_{neu\ j}\right) \times t_{a\ k} \times rb \times so \times cz}{1000}$$

$EE_{ges,\ k}$	Total energy savings [kWh per year] in project k
n	Number of light sources in the existing lighting system in project k
m	Number of light sources in the new lighting system in project k
$P_{altt,i}$	Power of the light source i (e.g. conventional halogen spotlight) of the existing lighting system in project k [W]
$P_{neu,j}$	Power of the light source j (e.g. IRC halogen spotlight) of the existing lighting system in project k [W]
$t_{a,k}$	Annual runtime in project k [h]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

4 Energy audits for businesses

4.1 General remarks

Art. 3(I) defines an 'energy audit' as a 'systematic procedure with the purpose of obtaining adequate knowledge of the existing energy consumption profile of a building or group of buildings, an industrial or commercial operation or installation or a private or public service, identifying and quantifying cost-effective savings opportunities, and reporting the findings.'

The method discussed in this section refers only to businesses (including agricultural businesses), and not to private households.

Specific energy audits can be recognised as well as comprehensive audits; specific audits might relate to a specific technology or measure such as pressurised air and/or repairing leaks, boiler replacement etc. Technical and organisational measures are treated identically in principle. The corresponding savings result from the implementation of the measures and should be stated in the report to the monitoring body.

4.2 Methodology

Energy audits must be carried out by qualified energy advisors who are independent of any product or energy source. An audit report must be produced. Planned and implemented measures should be documented regularly (e.g. annually).

Qualification requirements for energy auditors

Energy auditors must meet the following two compulsory criteria:

1. Having specialist knowledge of energy technology, which can be demonstrated through having successfully graduated from one of the following educational or training courses: Course in the relevant field at a secondary technical college (Höhere Technische Lehranstalt – HTL), a university of applied sciences, or a technical university; a European EnergyManager (EUREM) course; the Energieberater F-Kurs (final part of the standardised training to become an energy advisor), or comparable courses such as energy optimisation and energy management for businesses and institutions, commercial energy management, or training courses at the advice centres recognised by the Austrian federal states. The relevant courses are listed on the website www.monitoringstelle.at.

AND

2. Two years of experience in consultancy or planning in businesses in the energy sector

Energy auditors' independence from any product or energy source

The requirement for energy advisors to be independent of any product or energy source will in any case have been met if advisors are commissioned who are independent of any product or energy source and who are not internal to any company.

Creation of an audit report

The savings measures that are recommended must be set out for the business in a comprehensible manner in an energy audit report. This audit report is not transferred automatically to the monitoring body but it does constitute a record with an important documentary function; it means that during verification carried out by supervisory agencies of the public bodies, implemented measures can be individually traced, or the complete audit report accessed in anonymised form. It is ensured that the audit report is not passed on to third parties. The following details must be included as a minimum:

- Company name, industry sector, date of examination
- Description of the current situation:
    1. For general energy audits: Statement of total energy consumption based on the volume of purchased heat and electricity, indicating the period considered (e.g. one year); a breakdown of energy consumption showing the major energy drains; and the product mix and utilisation of production capacity during the period considered (where relevant to the energy consumption).
    2. Specific energy audits must include (where relevant): total energy consumption based on the volume of purchased heat and electricity during the period considered, energy consumption for the system in question, and the affected production output and product mix (if relevant to energy).
- Technical/organisational description of all recommended/ planned/ implemented measures for the company in question
- Easily comprehensible and realistic estimate of energy savings, or energy consumption before and after an energy-saving measure
- Description of the data-gathering and calculation methods applied. This includes any measurements or other sources of data which were needed for the assessment, e.g. annual energy consumption, meter readings, operating hours, nameplate data, monthly invoices, analyses from the control system, manufacturer's information, figures based on experience, or other data-gathering tools. The level of detail should depend on the size of the organisation and the extent of its energy consumption.
- Assessment of the lifetime of the measures or systems (see below)
- Affected system(s) or organisational unit (department, etc.)
- Assessment of cost-effectiveness (optional, but increases the likelihood of implementation)

Documentation of recommended and implemented measures

The following table is suggested for recording recommended/implemented energy-saving measures and reporting them to the monitoring body (one report to be produced per measure).

Table 4-1: Measures documentation form

Company (savings)	Company ID*
Total energy consumption [MWh], electricity (year)	
Total energy consumption [MWh], heat (year)	
Industry sector (e.g. using the Austrian 'ÖNACE' classification code)	
Description of the measure (in keywords)	
Energy source affected	
Implemented	Yes / No
Impact of the measure [savings in kWh], planned/**date**	
Impact of the measure [savings in kWh], implemented/**date**	
Savings in EUR	OPTIONAL
Investment, planning and installation costs	OPTIONAL
Lifetime of the measure/system (effectiveness of the savings)	

** In order to maintain confidentiality, only the company ID is given*

Describing the measure, the expected energy savings and the total energy consumption allows the impact of the measure to be checked at least roughly.

Determining the lifetime

When determining the lifetime of the measures, the appropriate standards (such as CEN WS 27) should be used first and foremost. If no such standards exist, then one should use information from the manufacturer or designer, or figures based on experience. A lifetime of 2 years is used for the implementation of activities that are to be carried out regularly (e.g. maintenance activities, repair of leaks in pipes for steam or pressurised air, repair of condensation drainage pipes) and organisational measures such as training or raising awareness (see also CEN Standard WS 27). This lifetime can be extended to eight years if the ongoing recurrence of the measure can be safeguarded. To do so, it is necessary to introduce a documented process; the activity must be specified and assigned to a person who is to be responsible for it (process instructions, transfer of responsibilities). Examples of this could be a maintenance process involving maintenance lists that specify dates for repeat maintenance and the person responsible, or a process whereby regular training is carried out. CEN Standard WS 27 currently sets out the following values for lifetimes in industry.

Table 4-2: Lifetime of measures in industry

Measure	**Lifetime**
Cogeneration	8
Heat recovery	8
Efficient pressurised air compressor systems	8
Efficient electric motor systems / use of frequency converters	8

Efficient pump systems	8
Good energy management and introduction of monitoring (organisational measure)	2

Subsequent implementation of measures

The full saving in connection with monitoring is only counted once the energy-saving measure has been implemented. Therefore, the implementation of measures must be noted, and documented in the table above. If the energy-saving measure is not implemented while the energy audit is being carried out, then the implementation of the measure must be checked after a year at the latest, or on an annually repeating basis (if still not implemented). Once the measure has been implemented, appropriate proof of this should be produced and submitted together with the audit report. It should include, as a minimum, the company name, date, contact person, date of implementation, and the most important technical details. Where relevant it should also include an updated record of the energy savings, an updated description of measures, updated calculations, and reference to a copy of a delivery receipt or similar. This proof is not transferred automatically to the monitoring body but it does constitute a record with an important documentary function; it means that during verification carried out by third parties, implemented measures can be individually traced, or the complete audit report accessed in anonymised form.

Default assumption: Measures that are planned but not yet demonstrably implemented must also be reported using the above table. For these measures, 5% of the target saving is acknowledged.[19] This 5% may only be counted for a maximum of the lifetime of the measure in question. Once the measure is implemented, the lifetime begins to run from the time of the implementation. (The 5% counted in previous years is unaffected by this).

Causal connection to the energy audit

Measures will only be acknowledged if they are causally connected to the energy audit. A broad approach is employed here: measures implemented due to more detailed investigations recommended by an energy audit, or due to data collected in the audit from systems / operational locations, are also acknowledged, i.e. measures are included even if it is the company itself that initiates or implements them. Also, estimations of savings due to the implementation of organisational measures can be acknowledged (e.g. training, employee motivation, engagement of management, procurement guidelines, or the introduction of an energy management system).

Documentary requirements and verification of energy savings

The directive (2006/32/EC) states that energy savings should be verified by third parties. In order to monitor the implementation of measures and evaluate energy-saving potential, it is essential to maintain the appropriate records relating to these. Records of savings estimates or data gathering must be legible, clearly identifiable and traceable. The documents must be kept (either as hard copy or electronically) until 2018. As well as the audit report and the

[19] This figure was taken from the following document: Gynther Lea, Suomi Ulla, 'Evaluation and Monitoring for the EU-Directive on Energy End Use Efficiency and Energy Services, harmonised bottom up evaluation methods, Method 20 Energy Audits', August 2007, p. 28.

proof of implementation, records can include proof of savings estimates and data gathering relating to the measures; examples might include analyses from the control system, copies of energy-source calculations, copies of meter readings, or records on capacity utilisation, the product mix, downtime, manufacturer's information, delivery confirmations, the results of measurements, calculations, and so on.

Third-party verification

The following procedure must be followed to enable verification by third-parties: when the auditee commissions the energy audit, the confidentiality of the audit report is to be guaranteed with the following exception: 'In the course of verification by public bodies (or by third parties instructed by public bodies), access can be granted to the planned measures contained in the audit report (and, if relevant, evidence that the measures have been implemented), or to the complete audit report in anonymised form.'

4.3 Recommendations for carrying out energy audits

Procedure

The following procedure is recommended for the carrying out of energy audits (according to VDI 3922, a guideline by the Association of German Engineers):

- Initial contact
- Offer and contract
- Ascertaining the current situation (check whether sufficient data is available, initiate measurements if not)
- Describe and evaluate the current situation
- Proposals for efficient energy usage
- Development of overall concepts (including a comparison of the proposed alternatives)
- Evaluation and selection of measures
- Presentation and audit report
- Implementation and monitoring of success

Energy auditing tools include

1. Information and documentation on technical matters
2. Energy audit handbook, energy management handbook
3. Checklists for energy checks
4. Calculation methods and software, measuring kit
5. Data gathering forms
6. Report templates
7. Checklist for quality control of audit reports
8. Target values, benchmarking
9. Databases of energy-saving options

Business auditing tools that can be used for this purpose have been developed as part of the klima:aktiv (active climate protection) programme. We would recommend trying out and making use of these tools, or if not then tools offered by similar programmes, or similar tools of one's own.

Further reading

Good Practice Guide 316, ‘Undertaking an industrial energy survey’, 02/2002, on behalf of the
Energy Efficiency Best Practice Program.

For energy audit procedure, please refer to VDI 3922 ‘Energieberatung für Industrie und Gewerbe’ (Energy audits for commerce and industry). Corresponding CEN/EN standards are in development:

- With regard to energy audits, a proposal for the possible development of a CEN standard has been initiated at a European level (‘proposal for creation of a new work item on ’Energy Audits’’).
- Development has begun on the standard ‘CEN/CLC/TF 190 general methodologies, including proposal dealing with energy efficiency calculations and savings on specific technologies or systems’ (does not yet have a mandate for implementation).
- The standard EN 16001 ‘Energy management system – requirements with guidance for use’ exists as a final draft and should be agreed upon this year in its final form.

Documentation

Audit report (see section ‘Creation of an audit report’) and a documentation form for each measure.

Proof of implementation of the measures, e.g. copies of delivery receipts, copies of energy-source invoices, manufacturer's information.

Documents providing evidence for the energy savings, e.g. analyses from a control system, copies of meter readings, records on utilisation of capacity, product mix, downtime, measurement results, calculations, etc.

5 Energy advice

Energy audits for private households[20] are offered in many different forms by advisory agencies, environmental associations, consumer organisations, and energy supply companies. The few studies that are available indicate that energy audits 'work' and can be an important part of the toolkit for reducing energy consumption in private households (Institute for Energy and Environmental Research (Institut für Energie und Umweltforschung – IFEU) (2007, 30).

The proposed methods for calculating the energy savings resulting from the energy audits for private households should provide an incentive to carry out audits, but at the same time represent the savings as realistically as possible.

5.1 Energy advice in the directive

Energy audits, information and advice concerning the end-user's final energy consumption play a central role in Directive 2006/32/EC. Art. 3(I) defines an 'energy audit' as a 'systematic procedure with the purpose of obtaining adequate knowledge of the existing energy consumption profile of a building or group of buildings, an industrial or commercial operation or installation or a private or public service, identifying and quantifying cost-effective savings opportunities, and reporting the findings.'

Art. 7(2) of the directive states that Member States must ensure that greater efforts are made to promote energy efficiency, and in particular that they establish 'appropriate conditions and incentives for market operators to provide more information and advice to final customers on energy end-use efficiency'. Art. 12(1) of the directive states that Member States 'shall ensure the availability of efficient, high-quality energy audit schemes which are designed to identify potential energy efficiency improvement measures and which are carried out in an independent manner, to all final consumers, including smaller domestic, commercial and small and medium-sized industrial customers'. Art. 12(2) of the directive also requires Member States to ensure the availability of audits for market segments where they are not sold commercially, and either to finance them through a mechanism in accordance with Art. 11 (funds) or to provide for them in voluntary agreements in accordance with Art. 6(2)(b).

The directive uses the same term 'energy audit' whether referring to audits in the commercial sector or to home energy audits (which could also be thought of as 'energy assessments' or 'energy consultations'). For the sake of clarity, we shall follow that usage here. Home energy audits can be carried out with various degrees of intensity (as with audits in the commercial sector).

[20] Energy audits for industrial, commercial and service companies are dealt with in the 'Energy audits for businesses' section.

5.2 Calculating the energy savings

Description of measure

A private household receives personalised advice from a trained energy advisor or internet tool on energy-saving possibilities for electricity and heat; the advice is categorised as being of a certain level of quality. Energy audits can only be treated as a measure for the purposes of the directive if they can be shown to have been carried out by a qualified and independent energy advisor or energy service company (see below, 'Qualification requirements for energy auditors', or Directive 2006/32/EC Art. 6
(2)(a)(ii)).

Home energy audits generally lead to investment measures such as boiler replacements or heat insulation, and also to changes in the behaviour of the energy consumer such as lowering the room temperature or turning off devices in standby mode. For the investment measures, there are separate methods and lifetimes that are used to calculate the energy savings in each case. The purpose of the method described here is to calculate the energy savings through changes in the behaviour of the energy consumer.

Default formula

Because of the difficulties inherent in separating behavioural aspects from investment aspects i.e. separating advice from investment in more efficient products, the proposed method takes the following approach: savings are calculated from the number of audits, their level of quality, the type of audit, and a default value for the energy savings brought about by an audit. A distinction is made between energy audits (including space heating) and electricity audits.

$$\mathbf{EE_{ges} = [(n_{Q1}\text{-}fr_1) \times EEV_{HH} \times e_{Q1} + (n_Q{}^2\text{-}fr^2) \times EEV_{HH} \times e_Q{}^2 + (n_{Q3}\text{-}fr_3) \times EEV_{HH} \times e_{Q3}] \times}$$
$$\mathbf{\times\ rb \times so \times cz}$$

$$\mathbf{EE_{ges/Strom} = [(n_{Q1}\text{-}fr_1) \times EEV_{HH/Strom} \times e_{Q1} + (n_Q{}^2\text{-}fr^2) \times EEV_{HH/Strom} \times e_Q{}^2 + (n_{Q3}\text{-}fr_3) \times}$$
$$\mathbf{\times\ EEV_{HH/Strom} \times e_{Q3}] \times rb \times so \times cz}$$

EE_{ges}	Total energy savings [kWh per year]
$EE_{ges/Strom}$	Total electricity savings [kWh per year] due to an audit concentrating solely on electrical applications
n_{Qn}	Number of energy audits carried out at quality level n
fr_n	Number of energy audits carried out at quality level n that would have taken place anyway regardless of the measure (free riders) (= 0)
EEV_{HH}	Final energy consumption of an average household [kWh per year]
$EEV_{HH/Strom}$	Electricity consumption of an average household [kWh per year]
e_{Qn}	Savings factor due to an energy audit carried out at quality level n [%]
rb	Rebound effects (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

If audits are carried out only for the consumption of electricity, then this reduces the attainable final energy savings. The proportion of electrical energy (not including electrical energy for space heating and air conditioning) compared to the total final energy consumption of private households is approx. 16.5%.[21] The electricity consumption of an average household is 3 600 kWh per year.

Default values

e_{Q1} Savings factor of an audit at quality level 1:	0.25%
$e_Q{}^2$ Savings factor of an audit at quality level 2:	1%
e_{Q3} Savings factor of an audit at quality level 3:	3%
Lifetime according to CEN (CEN WS 27 Final CWA Draft)[22]:	2 years
EEV_{HH} Final energy consumption of an average household [kWh per year][23]	22 000 KWh
$EEV_{HH/Strom}$ Electricity consumption (not including space heating and air conditioning) of an average household [kWh per year]	3 600 kWh

Types of audit

An energy audit must contain an element of feedback relating to a consumer's individual situation. Depending on the quality level, the audit can involve general energy-saving tips as well as a discussion of specific, individual problems. It can take various different forms: a conventional ‘stationary’ audit not conducted at the home itself; an energy audit on location at the home (which could be offered for free or as a commercial service); a phone audit; or the relatively new option of an online energy-saving audit involving individual input and feedback.

A distinction is made between the following **types of individual energy audits** (cf. IFEU 2006, 74 et seqq.):

1. **Energy audits on location:** The most intensive form of audit is an audit on location at the home. It allows energy-saving opportunities to be demonstrated directly rather than explained in the abstract; recommendations can be given and some energy-saving measures can be implemented immediately with the help of the advisor. Experience has shown that on-location audits can lead to the greatest energy savings per household.

[21] Source: Useful energy analysis 2006, Statistics Austria.

[22] This lifetime is, according to CEN WS 27 Final CWA Draft, a default value that can be adjusted at a national level if transparent data/studies are available.

[23] For the year 2006 the micro-census (family and household statistics) recorded 3.508 million private households. The total final energy consumption of private households in 2006 stood at 276 128 TJ, with final consumption of electrical energy at 53 620 TJ (Source: Statistics Austria, energy balance 2006).

2. **'Stationary' audits (not on location):** Stationary audits represent the classic approach, particularly for energy suppliers. Stationary audits can also be offered within the scope of energy and environmental services offered by regional energy agencies, charitable organisations, environmental groups or network operators. With stationary audits, interested households become active and contact the advising organisation. Informational brochures and energy-saving tips are often provided along with the audit.

   Conversations about energy at trade fairs can count as stationary audits if 1) they are carried out individually with a customer, 2) they meet the quality criteria, and 3) an audit log is kept as proof (a tally sheet is not sufficient proof).

3. **Phone audits:** Audits carried out by phone provide an alternative to stationary audits, and are used in particular for quick enquiries about energy savings. Phone audits can also be offered in combination with online audits.

4. **Personalised online audits:** Online audits with individual feedback on electricity-saving options in the home provide an alternative to face-to-face audits (e.g. the 'Profi-Check' provided by the Austrian Energy Agency and E-Control (the Austrian regulator for electricity and natural gas)). The advantages of online audits are the low running costs once a website has been set up, and the wide distribution of the audits, meaning that a large number of households can be reached. Also, the audit can be accessed at any time, from anywhere with internet access. In order to be counted as an energy efficiency improvement measure, online audits must include a comprehensive set of questions on the individual's situation with regard to energy consumption, as well as opportunities to make comparisons (peer-to-peer), personalised energy-saving tips, and a final report. The mere publication of energy-saving tips does not constitute an audit.

Energy saving campaigns: Unlike energy audits, energy saving campaigns have the goal of reaching as many households as possible by means of mass communication. The effects are less profound than those of individual audits. In particular, campaigns aim to raise awareness of the issue of energy savings amongst a particular target audience (IFEU 2006, 74). Information distributed as part of the campaign is often the trigger that prompts the individual to seek an energy audit. For profit-oriented companies, such campaigns can also serve as a marketing tool (cultivation of an image, market positioning, corporate branding).

Quality levels

In addition to the different types of audit, a distinction is made between three different **quality levels**:

- An **audit at quality level 1** has taken place if the audit 1) was carried out directly with the customer or through a personalised online service including an individual energy consumption analysis, and 2) took at least 15 minutes.

- An **audit at quality level 2** has taken place if the audit 1) was carried out directly with the customer, 2) included an individual energy consumption analysis, and 3) took at least 30 minutes.
- An **audit at quality level 3** has taken place if 1) the audit was carried out with the customer on location, 2) an individual energy concept was produced in a report, 3) the audit took longer than 60 minutes (e.g. construction and renovation audit, thermography), and 4) the audit was carried out by an energy advisor who is independent of any energy source or product. The requirement for energy advisors to be independent of any energy source will in any case have been met if advisors are commissioned who are independent of any product or energy source and who are not internal to any company.

Table 5-1 provides an overview of savings factors depending on the type of individual energy audit and the quality level.

Table 5-1: Savings factors of different types of audit and quality levels

	Quality level 1	Quality level 2	Quality level 3
Energy audit on location:		1%	3%
Stationary audit	0.25%	1%	3%
Phone audit	0.25%	1%	
Online audit	0.25%		

Lifetime of the measure

The measure ‘energy audits for private households’ does not consider the investment consequences of an energy audit; it only considers the changes in behaviour resulting from the audit. The studies that are available show that long-term, sustained behavioural changes on the part of the customer are rarely achievable through one-off measures; rather, a continual flow of information is required, for example in the form of educational programmes or training (IFEU 2006). The lifetime assumed here corresponds with the default value according to the CEN Workshop Agreement. If an energy audit is regularly ‘refreshed’, e.g. using an annotated visualisation of energy consumption including a weak-points analysis and suggested measures, then the lifetime can be doubled i.e. extended to four years.

Qualification requirements for energy auditors

Energy audits are to be carried out by qualified energy advisors. To be regarded as qualified they require proof of specialist knowledge of energy technology, which can be demonstrated through having successfully graduated from one of the following educational or training courses: a course in the relevant field at a secondary technical college (HTL), a university of applied sciences, or a technical university; a European EnergyManager (EUREM) course; the Energieberater F-Kurs (final part of the standardised training to become an energy advisor), or training at one of the advice centres recognised by the Austrian federal states. The relevant courses are listed on the website www.monitoringstelle.at.

Documentation of the energy audits

To enable a measure to be verified once it has been carried out, documentation of energy audits must first and foremost follow the **principle of transparency**: it must be possible to prove subsequently that the measure did take place. The type of energy audit will determine the form of the records that need to be kept.

- For every audit of quality level 2 or higher, an audit log must be kept, containing the energy saving issues that were discussed; improvements that were suggested along with the estimated energy-saving potential of these; the name and postcode of the customer; and the name, qualification and signature of the advisor.
- For on-location or stationary audits, the audit customer[24] must confirm the quality level of the audit and that it took place.
- The date, time, duration, type and quality of the audit must be included in the audit log.
- In the case of online audits, either the inputted data or the personalised audit reports can serve as proof.
- All records must be kept (either as hard copy or electronically) until 2018.

Documentation requirements – default formula:

Table 5-2: Documentation requirements – defaults

	Quality level 1	Quality level 2	Quality level 3
Audit on location		- Name, address and signature of the customer, confirming the quality level of the audit - Audit log with date, time, duration, location, type and quality of the audit - Signature of the advisor	- Name, address and signature of the customer, confirming the quality level of the audit - Audit log with date, time, duration, location, type and quality of the audit - Presentation of an energy concept (including suggested improvements and their estimated energy-saving potential) - Company stamp and signature of the advisor
Stationary audit (not on location)	- Name and postcode of the customer - Signature of the advisor.	- Name and postcode of the customer Audit log with date, time, duration, type and quality of the audit	Name, postcode and signature of the customer confirming the quality level of the audit;

[24] In the case of stationary audits carried out at a trade fair at quality level 1 or 2, the name and postcode of the customer is sufficient; a signature is not required here

		- Signature of the advisor.	- Audit log with date, time, duration, type and quality of the audit - Presentation of an energy concept (including suggested improvements and their estimated energy-saving potential) - Company stamp and signature of the advisor.
Phone audit	- Name, postcode and phone number of the customer; - Signature of the advisor.	- Name, postcode and phone number of the customer; - Audit log - Signature of the advisor.	
Personalised online audit	- Data inputted by the customer; - Personalised audit documentation (feedback) - Web access data		

Project-specific savings factors

If, for the energy audits that were carried out, transparent studies / investigations (quasi-experimental trial design) are available that demonstrate savings factors differing from the ones listed above, then these ‘project-specific savings factors’ can be applied.

Project-specific documentation requirements:

Presentation of the results of a study carried out by an independent company or institute.

Evaluation of energy audits

It is suggested that in future, the customer's consent should be obtained during the energy audit for the customer to be contacted by phone after the audit and asked a number of questions; this should make it possible to evaluate the effectiveness of energy audits once they have been carried out.

In the case of online audits, the data entered with regard to energy consumption and household set-up can be used in aggregated (i.e. anonymised form) as the basis for analyses.

5.3 Studies and background information

A recent study from Germany by Kuckartz et al. (2007) indicates that three quarters of the population do not know how much electricity their household consumes per year, or how much a kilowatt hour costs. At the same time there is energy-saving potential in private households that it would be possible to tap cost-effectively. A study by the Austrian Energy Agency[25] indicates that in the area of white goods alone (dishwashers, washing machines and fridges), the energy savings through more efficient machines could amount to around 8% in 2020 compared to the baseline scenario (about 800 TJ) or 17% compared to consumption in 2005 (1700 TJ). This savings potential only takes technical improvements into account and does not include any savings brought about by changes in user behaviour.

Energy audits can be designed in various different ways in the attempt to unlock these potential energy savings. One approach is to address purchasing decisions (house construction, acquisition of appliances, etc.), small investments to improve existing appliances (energy-saving bulbs, timer switches, etc.) and user behaviour (turning down the heating at night, airing a room in short bursts, etc.). There are many obstacles to these, however (economic, social, etc.), that need to be overcome through audit services.

But the majority of energy audits are not evaluated; they are only documented in the form of descriptions of actions. For this reason, there is only a very limited amount of empirical data available on the effectiveness of energy audits (Prognos 2007). Research into changes in user behaviour following an energy audit is particularly scarce (IFEU 2007, 16).

Moreover, one is faced with the methodological difficulty of differentiating between energy savings due to an energy audit and energy savings due to the purchase of more efficient products (for example, what energy savings can be ascribed exclusively to the energy audit if the customer, following an energy audit, selects a highly efficient building envelope with an efficient heating system?). However, such a differentiation is required if one is to properly categorise the energy savings. Finally, it should also be noted that many studies have painted an overly optimistic picture because the baseline development was not considered.[26]

Existing studies on the effects of energy audits have been carried out using widely differing methodologies, meaning that the results cannot really be compared directly.

[25] Abschätzung der Energieeffizienz-Potentiale in Österreich bis zum Jahr 2020 (EE-Pot) [Assessment of the energy efficiency potential in Austria up the year 2020]. Study by the Austrian Energy Agency, April 2008, Vienna. The study is available for download at www.monitoringstelle.at .

[26] 'When evaluating audit schemes there is always the possibility of obtaining an overly optimistic result or even a false positive result because of the free-rider effect, whereby investments in energy savings are wrongly attributed to a given audit when in reality they would have been implemented anyway' (Larsen/Jensen 1999, 558).

- IFEU carried out an evaluation of on-location electricity audits (IFEU 2007) provided by KliBA (Klimaschutz- und Energie-Beratungsagentur Heidelberg und Nachbargemeinden).[27] The audit consisted of an approx. one hour long home inspection which took stock of the major electricity-consuming appliances in the home (lamps, fridges and freezers, standby consumers, etc.). A while later customers received an audit report with suggestions on saving electricity and tips for carrying out the measures in a cost-effective way. In the households that were examined, the energy savings that could be attributed to the effect of the on-location audit stood at 8% (where n = 27) compared to a control group. However, the study did not examine whether the savings were achieved through changes in purchasing decisions, through small investments, or through changes in user behaviour.
- Stationary energy audits offered by the consumer centres of the German federal states (Verbraucherzentralen), the German Association of Housewives, Lower Saxony (Deutscher Hausfrauenbund Niedersachsen) and Consumer Service Bavaria (Verbraucherservice Bayern) were evaluated, again by IFEU (2005). IFEU determined the proportion of measures that were carried out compared to the number that were recommended. Amongst homeowners, the greatest energy savings were achieved through wall and roof insulation.[28]

Table 5-3: Final energy savings for homeowners through investments made after energy audits (not including electricity-saving measures)

Owner	New heating system	Wall insulation	Roof insulation	Solar thermal system	Photovolt aics
Final energy savings per person advised on the topic (kWh/year)	696 (n=158)	1 837 (n=118)	1 298 (n=118)	809 (n=87)	454 (n=39)
Savings factor on average value of 15 000 kWh/year	4.6%	12.2%	8.7%	5.4%	3.0%

Source: IFEU 2005, 84.

- The same study (IFEU 2005, 87) was able to attribute the greatest annual electricity savings to the areas of lighting and standby; savings ranged between 0.3% and 0.8% of the average electricity consumption, with homeowners achieving somewhat higher savings than renters.[29]

[27] Here, electricity consumption was partly determined based on representative measurements taken by a measurement device (particularly with regard to standby), and the expected useful life of the appliances was requested. Households could also borrow an electricity-measuring device for several days to check the energy consumption of appliances that draw a fluctuating amount of power (e.g. fridges, freezers). The households had to pay a 20 euro contribution towards the on-site audits designed for this project. The remaining costs (around 300 euros per audit) were met by KliBA, who was able to finance this through a parallel EU project. The offer was advertised by means of approx. 9 000 vouchers sent out with the electricity bills of Stadtwerke Heidelberg (Heidelberg's municipal utility company).

[28] To calculate the percentage savings, an average heating energy consumption of 15 000 kWh/year per household was assumed.

[29] To calculate the percentage savings, an average electrical energy consumption of 3 000 kWh/year was assumed.

Table 5-4: Final energy savings due to electricity-saving audits for homeowners and renters

	Lighting	Refrigeration / freezing	Refrigeration / freezing	Standby
Final energy savings per person advised (kWh/year)				
Owner (n = 350)	24.9	8.7		13.4
Renter (n = 150)	20.2	10.9		20.8
Owner plus renter (n = 500)			1.6	
Savings factor on average value of 3 000 kWh/year				
Owner (n = 350)	0.8%	0.3%		0.4%
Renter (n = 150)	0.7%	0.4%		0.7%
Owner plus renter (n = 500)			0.1%	

Source: IFEU 2005, p.86 and our own calculations

- An energy audit programme for Danish single-family houses was able to ascertain a 4% saving in heating energy. However, Larsen and Jensen (1999, 559) argue that many Danish energy audits ought to be stopped on the grounds that they are not cost-effective, because the costs are very high and the external benefits (lowering of greenhouse gases and energy consumption) could be achieved through other less expensive means.
- Holanek (2007) examined to what extent measures suggested as part of the klima:aktiv ‘wohnmodern’ audit scheme were implemented in the federal states of Vienna, Styria and Salzburg. The scheme offers modernisation audits exclusively for property developers and the property management companies of large-scale residential housing. The most frequently suggested modernisation measure was a renewal of the building façade including heat insulation, followed by insulation of the top-floor ceiling, and the replacement of windows. The average implementation rate of the measures across all the federal states was about 38%.
- In an earlier study in Wisconsin (1982–83), Hirst and Gray found a reduction in natural gas consumption of 1–2% (compared to a control group) one year after household audits performed on location.
- In an evaluation carried out by the Canadian ENERSAVE programme (McDougall et al. 1982–83), participating households completed a questionnaire on their energy usage and were then given individual advice. Two years later, the participants were contacted again. No differences in their energy usage could be determined compared to a control group.

5.4 Bibliography

Hirst, E. / Grady, S. (1982–1983). Evaluation of a Wisconsin utility home energy audit program. Journal of Environmental Systems, 12(4), 303–320.

Holanek, Nicole (2007). Evaluierung der wohnmodern-Beratungen unter energetischen, ökologischen und ökonomischen Aspekten [Evaluation of the 'wohnmodern' audits considering energy-related, environmental and economic aspects]. Diploma thesis, University of Applied Sciences Upper Austria, Wels.

IFEU (2005). Evaluation der stationären Energieberatung der Verbraucherzentralen, des Deutschen Hausfrauenbundes Niedersachsen und des Verbraucherservice Bayern [Evaluation of stationary energy audits carried out by the consumer centres of the federal German states, the German Association of Housewives and Consumer Service Bavaria]. Final report on behalf of the Federation of German Consumer Organisations (vzbv), December 2005, Heidelberg.

IFEU (2006). Effiziente Beratungsbausteine zur Verminderung des Stromverbrauchs in privaten Haushalten [Efficient audit components for reducing energy consumption in private households]. Interim report. IFEU. Heidelberg.

IFEU (2007). Effiziente Beratungsbausteine zur Verminderung des Stromverbrauchs in privaten Haushalten [Efficient audit components for reducing energy consumption in private households]. IFEU. Heidelberg.

Kuckartz U. / Rheingans-Heintze, A. / Rädiker S. (2007). Klimawandel aus der Sicht der deutschen Bevölkerung [Climate change from the perspective of the German population]. Study as part of the project 'Environmental Awareness in Germany' (Umweltbewusstsein in Deutschland). Marburg.

Larsen, Anders / Mette Jensen (1999). Evaluations of energy audits and the regulator. In: Energy Policy Vol. 27, 557–564.

McDougall, G. H. G. / Claxton, J. D. / Ritchie, J. R. B. (1982–1983). Residential home audits: An empirical analysis of the ENEVERSAVE program. Journal of Environmental Systems, 12(3), 265–278.

Prognos (2007). Potentiale für Energieeinsparung und Energieeffizienz im Lichte aktueller Preisentwicklungen [Potential for energy savings and energy efficiency in the light of current price developments]. Final report 18/06. Basel.

6 District heating

In line with how the statistical data is recorded, with district heating being categorised as a source of final energy, this method considers the difference between the final energy usage of district heating and the final energy usage of fuels in conventional boilers in order to provide space heating and hot water. In doing so we will consider residential buildings connected to local and district heating (which can be supplied by various different energy sources).

With this approach one should remain mindful of the fact that there are two different sources of final energy involved. The step prior to district heating is a conversion of energy through a combustion process (analogous to single combustion systems) or through cogeneration; and district heating also requires distribution through a district heating grid. Therefore, to fully understand the savings potential of both systems one would have to examine the primary energy usage.

6.1 Connection to district heating (for existing buildings with no thermal renovation / after thermal renovation)

The connection to local or district heating takes the place of an existing, average, single combustion system in an existing building. The provision of heat (space heating and hot water) through district heating is compared to the existing system's usage of fuel. The measure can be carried out for single-family houses, small blocks of flats, or large-scale residential buildings.

The approach with regard to installing a district heating connection in existing buildings or renovated existing buildings is as described in section 8.1.

Default formula

$$\mathbf{EE_{ges}} = (n - fr)^2 \times m^2 \times (E_{Bestand} - E_{Fernwärme}) \times rb \times so \times cz$$

$$E_{Bestand} = (HWB_{Bestand} + WWWB) \times AZ_{Bestand}$$

$$E_{Fernwärme} = (HWB_{Bestand} + WWWB) \times AZ_{Fernwärme}$$

EE_{ges}	Total final energy savings [kWh per year]
n	Number of participants / connections to district heating
fr	Number of participants that would have been connected to the district heating anyway regardless of the measure (free riders) = 0
m^2	Average building size in m^2 (gross floor area – GFA)
$E_{Bestand}$	Average annual final energy consumption per m^2 GFA for average existing systems [kWh/m^2/year]
$E_{Fernwärme}$	Average annual final energy consumption per m^2 GFA after connection to district heating [kWh/m^2/year]
$HWB_{Bestand}$	Heating requirement per m^2 GFA per year in the existing building (without thermal renovation / after thermal renovation) [kWh/m2/year]

WWWB	Hot water heating requirement [kWh/m^2/year]
$AZ_{Bestand}$	Expenditure factor for converting useful energy to final energy for an average existing standard heating system
$AZ_{Fernwärme}$	Expenditure factor for converting useful energy to final energy after connection to district heating
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values – existing buildings (without thermal renovation)

Lifetime of district heating (heat exchanger): 30 years (ÖNORM M7140), CEN proposal 20 years[30]

		Singl	Small	Large-scale	Large-
		Existing	Existing	Existing	Old
GFA [m²]		176	825	2445	2445
$HWB_{Bestand}$ [kWh/m^2/year]		156	107	80	141
WWWB [kWh/m^2/year]		12.5			
Oil	$AZ_{Bestand}$	2.00	2.15	2.38	1.91
Gas	$AZ_{Bestand}$	1.93	2.09	2.32	1.86
District heating	$AZ_{Fernwärme}$	1.18	1.17	1.21	1.13

Default values – existing buildings (after thermal renovation)

Lifetime of district heating (heat exchanger): 30 years (ÖNORM M7140), CEN proposal 20 years[31]

		Singl	Small	Large-
		Existing, renovated	Existing, renovated	Existing, renovated
GFA [m²]		176	825	2445
$HWB_{Bestand}$ [kWh/m^2/year]		83	69	50
WWWB [kWh/m^2/year]		12.5		
Oil	$AZ_{Bestand}$	2.57	2.60	3.00
Gas	$AZ_{Bestand}$	2.48	2.52	2.92
District heating	$AZ_{Fernwärme}$	1.31	1.25	1.34

[30] Proposal to use the relevant CEN-WS 27 proposal. CEN – Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations; Final CWA draft (CEN WS 27)

[31] Proposal to use the relevant CEN-WS 27 proposal. CEN – Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations; Final CWA draft (CEN WS 27)

Formula for project-specific information

$$EE_{ges} = \sum_{i=1}^{n} \left(m_i^2 \times \left((HWB_{i,Bestand} + WWWB_i) \times AZ_{i,Bestand} - (HWB_{i,Bestand} + WWWB_i) \times AZ_{i,Fernwärme} \right) \right) \times rb \times so \times cz$$

EE_{ges}	Total final energy savings [kWh per year]
n	Number of participants / connections to district heating
$m2_i$	Gross floor area of participant i [m^2]
$HWB_{i,Bestand}$	Heating requirement of participant i, in the existing building (without thermal renovation / after thermal renovation) [$kWh/m_2/year$]
$WWWB_i$	Hot water heating requirement of participant i [$kWh/m_2/year$]
$AZ_{i,Bestand}$	Expenditure factor for converting useful energy to final energy for the existing (replaced) heating system
$AZ_{i,Fernwärme}$	Expenditure factor for converting useful energy to final energy after connection to district heating
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

6.2 Connection to district heating for new buildings

Description of measure

When connecting a new residential building to a local or district heating supply, the supply of heat from district heating is compared to the fuel consumption of an average new single combustion system. The measure can be carried out for single-family houses, small blocks of flats, or large-scale residential buildings.

Default formula

$$EE_{ges} = (n - fr) \times m^2 \times (E_{Standard} - E_{Fernwärme}) \times rb \times so \times cz$$

$$E_{Standard} = (HWB_{NB} + WWWB) \times AZ_{Standard}$$

$$E_{Fernwärme} = (HWB_{NB} + WWWB) \times AZ_{Fernwärme}$$

EE_{ges}	Total final energy savings [kWh per year]
n	Number of participants / connections to district heating
fr	Number of participants that would have been connected to the district heating anyway regardless of the measure (free riders) = 0
m^2	Average building size in m^2 (gross floor area – GFA)
$E_{Standard}$	Average annual final energy consumption per m^2 GFA in a new building with new average systems [$kWh/m^2/year$]

$E_{Fernwärme}$ Average annual final energy consumption per m² GFA in a new building when connected to district heating [kWh/m²/year]

HWB_{NB}	Heating requirement per m² gross floor area per year in the new building [kWh/m²/year]
WWWB	Hot water heating requirement [kWh/m²/year]
$AZ_{Standard}$	Expenditure factor for converting useful energy to final energy for a new average heating system
$AZ_{Fernwärme}$	Expenditure factor for converting useful energy to final energy for a connection to district heating
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Lifetime of district heating (heat exchanger): 30 years (ÖNORM M7140), CEN proposal 20 years[32]

		Single-family house	Small block of flats	Large-scale residential building
		New building	New building	New building
GFA [m²]		176	825	2445
HWB_{NB} [kWh/m²/year]		66	49	38
WWWB [kWh/m²/year]		12.5		
Oil	$AZ_{Standard}$	1.53	1.52	1.54
Gas	$AZ_{Standard}$	1.45	1.45	1.48
District heating	$AZ_{Fernwärme}$	1.2	1.25	1.32

Formula for project-specific information

$$EE_{ges} = \sum_{i=1}^{n} \left(m_i^2 \times \left((HWB_{i,NB} + WWWB_i) \times AZ_{i,Standard} - (HWB_{i,NB} + WWWB_i) \times AZ_{i,Fernwärme} \right) \right) \times rb \times so \times cz$$

EE_{ges}	Heating requirement per m² gross floor area per year in the new building [kWh/m²/year]
n	Number of participants / connections to district heating
m^2_i	Gross floor area of participant i [m²]
$HWB_{i,NB}$	Heating requirement of participant i in the new building [kWh/m²/year]
WWWBi	Hot water heating requirement of participant i [kWh/m²/year]
$AZ_{i,Standard}$	Expenditure factor for converting useful energy to final energy for the average new standard heating system
$AZ_{i,Fernwärme}$	Expenditure factor for converting useful energy to final energy after connection to district heating
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

[32] Proposal to use the relevant CEN-WS 27 proposal. CEN – Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations; Final CWA draft (CEN WS 27)

7 Thermally improved building envelope

7.1 Thermally improved building envelope in connection with the residential building subsidy (construction of new buildings)

Description of measure

If the building envelope of a new building is more energy efficient than required by the current building regulation, then a higher amount of residential building subsidy is awarded. New buildings have to meet tougher heat insulation requirements to qualify for the additional subsidy, which leads to energy savings.

The baseline for calculating energy savings due to the additional residential building subsidy:

ƒ For new buildings from 2008: heating requirement values in the building regulation valid in the year of construction (corresponding to the heating requirement values in OIB Guideline 6).

Default formula

$$EE_{ges} = (EE_{NB,EFH,mittel} \times m^2_{NBWBF,EFH,a} + EE_{NB,MFH,mittel} \times m^2_{NBWBF,MFH,a}) \times rb \times so \times cz$$

$$\text{HWB-M}_{NB,EFH,St,mittel} = \frac{\sum_{sp=1}^{n} (\text{HWB-M}_{NB,EFH,St,sp} \times m^2_{NBWBF,EFH,sp})}{m^2_{NBWBF,EFH,a}}$$

$$\text{HWB-M}_{NB,MFH,St,mittel} = \frac{\sum_{sp=1}^{n} (\text{HWB-M}_{NB,MFH,St,sp} \times m^2_{NBWBF,MFH,sp})}{m^2_{NBWBF,MFH,a}}$$

$$EE_{NB,EFH,mittel} = (\text{HWB-B}_{NB,EFH,St} - \text{HWB-M}_{NB,EFH,St,mittel}) \times AZ_{Neu}$$

$$EE_{NB,MFH,mittel} = (\text{HWB-B}_{NB,MFH,St} - \text{HWB-M}_{NB,MFH,St,mittel}) \times AZ_{Neu}$$

EFH	Single-family house
Small block of flats	Small block of flats
HWB-$_{MNB,EFH,St,mittel}$ *or* HWB-M$_{NB,MFH,St,mittel}$	Average heating requirement, in the local climate, for a newly built single-family house or small block of flats (requirements according to the residential building subsidy) per m^2 gross floor area per year [kWh/m^2 /year]
HWB-M$_{NB,EFH,St,sp}$ *or* HWB-M$_{NB,MFH,St,sp}$	Specific heating requirement per subsidy category, in the local climate, for the newly built single-family house or small block of flats per m^2 gross
m$^2_{NBWBF,EFH,sp}$ *or* m$^2_{NBWBF,MFH,s}$	m^2 in single-family houses or small blocks of flats that are subsidised annually in accordance with subsidy category 'sp' with a specific HWB-M$_{NB,EFH,St,sp}$ or HWB-M$_{NB,MFH,St,sp}$
sp	Specific subsidy category / subsidy level
n	Number of subsidy categories / subsidy levels

$m^2_{NBWBF,EFH,a}$ *or* $m^2_{NBWBF,MFH,a}$	m^2 per year of floor area of a single-family house or small block of flats newly built using the residential building subsidy
St	Local climate
m^2_{BGF}	Gross floor area in square metres
$EE_{NB,EFH,mittel}$ *or* $EE_{NB,MFH,mittel}$	Average final energy savings in newly built single-family houses or small blocks of flats [kWh/m^2_{BGF}/year] BGF,
$HWB\text{-}B_{NB,EFH,St}$ *or* $HWB\text{-}B_{NB,MFH,St}$	Baseline heating requirement for newly built single-family houses or small blocks of flats, in the local climate, per m^2 gross floor area per year [kWh/m^2_{BGF}/year] BGF,
AZ_{Neu}	Expenditure factor for converting useful energy to final energy
EE_{ges}	Total final energy savings [kWh per year]
$HWB_{BGF,Ref}$	Annual residential building heating requirement per m^2 of conditioned gross floor area at the building location [kWh/m2BGF/year]
$HWB_{BGF,Ref}$	Annual residential building heating requirement per m^2 of conditioned gross floor area in a reference climate [kWh/m^2_{BGF}/year]
a	Year

rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

AZ_{Neu}	1.5 (reporting template according to Art. 10 of the 15a agreement on residential building subsidies (15a WBF)[33]

[33] Source: Reporting template of the Federal Ministry of Agriculture, Forestry, Environment and Water Management for meeting the reporting requirements according to Art. 10 of the agreement under Art. 15a of the B-VG between the federal government and the federal states concerning joint quality standards to subsidise the construction and renovation of residential buildings in order to reduce greenhouse gas emissions (BGBl II No 19/2006).

Baseline heating requirement

Default values in accordance with OIB Guideline 6

Until 31/12/2009	**$HWB_{BGF,WG,max,Ref}$ =26*(1+2.0/l_c) [kWh/m²/year]**	**Maximum of 78.0 [kWh/m²/year]**
Single-family house		67.6 (where lc = 1.25)
Small block of flats		46.8 (where lc = 2.5)
From 01/01/2010	**$HWB_{BGF,WG,max,Ref}$ =19*(1+2.5/l_c) [kWh/m²/year]**	**Maximum of 66.5 [kWh/m²/year]**
Single-family house		57.0 (where lc = 1.25)
Small block of flats		38 (where lc = 2.5)

lc	Characteristic length
Single-family house	Single-family and two-family houses
Small block of flats	Multi-storey residential buildings

Where possible, building-specific values are used, i.e. the actual lc value is used in the formula according to OIB Guideline 6 (baseline for formula for building-specific information). If this is not possible then the default values given for single-family houses and small blocks of flats are used.

The default values given in the above table according to OIB Guideline 6 refer to the reference climate (Ref) and therefore have to be converted into the local climate. Conversion between the reference climate and local climate according to OIB Guideline 6:

$HWB_{BGF,WG,max,St} = HWB_{BGF,WG,max,Ref} \times HGT_{St}/3400$

$HWB_{BGF,WG,max,St}$ = Maximum permissible annual residential building heating requirement per m²

of conditioned gross floor area at the building location

Ref = reference climate (3400

Kd)St = Local climate

HGT_{ST}= Heating degree days according to the local climate; see also the annex to the guideline on calculating energy indicators and climate data, number OIB-382-011/99, or the average values for the federal states in the following table.

Table 7-1: Heating degree days, average 2001 to 2005

	HGT_{st}
Federal state	**Average from 2001 to 2005**
Vienna	3102.0
Lower Austria	3300.6
Burgenland	3152.6
Upper Austria	3440.7
Salzburg	3585.4
Styria	3418.8
Carinthia	3551.8
Tyrol	3680.1
Vorarlberg	3341.0
Austria	3359.3

Source: Statistics Austria

Therefore, the default values to be used for the purposes of this method are calculated as follows:

Until 31/12/2009:

$HWB\text{-}B_{NB,EFH,St} = 67.6 \times HGT_{St}/3400$
$HWB\text{-}B_{NB,MFH,St} = 36.4 \times HGT_{St}/3400$

From 01/01/2010:

$HWB\text{-}B_{NB,EFH,St} = 57.0 \times HGT_{St}/3400$
$HWB\text{-}B_{NB,MFH,St} = 28.5 \times HGT_{St}/3400$

Formula for building-specific information

This formula can be used if building-specific information is known:

$$\mathbf{EE_{ges}} = (EE_{NB,EFH,mittel} \times m^2_{NBWBF,EFH,a} + EE_{NB,MFH,mittel} \times m^2_{NBWBF,MFH,a}) \times rb \times so \times cz$$

$$\mathbf{HWB\text{-}M_{NB,EFH,St,mittel}} = \frac{\sum_{i=1}^{n} (HWB\text{-}M_{NB,EFH,St,i} \times m^2_{NBWBF,EFH,i})}{m^2_{NBWBF,EFH,a}}$$

$$\mathbf{HWB\text{-}M_{NB,MFH,St,mittel}} = \frac{\sum_{i=1}^{n} (HWB\text{-}M_{NB,MFH,St,i} \times m^2_{NBWBF,MFH,i})}{m^2_{NBWBF,MFH,a}}$$

$$\mathbf{EE_{NB,EFH,mittel}} = (HWB\text{-}B_{NB,EFH,St} - HWB\text{-}M_{NB,EFH,St,mittel}) \times AZ_i$$

$$\mathbf{EE_{NB,MFH,mittel}} = (HWB\text{-}B_{NB,MFH,St} - HWB\text{-}M_{NB,MFH,St,mittel}) \times AZ_i$$

i	Building i (single-family house or small block of flats)
n	Number of buildings (single-family houses or small blocks of flats)
EFH	Single-family house
Small block of flats	Small block of flats
$HWB\text{-}M_{NB,EFH,St,mittel}$ *or* $HWB\text{-}M_{NB,MFH,St,mittel}$	Average heating requirement in the local climate for a newly built single-family house or small block of flats (requirements according to the residential housing subsidy) per m_2 gross floor area per year [kWh/m^2_{BGF}/year]
$HWB\text{-}M_{NB,EFH,St,I}$ *or* $HWB\text{-}M_{NB,MFH,St,i}$	Specific heating requirement in building i, in the local climate, for the newly built single-family house or small block of flats per m_2 gross floor area per year [kWh/m^2_{BGF}/year]
$m_{2NBWBF,EFH,i}$ *or* $m_{2NBWBF,MFH,}$	m_2 in building i with a specific $HWB\text{-}M_{NB,EFH,St,i}$ or $HWB\text{-}M_{NB,MFH,St,i}$
$m_{2NBWBF,EFH,a}$ *or* $m_{2NBWBF,MFH,}$	m_2 per year of floor area of a single-family house or small block of flats newly built using the residential building subsidy
St	Local climate
$m_{2\,BGF}$	Gross floor area in square metres
$EE_{NB,EFH,mittel}$ *or* $EE_{NB,MFH,mitte}$	Average final energy savings in newly built single-family houses or small blocks of flats [kWh/m^2_{BGF}/year]
$HWB\text{-}B_{NB,EFH,St}$ *Or* $HWB\text{-}B_{NB,MFH,St}$	Baseline heating requirement in newly built single-family houses or small blocks of flats in the local climate per m_2 gross floor area per year [kWh/m^2_{BGF}/year]

AZ_i	Expenditure factor for converting useful energy to final energy for building i
EE_{ges}	Total final energy savings [kWh per year]
$HWB_{BGF,Ref}$	Annual residential building heating requirement per m² of conditioned gross floor area at the building location [kWh/m^2_{BGF}/year]
$HWB_{BGF,Ref}$	Annual residential building heating requirement per m² of conditioned gross floor area in the reference climate [kWh/m^2_{BGF}/year]
a	Year
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Lifetime of the measure

The measure 'thermally improved building envelope' consists of the following measures: insulation of the building envelope, windows/glazing, and air conditioning systems with heat recovery.

According to Final CWA Draft (CEN WS 27), the lifetimes of these are to be set as follows:

- Insulation of the building envelope: > 25 years
- Windows/glazing: 24 years

We therefore propose setting the lifetime of the measure 'thermally improved building envelope' at 25 years.

Data sources

- Data from the funding bodies for the residential building subsidy
- Evaluations of the data contained in energy performance certificates
- Evaluations via the ZEUS internet platform

7.2 Thermally improved building envelope in connection with a residential building renovation subsidy

Description of measure

For renovations, a more energy-efficient thermal building envelope (compared to the status quo) is required in order to receive the additional residential building subsidy for energy-saving measures. Buildings in need of renovation have to meet tougher insulation requirements in order to receive the additional energy-related part of the residential building subsidy for the renovation. The measure focuses on improvements to the building envelope.

he following approaches can be used (depending on the data available) to determine the baseline for calculating the savings achieved through the additional residential building subsidy:

- Heating requirement values in existing data gathered prior to renovation, as a building-specific baseline for a building-specific approach

- Heating requirement values from the reporting template of the Federal Ministry of Agriculture, Forestry, Environment and Water Management, for use with the default formula.

Default formula

$$EE_{ges} = (EE_{SAN,EFH,mittel} \times m^2_{SANWBF,EFH,a} + EE_{SAN,MFH,mittel} \times m^2_{SANWBF,MFH,a}) \times rb \times so \times cz$$

$$HWB\text{-}M_{SAN,EFH,St,mittel} = \frac{\sum_{sp=1}^{n} (HWB\text{-}M_{SAN,EFH,St,sp} \times m^2_{SANWBF,EFH,sp})}{m^2_{SANWBF,EFH,a}}$$

$$HWB\text{-}M_{SAN,MFH,St,mittel} = \frac{\sum_{sp=1}^{n} (HWB\text{-}M_{SAN,MFH,St,sp} \times m^2_{SANWBF,MFH,sp})}{m^2_{SANWBF,MFH,a}}$$

$$EE_{SAN,EFH,mittel} = (HWB\text{-}B_{SAN,EFH,St} \times AZ_{Bestand} - HWB\text{-}M_{SAN,EFH,St,mittel} \times AZ_{SAN})$$

$$EE_{SAN,MFH,mittel} = (HWB\text{-}B_{SAN,MFH,St} \times AZ_{Bestand} - HWB\text{-}M_{SAN,MFH,St,mittel} \times AZ_{SAN})$$

EFH	Single-family house
Small block of flats	Small block of flats
$HWB\text{-}M_{SAN,EFH,St,mittel}$ *or* $HWB\text{-}M_{SAN,MFH,St,mittel}$	Average heating requirement in the local climate for a renovated single-family house or small block of flats (requirements according to the residential housing subsidy) per m^2 gross floor area per year [$kWh/m^2_{BGF}/y$]
$HWB\text{-}M_{SAN,EFH,St,sp}$ *or* $HWB\text{-}M_{SAN,MFH,St,sp}$	Specific heating requirement per subsidy category, in the local climate, for the renovated single-family house or small block of flats per m^2 gross floor area per year [kWh/m^2_{BGF}/year]
$m^2_{SANWBF,EFH,sp}$ *or* $m^2_{SANWBF,MFH,sp}$	m^2 in single-family houses or small blocks of flats that are subsidised annually in accordance with subsidy category ‘sp’ with a specific $HWB\text{-}M_{SAN,EFH,St,sp}$ or $HWB\text{-}M_{SAN,MFH,St,sp}$
sp	Specific subsidy category / subsidy level
n	Number of subsidy categories / subsidy levels
$m^2_{SANWBF,EFH,a}$ *or* $m^2_{SANWBF,MFH,a}$	m^2 of single-family house floor area or small block of flats floor area renovated per year using the residential building subsidy

St	Local climate
m^2	Gross floor area in square metres
$EE_{SAN,EFH,mittel}$ *or* $EE_{SAN,MFH,mittel}$	Average final energy savings in renovated single-family houses or small blocks of flats [kWh/m^2_{BGF}/year]
$HWB\text{-}B_{SAN,EFH,St}$ *or* $HWB\text{-}B_{SAN,MFH,St}$	Baseline heating requirement in renovated single-family houses or small blocks of flats, in the local climate, per m^2 gross floor area per year [kWh/m^2_{BGF}/year]
$AZ_{Bestand}$	Expenditure factor for converting useful energy to final energy in the existing stock
AZ_{SAN}	Expenditure factor for converting useful energy to final energy in the renovated stock (without a boiler replacement)
EE_{ges}	Total final energy savings [kWh per year]
$HWB_{BGF,Ref}$	Annual residential building heating requirement per m^2 of conditioned gross floor area at the building location [kWh/m^2_{BGF}/year]
a	Year
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

$AZ_{Bestand}$	1.8 (reporting template according to Art. 10 of 15a WBF[34])
AZ_{SAN}	2.2 (reporting template according to Art. 10 of 15a WBF)

[34] Reporting template of the Federal Ministry of Agriculture, Forestry, Environment and Water Management for meeting the reporting requirements according to Art. 10 of the agreement under Art. 15a of the B-VG between the federal government and the federal states concerning joint quality standards to subsidise the construction and renovation of residential buildings in order to reduce greenhouse gas emissions (BGBl II No 19/2006).

Baseline heating requirement

Default values

Baseline heating requirement, renovation: from the reporting template of the Federal Ministry of Agriculture, Forestry, Environment and Water Management for meeting the reporting requirements according to Art. 10 of the agreement under Art. 15a of the B-VG between the federal government and the federal states concerning joint quality standards to subsidise the construction and renovation of residential buildings in order to reduce greenhouse gas emissions (BGBl II No 19/2006).

EFH		
HWB-$B_{SAN,EFH,Ref}$	EFH	200 kWh/m^2_{BGF}/year
Small block of flats		
HWB-$B_{SAN,MFH,Ref}$	Small	90 kWh/m^2_{BGF}/year

Note: Default values are to be used if there is no existing data gathered prior to renovation. For single-family / two-family houses, a SA/V ratio of 0.8 is assumed for the above default value; for multi-storey residential buildings, an SA/V ratio of 0.2 is assumed. If the average or specific SA/V ratio is known, then one can interpolate in a linear fashion between the above default values, depending on the concrete SA/V ratio. If one has values that are verified to a higher standard, these should be used.

SA/V	Surface area to volume ratio
EFH	Single-family and two-family houses
Small block of flats	Multi-storey residential buildings

Building-specific values are used if possible (baseline for formula for building-specific information). If this is not possible then the default values given for single-family houses and small blocks of flats are used.

The default values apply for the reference climate (Ref); for the baseline, one has to convert to the relevant local climate. A conversion table is included.

$$\text{HWB-B}_{NB,EFH,St} = 200 \times \text{HGT}_{St}/3400$$
$$\text{HWB-B}_{NB,MFH,St} = 90 \times \text{HGT}_{St}/3400$$

HGT_{ST}= Heating degree days according to the local climate; see also the annex to the guideline on calculating energy indicators and climate data, number OIB-382-011/99, or the average values for the federal states in the following table.

Table 7-2: Heating degree days, average 2001 to 2005

Federal state	HGT_{St} Average from 2001 to 2005
Vienna	3102.0
Lower Austria	3300.6
Burgenland	3152.6
Upper Austria	3440.7
Salzburg	3585.4
Styria	3418.8
Carinthia	3551.8
Tyrol	3680.1
Vorarlberg	3341.0
Austria	3359.3

Source: Statistics Austria

Formula for building-specific information

$$EE_{ges} = (EE_{SAN,EFH,mittel} \times m^2_{SANWBF,EFH,a} + EE_{SAN,MFH,mittel} \times m^2_{SANWBF,MFH,a}) \times rb \times so \times cz$$

$$HWB\text{-}M_{SAN,EFH,St,mittel} = \frac{\sum_{i=1}^{n} (HWB\text{-}M_{SAN,\,EFH,St,i} \times m^2_{SANWBF,\,EFH,i})}{m^2_{SANWBF,\,EFH,a}}$$

$$HWB\text{-}M_{SAN,MFH,St,mittel} = \frac{\sum_{i=1}^{n} (HWB\text{-}M_{SAN,\,MFH,St,i} \times m^2_{SANWBF,\,MFH,i})}{m^2_{SANWBF,\,MFH,a}}$$

$$EE_{SAN,EFH,mittel} = (HWB\text{-}B_{SAN,EFH,St} \times AZ_{i,Bestand} - HWB\text{-}M_{SAN,EFH,St,\,mittel} \times AZ_{i,SAN})$$

$$EE_{SAN,MFH,mittel} = (HWB\text{-}B_{SAN,\,MFH,St} \times AZ_{i,Bestand} - HWB\text{-}M_{SAN,\,MFH,St,\,mittel} \times AZ_{i,SAN})$$

EFH	Single-family house
MFH	Small block of flats
$HWB\text{-}M_{SAN,EFH,St,mittel}$ *or* $HWB\text{-}M_{SAN,MFH,St,mittel}$	Average heating requirement in the local climate in the renovated single-family house or small block of flats (requirements according to the residential building subsidy) per m^2 gross floor area per year [kWh/m^2_{BGF}/year]
$HWB\text{-}M_{SAN,EFH,St,I}$ *or* $HWB\text{-}M_{SAN,MFH,St,i}$	Specific heating requirement per building i, in the local climate, in the renovated single-family house or small block of flats per m^2 gross floor area per year [kWh/m^2_{BGF}/year]
$m^2_{SANWBF,EFH,i}$ *or* $m^2_{SANWBF,MFH,i}$	m^2 in building i with specific $HWB\text{-}M_{SAN,EFH,St,i}$ or $HWB\text{-}M_{SAN,MFH,St,i}$

i	Building i
n	Number of buildings
$m^2_{SANWBF,EFH,a}$ *or* $m^2_{SANWBF,MFH,a}$	m^2 of single-family house floor area or small block of flats floor area renovated per year using the residential building subsidy
St	Local climate
m^2_{BGF}	Gross floor area in square metres
$EE_{SAN,EFH,mittel}$ *or* $EE_{SAN,MFH,mittel}$	Average final energy savings in renovated single-family houses or small blocks of flats [kWh/m^2_{BGF}/year]
$HWB\text{-}B_{SAN,EFH,St}$ *or* $HWB\text{-}B_{SAN,MFH,St}$	Baseline heating requirement in renovated single-family houses or small blocks of flats, in the local climate, per m^2 gross floor area per year [kWh/m^2_{BGF}/year]
$AZ_{i,Bestand}$	Expenditure factor for converting useful energy to final energy in building i prior to renovation
$AZ_{i,SAN}$	Expenditure factor for converting useful energy to final energy in building i prior to renovation (without a boiler replacement)
EE_{ges}	Total final energy savings [kWh per year]
$HWB_{BGF,Ref}$	Annual residential building heating requirement per m^2 of conditioned gross floor area at the building location [kWh/m^2_{BGF}/year]
a	Year
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Formula for taking improvements to building elements into account (U-values)

$$\textbf{HWB-eingespart} = \sum_{i=1}^{n} ((U_{bialt} - U_{bineu}) \times m^2_{SANbi} \times 100)$$

$$\textbf{EEges} = \text{HWB-eingespart} \times AZ_{SAN} \times rb \times so \times cz$$

U_{bialt}	U-value of building element i before renovation
U_{bineu}	U-value of building element i after renovation
$m_{2\,SANbi}$	m_2 renovated area of building element i
HWB-eingespart	Difference between the U-value of the building element prior to renovation and the U-value of the building element after renovation, multiplied by the m_2 of the renovated area
AZ_{SAN}	Expenditure factor for converting useful energy to final energy after renovation (without a boiler replacement)
EE_{ges}	Total final energy savings [kWh per year]

HWB-eingespart	Difference between the U-value of building element i prior to renovation and the U-value of building element i after renovation, multiplied by the m_2 of the renovated area
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Lifetime of the measure

The measure 'thermal improvement of the building envelope' consists of the following measures: insulation of the building envelope, windows/glazing, and air conditioning systems with heat recovery.

According to Final CWA Draft (CEN WS 27), the lifetimes of these are to be set as follows:

- Insulation of the building envelope: > 25 years
- Windows/glazing: 24 years

We therefore propose setting the lifetime of the measure 'thermally improved building envelope' at 25 years.

Data sources

- Data from the funding bodies for the residential building subsidy
- Evaluations of the data contained in energy performance certificates
- Evaluations via the ZEUS internet platform

7.3 Thermal improvement of the building envelope in existing buildings (without a residential building renovation subsidy)

This method covers the energy-related renovation of buildings leading to an improvement in energy-efficiency compared to the status quo, but without making use of the residential building subsidy. The actual saving depends on the measures carried out and can be determined using the formula for taking improvements to building elements into account:

Formula for taking improvements to building elements into account (U-values)

$$\text{HWB-eingespart} = \sum_{i=1}^{n} ((U_{bialt} - U_{bineu}) \times m^2_{SANbi} \times 100)$$

$$\text{EEges} = \text{HWB-eingespart} \times AZ_{SAN} \times rb \times so \times cz$$

U_{bialt}	U-value of building element i before renovation
U_{bineu}	U-value of building element i after renovation
m^2_{SANbi}	m_2 of the renovated area of building element i
HWB-eingespart	Difference between the U-value of the building element prior to renovation and the U-value of the building element after renovation, multiplied by the m_2 of the renovated area
AZ_{SAN}	Expenditure factor for converting useful energy to final energy after renovation (without a boiler replacement)
EE_{ges}	Total final energy savings [kWh per year]
HWB-eingespart	Difference between the U-value of building element i prior to renovation and the U-value of building element i after renovation, multiplied by the m_2 of the renovated area
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Lifetime of the measure

The measure ‘thermal improvement of the building envelope’ consists of the following measures: insulation of the building envelope, windows/glazing, and air conditioning systems with heat recovery.

According to Final CWA Draft (CEN WS 27), the lifetimes of these are to be set as follows:

- Insulation of the building envelope: > 25 years
- Windows/glazing: 24 years

We therefore propose setting the lifetime of the measure ‘thermally improved building envelope’ at 25 years.

In future, an additional formula will be offered to enable one to estimate the energy savings of a renovation measure using the final energy consumption of the building or flat's space heating provision.

7.4 Thermally improved building envelope in the construction of non-residential buildings

Description of measure

The building envelope in newly constructed non-residential buildings is more energy-efficient than required by the relevant building regulation. Energy savings can be achieved due to the better insulation. A distinction is made between the following categories of buildings[35]:

[35] Categorisation according to OIB Guideline 6 (version of October 2011)

1) Office buildings
2) Nurseries and compulsory-attendance schools
3) Post-secondary schools, colleges and universities
4) Hospitals
5) Care homes
6) Bed and breakfasts
7) Hotels
8) Restaurants
9) Event venues
10) Sporting venues
11) Shops
12) Indoor swimming pools
13) Other conditioned buildings

Default formula

$$EE_{ges} = (HWB\text{-}B_{NWG,St} – HWB\text{-}M_{NWG,St,mittel}) \times BV \times AZ_{Neu} \times rb \times so \times cz$$

$$HWB\text{-}M_{NWG,St,mittel} = \frac{\sum_{i=1}^{n} (HWB\text{-}M_{NWG,St,i} \times BV_i)}{BV}$$

$HWB\text{-}M_{NWG,St}$	Average heating requirement, in the local climate, in a new building per m_3 conditioned gross volume per year [kWh/$m^3{}_{BV}$/year]$_{BV,}$
$HWB\text{-}B_{NWG,St}$	Baseline heating requirement in the new building, in the local climate, per m^3 conditioned gross volume per year [kWh/$m^3{}_{BV}$/year]
BV	Conditioned gross volume of the buildings to which the average heating requirement refers.
AZ_{Neu}	Expenditure factor for converting useful energy to final energy
EE_{ges}	Total final energy savings [kWh per year]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision
so	Spill-over effects = multiplier effects
cz	Confidence factor

Default values

AZ_{Neu}	1.24 (reporting template according to Art. 16 of 15a WBF)[36]
Rb	1
So	1
Cz	1

Baseline heating requirement

Default values in accordance with OIB Guideline 6

Until 2011	**$HWB_{V,NWG,max,RK}$ = 9.0*(1+2.0/l_c) [kWh/m³/year]**	**Maximum of 27.0 kWh/m³/year**
From 2011	**$HWB_{V,NWG,max,RK}$ = 5.5*(1+3.0/l_c) [kWh/m³/year]**	**Maximum of 18.7 kWh/m³/year**

lc	Characteristic length in m

Where possible, building-specific values are used, i.e. the actual lc value is used in the formula according to OIB Guideline 6 (baseline for formula for building-specific information). If this is not possible, the highest value is taken as the standard value. The default values listed in the above table in accordance with OIB Guideline 6 refer to the reference climate (RK) and therefore have to be converted into the locate climate. Conversion between the reference climate and local climate according to OIB Guideline 6:

$HWB_{V,NWG,max,St} = HWB_{V,NWG,max,RK} \times HGT_{St} /3400$

$HWB_{V,NWG,max,St}$ = maximum permissible annual heating requirement for residential buildings per m^3 conditioned gross volume at the building location

RK = Reference climate (3400

Kd)St = Local climate

HGT_{ST}= Heating degree days according to the local climate; see also the annex to the guideline on calculating energy indicators and climate data, number OIB-382-011/99, or the average values for the federal states in the following table.

[36] Source: Reporting template of the Federal Ministry of Agriculture, Forestry, Environment and Water Management for meeting the reporting requirements according to Art. 10 of the agreement under Art. 15a of the B-VG between the federal government and the federal states concerning joint quality standards to subsidise the construction and renovation of residential buildings in order to reduce greenhouse gas emissions (BGBl II No 19/2006).

Federal state	HGT_{St} Average from 2001 to 2005
Vienna	3102.0
Lower Austria	3300.6
Burgenland	3152.6
Upper Austria	3440.7
Salzburg	3585.4
Styria	3418.8
Carinthia	3551.8
Tyrol	3680.1
Vorarlberg	3341.0
Austria	3359.3

Table 3: Heating degree days, average 2001 to 2005

Source: Statistics Austria

Therefore, the default values to be used for the purposes of this method are calculated as follows:

$$HWB\text{-}B_{NWG,St} = HWB\text{-}B_{V,NWG,max,RK} \times HGT_{St} / 3400$$

Formula for building-specific information

The project-specific formula is used for building-specific information, with the following parameters being entered in addition to the input values of the default formula:

- $HWB\text{-}B_{NWG,St}$: If the characteristic length of the building is known, the exact heating requirement reference value (baseline) can be calculated. However, the maximum value cannot be exceeded.
- AZ_{Neu}: Expenditure factor of the heating technology

Lifetime of the measure

The measure ‘thermally improved building envelope’ consists of the following measures: insulation of the building envelope, windows/glazing, and air conditioning systems with heat recovery.

According to Final CWA Draft (CEN WS 27), the lifetimes of these are to be set as follows:

- Insulation of the building envelope: > 25 years
- Windows/glazing: 24 years

We therefore propose setting the lifetime of the measure ‘thermally improved building envelope’ at 25 years.

7.5 Thermally improved building envelope in the renovation of non-residential buildings (volume)

Description of measure

The method describes the calculation process for a reduction in the heating requirement of non-residential buildings through improving the exterior building envelope. Final energy savings are only calculated if the requirements for the heating requirement set out in Guideline 6 of the Austrian Institute of Construction Engineering (OIB) are surpassed.

A distinction is made between the following categories of buildings:[37]

1) Office buildings
2) Nurseries and compulsory-attendance schools
3) Post-secondary schools, colleges and universities
4) Hospitals
5) Care homes
6) Bed and breakfasts
7) Hotels
8) Restaurants
9) Event venues
10) Sporting venues
11) Shops
12) Indoor swimming pools
13) Other conditioned buildings

Default formula

$$\mathbf{EE_{ges}} = (\text{HWB-B}_{NWG,St} \times AZ_{Bestand} - \text{HWB-M}_{NWG,St,mittel} \times AZ_{San}) \times BV \times rb \times so \times cz$$

$$\mathbf{HWB\text{-}M}_{NWG,St,mittel} = \frac{\sum_{i=1}^{n} (\text{HWB - M}_{NWG,St,i} \times BV_i)}{BV}$$

If the renovation work causes the conditioned gross volume prior to the renovation to be different to the conditioned gross volume afterwards, then the calculation shall refer to the gross volume after the renovation.

[37] Categorisation according to OIB Guideline 6 (version of October 2011)

$HWB\text{-}M_{NWG,St,mittel}$	Average heating requirement in the local climate in a renovated non-residential building per m_3 gross volume per year [kWh/m^3_{BV}/year]
BV	Conditioned gross volume of the buildings to which the average heating requirement refers. [m^3]
$HWB\text{-}B_{NWG,St}$	Baseline heating requirement in renovated non-residential buildings in the local climate per m_3 gross volume per year [kWh/m^3_{BV}/year]
$AZ_{Bestand}$	Expenditure factor for converting useful energy to final energy in the existing building
AZ_{SAN}	Expenditure factor for converting useful energy to final energy in the renovated building (without a boiler replacement)
EE_{ges}	Total final energy savings [kWh/year]
$HWB_{BGF,Ref}$	Annual residential building heating requirement per m^2 conditioned gross floor area at the building location [kWh/m^2_{BGF}/year]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision
so	Spill-over effects = multiplier effects
cz	Confidence factor

Default values

$AZ_{Bestand}$	1.51 (reporting template according to Art. 16 of 15a WBF[38])
AZ_{SAN}	2.00 (reporting template according to Art. 16 of 15a WBF)
rb	1
so	1
cz	1

Baseline heating requirement

Default values

Baseline heating requirement, renovation: from OIB Guideline 6

Until 2011	**$HWB_{V,NWG,max,RK}$ = 11.0*(1+2.0/l_c) [kWh/m^3/year]**	**Maximum of 33.0 kWh/m^3/year**
From 2011	**$HWB_{V,NWG,max,RK}$ = 8.5*(1+2.5/l_c) [kWh/m^3/year]**	**Maximum of 30.0 kWh/m^3/year**

[38] Source: Reporting template of the Federal Ministry of Agriculture, Forestry, Environment and Water Management for meeting the reporting requirements according to Art. 10 of the agreement under Art. 15a of the B-VG between the federal government and the federal states concerning joint quality standards to subsidise the construction and renovation of residential buildings in order to reduce greenhouse gas emissions (BGBl II No 19/2006).

Note: If possible, building-specific values are used. If this is not possible then the stated default values are used.

The default values apply for the reference climate (Ref); for the baseline, one has to convert to the relevant local climate. A conversion table is included.

$$HWB\text{-}B_{NWG,St} = HWB\text{-}B_{V,NWG,max,RK} \times HGT_{St} / 3400$$

HGT_{ST}= Heating degree days according to the local climate; see also the annex to the guideline on calculating energy indicators and climate data, number OIB-382-011/99, or the average values for the federal states in the following table.

Federal state	HGT_{St} Average from 2001 to 2005
Vienna	3102.0
Lower Austria	3300.6
Burgenland	3152.6
Upper Austria	3440.7
Salzburg	3585.4
Styria	3418.8
Carinthia	3551.8
Tyrol	3680.1
Vorarlberg	3341.0
Austria	3359.3

Table 4: Heating degree days, average 2001 to 2005

Source: Statistics Austria

Formula for building-specific information

The project-specific formula is used for building-specific information, with the following parameters being entered in addition to the input values of the default formula:

- $HWB\text{-}B_{NWG,St}$: If the characteristic length of the building is known, the exact heating requirement reference value (baseline) can be calculated. However, the maximum value cannot be exceeded.
- $AZ_{Bestand}$: Expenditure factor of the heating technology before the renovation of the building
- AZ_{SAN}: Expenditure factor of the heating technology after the renovation of the building

Lifetime of the measure

The measure 'thermal improvement of the building envelope' consists of the following measures: insulation of the building envelope, windows/glazing, and air conditioning systems with heat recovery.

According to Final CWA Draft (CEN WS 27), the lifetimes of these are to be set as follows:

- Insulation of the building envelope: > 25 years
- Windows/glazing: 24 years

We therefore propose setting the lifetime of the measure 'thermally improved building envelope' at 25 years.

8 Boiler replacement

Use is made of ‘expenditure factors’ (in German: Aufwandzahlen) to calculate the final energy savings brought about by a variety of heating technology measures. The expenditure factor describes the relationship of final energy (in the case of space heating and hot water, this is the ‘heating energy consumption’) to useful energy (the ‘heating requirement’ plus the ‘hot water heating requirement’). In this way the full chain of heat provision is included, taking into account the storage, distribution and emission of the heat.

$$EF = \frac{HEC}{HR + HWHR}$$

EF	Expenditure factor
HEC	Heating energy consumption
HR	Heating requirement
HWHR	Hot water heating requirement

The final energy savings are computed in a back-calculation using the useful energy.

The difference between the expenditure factor of a reference system and that of a system after an energy efficiency improvement measure has taken place is a key element for the final energy savings; also key (when calculating energy savings using the model buildings) is the heating requirement figure (determined using the specifics of the buildings) and the gross floor area.

The calculation of final energy and useful energy is based on information on model buildings and reference heating systems that take current standards into account. Detailed descriptions of the model buildings can be found in the report ‘Description of the model buildings for the calculation of expenditure factors’.

The details of the model buildings and reference heating systems, along with the calculations of final energy and useful energy that rest upon them, were formulated during the development of the methods in a participative process that involved the relevant stakeholders through workshops, position statements, etc. The expenditure factors were then derived from these.

The calculations of useful and final energy figures took place with the help of the OIB's Excel training tool for calculating energy indicators for residential buildings (2008-07-11 V 08 b – Dr. Pöhn, MA 39, City of Vienna).

8.1 Boiler replacement, natural gas / oil condensing boiler (in existing buildings without extensive thermal renovation)

Description of measure

The existing old-style boiler for centralised heat provision (space heating + hot water) is replaced with a more efficient condensing boiler. The building's envelope is still in its original state and does not undergo extensive thermal renovation. The measure can be carried out for single-family houses, small blocks of flats, or large-scale residential buildings.

Default formula

$$EE_{ges} = (n - fr) \times m^2 \times (E_{Bestand} - E_{Kesseltausch}) \times rb \times so \times cz$$

$$E_{Bestand} = (HWB_{Bestand} + WWWB) \times AZ_{Bestand}$$

$$E_{Kesseltausch} = (HWB_{Bestand} + WWWB) \times AZ_{Kesseltausch}$$

EE_{ges}	Total final energy savings [kWh per year]
n	Number of participants / condensing boilers
fr	Number of participants that would have had a condensing boiler installed anyway regardless of the measure (free riders) = 0
m^2	Average building size in m^2 (gross floor area, GFA)
$E_{Bestand}$	Average annual final energy consumption per m^2 GFA for average existing systems [kWh/m^2/year]
$E_{Kesseltausch}$	Average annual final energy consumption per m^2 GFA after installing the condensing boiler [kWh/m^2/year]
$HWB_{Bestand}$	Heating requirement per m^2 gross floor area per year in the existing building [kWh/m^2/year]
WWWB	Hot water heating requirement [kWh/m^2/year]
$AZ_{Bestand}$	Expenditure factor for converting useful energy to final energy for an average existing standard heating system
$AZ_{Kesseltausch}$	Expenditure factor for converting useful energy to final energy for a new natural gas or oil condensing boiler
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Lifetime: 17 years (CEN proposal)[39]

		Singl	Small	Large-	
		existing	existing	existing	Old building
GFA [m²]		176	825	2445	2445
$HWB_{Bestand}$ [kWh/m^2/year]		156	107	80	141
WWWB [kWh/m^2/year]		12.5			
Oil	$AZ_{Bestand}$	2.00	2.15	2.38	1.91
Gas	$AZ_{Bestand}$	1.93	2.09	2.32	1.86
Oil	$AZ_{Kesseltausch}$	1.35	1.30	1.30	1.21
Gas	$AZ_{Kesseltausch}$	1.28	1.25	1.25	1.17

[39] Proposal to use the relevant CEN-WS 27 proposal. CEN – Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations; Final CWA draft (CEN WS 27)

Formula for project-specific information

$$EE_{ges} = \sum_{i=1}^{n} \left(m_i^2 \times \left((HWB_{i,Bestand} + WWWB_i) \times AZ_{i,Bestand} - (HWB_{i,Bestand} + WWWB_i) \times AZ_{i,Kesseltausch} \right) \right) \times rb \times so \times cz$$

EE_{ges}	Total final energy savings [kWh per year]
n	Number of participants with condensing boilers
m^2_i	Gross floor area of participant i [m^2]
$HWB_{i,Bestand}$	Heating requirement of participant i [kWh/m^2/year]
$WWWB_i$	Hot water heating requirement of participant i [kWh/m^2/year]
$AZ_{i,Bestand}$	Expenditure factor for converting useful energy to final energy for the existing (replaced) heating system
$AZ_{i,Kesseltausch}$	Expenditure factor for converting useful energy to final energy for the new efficient heating system
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

8.2 Boiler replacement, natural gas / oil condensing boiler (in existing buildings after thermal renovation)

Description of measure

An existing old-style boiler for centralised heat provision (space heating + hot water) is located in a building whose envelope has already been thermally renovated. The boiler is replaced with an efficient condensing boiler. The measure can be carried out for single-family houses, small blocks of flats, or large-scale residential buildings.

Default formula

$$\mathbf{EE_{ges}} = (n - fr) \times m^2 \times (E_{Bestand} - E_{Kesseltausch}) \times rb \times so \times cz$$

$$E_{Bestand} = (HWB_{SAN} + WWWB) \times AZ_{SAN,Bestand}$$

$$E_{Kesseltausch} = (HWB_{SAN} + WWWB) \times AZ_{SAN,Kesseltausch}$$

EE_{ges}	Total final energy savings [kWh per year]
n	Number of participants / condensing boilers
fr	Number of participants that would have had a condensing boiler installed anyway regardless of the measure (free riders) = 0
m^2	Average building size in m^2 (gross floor area – GFA)
$E_{Bestand}$	Average annual final energy consumption per m^2 GFA for average existing systems [kWh/m^2/year]

$E_{Kesseltausch}$	Average annual final energy consumption per m² GFA after installing the condensing boiler [kWh/m²/year]
HWB_{SAN}	Heating requirement per m² gross floor area per year after thermal renovation [kWh/m²/year]
WWWB	Hot water heating requirement [kWh/ m²/year]
$AZ_{SAN,Bestand}$	Expenditure factor for converting useful energy to final energy of an existing heating system in an existing renovated building
$AZ_{SAN,Kesseltausch}$	Expenditure factor for converting useful energy to final energy for a new natural gas or oil condensing boiler in an existing renovated building
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Lifetime: 17 years (CEN proposal)[39]

		Singl	Small	Large-
		Existing, renovated	Existing, renovated	Existing, renovated
GFA [m²]		176	825	2445
HWB_{SAN} [kWh/m²/year]		83	69	50
WWWB [kWh/ m²/year]		12.5		
Oil	$AZ_{SAN,Bestand}$	2.57	2.60	3.00
Gas	$AZ_{SAN,Bestand}$	2.48	2.52	2.92
Oil	$AZ_{SAN,Kesseltausch}$	1.50	1.40	1.44
Gas	$AZ_{SAN,Kesseltausch}$	1.42	1.33	1.39

Formula for project-specific information

$$EE_{ges} = \sum_{i=1}^{n} \left(m_i^2 \times \left((HWB_{i,SAN} + WWWB) \times AZ_{i,SAN,Bestand} - (HWB_{i,SAN} + WWWB) \times AZ_{i,SAN,Kesseltausch} \right) \right) \times rb \times so \times cz$$

EE_{ges}	Total energy savings [kWh per year]
n	Number of participants with condensing boilers
M^2_i	Gross floor area of the participant i [m]
$HWB_{i,SAN}$	Heating requirement of the existing renovated building [kWh/m²/year]
$WWWB_i$	Hot water heating requirement for project i [kWh/m²/year]
$AZ_{i,SAN,Bestand}$	Expenditure factor for converting useful energy to final energy for the existing heating system in an existing renovated building

$AZ_{i,SAN,Kesseltausch}$	Expenditure factor for converting useful energy to final energy for the new condensing boiler in an existing renovated building
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

8.3 Replacement of gas-fired combi boiler – decentralised heat provision

Description of measure

The existing combi boiler for decentralised heat provision (space heating + hot water) is replaced with a new device. The measure can be carried out in small blocks of flats and large-scale residential buildings.

The approach to replacing the device in existing buildings or renovated existing buildings is as described in section 8.1.

Default formula

E E e g s =

$$\mathbf{EE_{ges}} = (n - fr) \times m^2 \times (E_{Bestand} - E_{Kesseltausch}) \times rb \times so \times cz$$

$$E_{Bestand} = (HWB_{Bestand} + WWWB) \times AZ_{Bestand}$$

$$E_{Kesseltausch} = (HWB_{Bestand} + WWWB) \times AZ_{Kesseltausch}$$

EE_{ges}	Total final energy savings [kWh per year]
n	Number of participants / combi boiler replacements
fr	Number of participants that would have replaced their combi boiler anyway regardless of the measure (free riders) = 0
m^2	Average flat size in m^2 (gross floor area – GFA)
$E_{Bestand}$	Average annual final energy consumption per m^2 GFA for average existing systems [kWh/ m^2/year]
$E_{Kesseltausch}$	Average annual final energy consumption per m^2 GFA after the new device has been installed [kWh/m^2/year]
$HWB_{Bestand}$	Heating requirement per m^2 gross floor area per year in the existing stock of flats (without thermal renovation / after thermal renovation) [kWh/m^2/year]
WWWB	Hot water heating requirement [kWh/ m^2/year]
$AZ_{Bestand}$	Expenditure factor for converting useful energy to final energy for an average existing standard heating system
$AZ_{Kesseltausch}$	Expenditure factor for converting useful energy to final energy for a new device

rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Lifetime: 17 years (CEN proposal)[40]

		Large-	Small	Large-	Small	Large-scale
		Old	existing stock		Existing, renovated	
GFA [m^2]		85.6	85.6	85.6	85.6	85.6
$HWB_{Bestand}$ [kWh/ m^2/year]		141	107	80	69	50
WWWB [kWh/ m^2/year]		12.5				
Gas	$AZ_{Bestand}$	1.91	2.04	2.33	2.50	2.97
Gas	$AZ_{Kesseltausch}$	1.44	1.48	1.57	1.64	1.80

Formula for project-specific information

$$EE_{ges} = \sum_{i=1}^{n} \left(m_i^2 \times \left((HWB_{i,Bestand} + WWWB_i) \times AZ_{i,Bestand} - (HWB_{i,Bestand} + WWWB_i) \times AZ_{i,Kesseltausch} \right) \right) \times rb \times so \times cz$$

EE_{ges}	Total final energy savings [kWh per year]
n	Number of participants / combi boiler replacements
m^2_i	Gross floor area of participant i [m^2]
$HWB_{i,Bestand}$	Heating requirement of the participant i in the existing stock of flats (without thermal renovation / after thermal renovation) [kWh/m^2/year]
$WWWB_i$	Hot water heating requirement of participant i [kWh/m^2/year]
$AZ_{i,Bestand}$	Expenditure factor for converting useful energy to final energy for the existing (replaced) device
$AZ_{i,Kesseltausch}$	Expenditure factor for converting useful energy to final energy for the new efficient device
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

[40] Proposal to use the relevant CEN-WS 27 proposal. CEN – Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations; Final CWA draft (CEN WS 27)

8.4 Boiler replacement: biomass boiler

Description of measure

The existing old-style boiler for centralised heat provision (space heating + hot water) is replaced by a more efficient biomass boiler. The measure can be carried out for single-family houses, small blocks of flats, or large-scale residential buildings. The measure is limited to the installation of biomass boilers that meet the energy efficiency levels for boilers set out in the Umweltzeichen (Austrian environmental certification mark) guidelines[41]. Also, boilers and stoves are excluded from the method if they are not connected to the heating system (e.g. single-room stoves).

The calculations of useful and final energy figures took place with the help of the OIB's Excel training tool for calculating energy indicators for residential buildings (2008-07-11 V 08 b – Dr. Pöhn, MA 39, City of Vienna).

[41] Österreichisches Umweltzeichen (Austrian environmental certification mark) (2012) Guideline UZ 37 – Wood heating systems

Default formula

$$EEges = (n - fr) \times m^2 \times \left(E_{Bestand} - E_{Kesseltausch}\right) \times rb \times so \times cz$$

$$E_{Bestand} = (HWB_{Bestand} + WWWB) \times AZ_{Bestand}$$

$$E_{Kesseltaus\ ch} = (HWB_{Bestand} + WWWB) \times AZ_{Kesseltausch}$$

EEges	Total final energy savings [kWh per year]
n	Number of participants / biomass boilers
fr	Number of participants that would have had a biomass boiler installed anyway regardless of the measure (free riders) = 0
m^2	Average building size in m^2 (gross floor area – GFA)
$E_{Bestand}$	Average annual final energy consumption per m^2 GFA for average existing systems [kWh/ m^2/year]
$E_{Kesseltausch}$	Average annual final energy consumption per m^2 GFA after installation of the condensing boiler [kWh/ m^2/year]
$HWB_{Bestand}$	Heating requirement per m^2 gross floor area per year in the existing building [kWh/m^2/year]
WWWB	Hot water heating requirement [kWh/m^2/year]
$AZ_{Bestand}$	Expenditure factor for converting useful energy to final energy for an average existing standard heating system
$AZ_{Kesseltausch}$	Expenditure factor for converting useful energy to final energy for a new biomass boiler
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values – existing building without thermal renovation

Lifetime: 17 years (CEN proposal)[42]

		Single-family house	Small block of flats	Large-scale residential building	
		Existing stock	Existing stock	Existing stock	Old building
GFA [m^2]		176	825	2445	2445
$HWB_{Bestand}$ [kWh/ m^2/year]		156	107	80	141
WWWB [kWh/ m^2/year]		12.5			
Oil	$AZ_{Bestand}$	2.00	2.15	2.38	1.91
Gas	$AZ_{Bestand}$	1.93	2.09	2.32	1.86
Biomass	$AZ_{Kesseltausch}$	1.44	1.39	1.38	1.41

Default values – existing building after thermal renovation

Lifetime: 17 years (CEN proposal)

		Single-family house	Small block of flats	Large-scale residential building
		Existing, renovated	Existing, renovated	Existing, renovated
GFA [m^2]		176	825	2445
HWB_{SAN} [kWh/ m^2/year]		83	69	50
WWWB [kWh/m^2/year]		12.5		
Oil	$AZ_{SAN,Bestand}$	2.57	2.60	3.00
Gas	$AZ_{SAN,Bestand}$	2.48	2.52	2.92
Biomass	$AZ_{SAN,Kesseltausch}$	1.77	1.54	1.60

[42] Proposal to use the relevant CEN-WS 27 proposal. CEN – Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations; Final CWA draft (CEN WS 27)

Formula for project-specific information

$$EE_{ges} = \sum_{i=1}^{n} \left[BGF_i \times \left(HWB_{i,Bestand} + WWWB_i \right) \times \left(AZ_{i,Bestand} - AZ_{i,Kesseltausch} \right) \right] \times rb \times so \times cz$$

EE_{ges}	Total final energy savings [kWh per year]
n	Number of participants with biomass boilers
BGF_i	Gross floor area of participant i [m^2]
$HWB_{i,Bestand}$	Heating requirement of participant i [kWh/m²/year]
$WWWB_i$	Hot water heating requirement of the participant [kWh/m²/year]
$AZ_{i,Bestand}$	Expenditure factor for converting useful energy to final energy for the existing (replaced) heating system
$AZ_{i,Kesseltausch}$	Expenditure factor for converting useful energy to final energy for the new efficient heating system
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

9 Cogeneration

9.1 Cogeneration systems in the Energy Services Directive

Energy efficiency improvement measures in the **‘energy supply’ sector** are completely excluded from the scope of the ESD, because in the IEA/Eurostat or Austrian energy balance this sector does not contain any (final energy) ‘final customers’ in the sense of Articles 2(b) and 3(n) of the directive. This means that energy efficiency improvement measures relating to cogeneration technology in this sector cannot be counted towards the attainment of the energy savings target.

In the **manufacturing sector**, cogeneration systems or energy conversion systems (‘commercial self-generation systems’ within the meaning of the Austrian energy balance) are excluded from the scope of the ESD if they are subject to the Emissions Trading Directive; all other systems fall under the scope of the ESD.

In the Austrian energy balance, within the manufacturing sector, the parts of the conversion input of cogeneration systems that cover the industrial business's own use of electricity and heat are listed as final energy.

9.2 Conversion of existing hot water / steam boiler systems in the manufacturing sector to cogeneration systems

Description of measure

The methodology applies to hot-water / steam boiler systems in the manufacturing sector (commercial self-generation systems) that fall under the scope of the ESD. This measure concerns the replacement or expansion of existing hot-water or steam boiler systems through one of the following three systems,

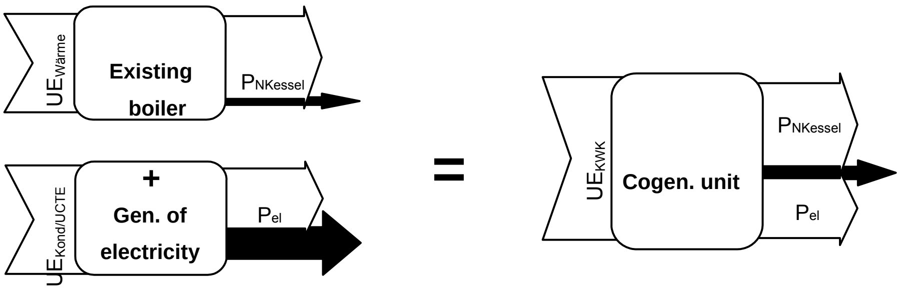
1. Steam boiler plus downstream steam turbine for the generation of electricity
2. Gas turbine for the generation of electricity plus downstream heat recovery boiler for the generation of hot water or steam
3. Replacement of the existing boiler system(s) with a combined heat and power unit(s)

delivering the same annual quantity of heating and having the same nominal heat capacity as prior to the cogeneration expansion.

The methodology assumes that the nominal capacities of the existing boilers are known, along with the maximum electrical capacity of the planned cogeneration system. It is assumed that all the produced cogeneration heat is used in technical applications, because it is generally ‘heat-led’ cogeneration systems that are used in the manufacturing sector.

Existing boiler system and reference electricity generation

New system with simultaneous heat provision and extraction of electricity



Default formula

$$UE_{ges} = (UE_{Ref} - UE_{KWK}) \times rb \times so \times cz$$

$$UE_{Ref} = UE_{Kond} + UE_{Wärme}$$

$$UE_{KWK} = PN_{Kessel} / \eta_{th\ KWK} \times t_{100} \text{ or } UE_{KWK} = P_{el\ KWK} / \eta_{el\ KWK} \times t_{100}$$

$$UE_{Kond} = UE_{KWK} \times \eta_{el\ KWK} / \eta_{el\ Ref}$$

$$UE_{Wärme} = PN_{Kessel} / \eta_{th\ Ref} \times t_{100}$$

UE_{ges}	Total energy savings expressed as conversion input measured with the calorific value (H_u) of the fuels under consideration [MWh/year]
UE_{Ref}	Conversion input (H_u) of the reference scenario with separate provision of electricity and heat [MWh/year]
UE_{Kond}	Conversion input (H_u) of the reference electricity generation (natural gas combined-cycle power plant or the UCTE electricity mix) for an output of electricity equivalent to the gross annual electricity generation from cogeneration [MWh/year]
UE_{KWK}	Conversion input (H_u) of the new commercial cogeneration system [MWh/year]
$UE_{Wärme}$	Total conversion input (H_u) of the existing hot-water and/or steam boiler systems that were expanded to include electricity generation [MWh/year]
PN_{Kessel}	Total nominal capacity of the existing hot water and/or steam boiler systems that were expanded to include electricity generation [kW_{th}]
$P_{el\ KWK}$	Maximum electrical capacity of the cogeneration system [kW_{el}]
t_{100}	Average (weighted by their conversion inputs) annual full-load hours of the existing hot-water and/or steam boiler(s) that were expanded to include electricity generation [h/year]
$\eta_{el\ KWK}$	Average gross electrical efficiency of the revitalised cogeneration system; this is the ratio of (gross) conversion output to electrical energy [MWh_{el}/year] / UE_{KWK} [MWh_{th}/year]
$\eta_{th\ KWK}$	Average gross thermal efficiency of the revitalised cogeneration system; this is the ratio of (gross) conversion output to thermal energy [MWh_{th}/year] / UE_{KWK} [MWh_{th}/year]

$\eta_{el\ Ref}$	Average gross electrical efficiency of the reference electricity generation
$\eta_{th\ Ref}$	Average (weighted by their conversion inputs) thermal efficiency of the existing hot-water and/or steam boiler systems that were expanded to include electricity generation
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

The default formula above is equivalent to the formula from EU Directive 2004/8/EC (Cogeneration) Annex III, point b; if the formula from that directive is used, then one has to multiply the result by the conversion input of the reference scenario (UE_{Ref}) in order to arrive at the desired annual energy savings figure (MWh/year).

PES (primary energy savings) = UE_{ges} / UE_{Ref}

Lifetime of a cogeneration system: 15 years (VDI 2067), CEN suggestion 8 years.

Default values

Reference heat generation ($\eta_{th\ Ref}$)

Reference values for heat generation are taken from the Commission decision (ref. no. *K(2006) 6817*).[43]

Table 5: Efficiency reference values for separate production of heat (excerpt from *C(2006) 6817*)

Efficiency reference values, heat Fuel	Value
Biogas, gas from purification plants, landfill gas	0.70
Solid biomass	0.83
Liquid biomass	0.89
Lignite	0.86
Natural gas / extra-light heating oil	0.90
Liquefied petroleum gas	0.89
Heavy fuel oil	0.89
Waste	0.80
Lean gases (blast furnace gas, etc.)	0.80
Hard coal	0.88

Annual full-load hours: (t_{100})

The values highlighted in the table below are rough average values; they can differ substantially for specific individual firms.

Table 6: Average full-load hours for each type of useful energy and economic sector (E-Bridge, 2005)

Average full-load hours per type of useful energy and economic sector	Electrical energy	Space heating, A/C, hot water	Production of steam	Industrial furnaces	Non-electric stationary engine
	h	h	h	h	h
Agriculture and forestry	1000	1700	1000	2000	1000
Manufacturing sector, standard	8000	4000	7000	8000	8000
Manufacturing sector, standard	2000	4000	2000	4000	2000
Public sector and private services	1000	2000	2000	2000	1000
Households	700	1700	0	500	0

Depending on whether the existing heating system produces mainly hot water or steam, the figures in either the 'Space heating, A/C, hot water' column or the 'Steam production' column can be used. Also, a distinction can be made in the manufacturing sector between 'standard' or 'energy-intensive' areas (glass, minerals, metals, paper and cellulose, etc.).

[43] Commission Decision of 21 December 2006 establishing harmonised efficiency reference values for separate generation of electricity and heat in application of Directive 2004/8/EC of the European Parliament and of the Council

Reference electricity generation ($\eta_{el\ Ref}$)

Reference values for electricity generation are taken from the Commission decision (ref. no. *C(2006) 6817*).[44]

Table 7: Efficiency reference values for the separate production of electricity, for various fuels and years of construction (extract from *C(2006) 6817*)

Efficiency reference values, electricity		
Fuel	**Until 2005**	**From 2005**
Biogas, gas from purification plants, landfill gas	0.40	0.42
Solid biomass	0.26	0.29
Liquid biomass	0.42	0.44
Lignite	0.40	0.42
Natural gas / extra-light heating oil	0.51	0.53
Liquefied petroleum gas	0.42	0.44
Heavy fuel oil	0.42	0.44
Waste	0.23	0.25
Lean gases (blast furnace gas, etc.)	0.35	0.35
Hard coal	0.42	0.44

To be able to compare a cogeneration system to the separate production of electricity, both systems must have

1. the same energy source
2. the same year of construction, unless this is older than 1995, in which case 1995 is used as the year.

[44] Commission Decision of 21 December 2006 establishing harmonised efficiency reference values for separate generation of electricity and heat in application of Directive 2004/8/EC of the European Parliament and of the Council

Concrete default formulas for the three different cogeneration systems

Average efficiency values are calculated depending on the type of cogeneration system installed, giving rise to the default formulas listed below[45]. A key aspect in determining the energy savings is which of the three following cogeneration systems is replacing the existing hot-water or steam boiler systems:

1. **Steam boiler of the same nominal capacity, plus downstream steam turbine for the generation of electricity**

$\eta_{el\ KWK} = 0.3813 \times P_{el\ KWK} \wedge 0.0618$

$P_{el\ KWK}$ … Installed average maximum gross electrical capacity of the cogeneration unit in MW

$\eta_{th\ KWK} = \eta_{th\ Ref} - \eta_{el\ KWK}$

Valid for capacities **up to 1 000 MW_{el}**

If this approximation equation is inserted into the default formula, the following formula is produced:

$$UE_{ges} = (P_{elKWK} / \eta_{elRef} + PN_{Kessel} / \eta_{thRef} - P_{elKWK} / \eta_{el\ KWK}) \times t_{100} \times rb \times so \times cz$$

And therefore

$$UE_{ges} = (P_{elKWK} / \eta_{elRef} + PN_{Kessel} / \eta_{thRef} - P_{elKWK} / (0.3813 \times (P_{elKWK} / 1000) \wedge 0.0618)) \times t_{100} \times rb \times so \times cz$$

2. **Industrial gas turbines (heavy duty) for the production of electricity, plus downstream recovery boiler of the same nominal capacity for the production of hot water or steam**

$\eta_{el\ KWK} = 0.2181 \times P_{el\ KWK} \wedge 0.0993$

$P_{el\ KWK}$ … Installed average maximum gross electrical capacity of the cogeneration unit in MW

$\eta_{th\ KWK} = \eta_{th\ Ref} - \eta_{el\ KWK}$

Valid for capacities **up to 350 MW_{el}**

If this approximation equation is inserted into the default formula, the following formula is produced:

$$UE_{ges} = (P_{elKWK} / \eta_{elRef} + PN_{Kessel} / \eta_{thRef} - P_{elKWK} / \eta_{el\ KWK}) \times t_{100} \times rb \times so \times cz$$

And therefore

[45] Source: Referenzkosten von Strom- und Wärmeerzeugungsanlagen. Ermittlung von Referenzkosten für Wasserkraft- und KWK-Anlagen gemäß Umweltbeihilfenrahmen. [Reference costs of electricity and heat production systems. Determination of reference costs for hydropower and cogeneration systems in accordance with environmental subsidy frameworks.] Austrian Energy Agency 2007, on behalf of Kommunalkredit Public Consulting GmbH.

$$UE_{ges} = (P_{elKWK} / \eta_{elRef} + PN_{Kessel} / \eta_{thRef} - P_{elKWK} / (0.2181 \times (P_{elKWK} / 1000) \wedge 0.0399)) \times t_{100} \times rb \times so \times cz$$

3. Replacement of the existing boiler system(s) with a combined heat and power unit(s) of the same nominal heat capacity

$\eta_{el\ KWK}$ = 0.2342 x $P_{el\ KWK}$ ^ 0.0756

$\eta_{th\ KWK}$ = 0.6877 x $P_{el\ KWK}$ ^ -0.0548

$P_{el\ KWK}$…Installed average maximum gross electrical capacity of the cogeneration unit in kW

Source: (AEA, 2007)

However, because the method is based on an existing boiler being converted to a cogeneration unit, and only the thermal capacity is known, the formula has to relate to the boiler's thermal capacity.

$\eta_{el\ KWK}$ = 0.213264 x PN_{Kessel} ^ 0.086937

$\eta_{th\ KWK}$ = 0.736 x PN_{Kessel} ^ -0.063018

PN_{Kessel}…Boiler capacity of the existing hot-water and steam boiler system in kW

Valid for capacities **up to 7 000 kW_{th}**

If this approximation equation is inserted into the default formula, the following formula is produced:

$$UE_{ges} = (PN_{Kessel} \times \eta_{el\ KWK} / (\eta_{elRef} \times \eta_{th\ KWK}) + PN_{Kessel} / \eta_{th\ Ref} - PN_{Kessel} / \eta_{th\ KWK}) \times t_{100} \times rb \times so \times cz$$

And therefore

$$UE_{ges} = (PN_{Kessel} \times (0.213264 \times PN_{Kessel} \wedge 0.086937) / (\eta_{elRef} \times 0.736 \times PN_{Kessel} \wedge -0.063018) + PN_{Kessel} / \eta_{thRef} - PN_{Kessel} / (0.736 \times PN_{Kessel} \wedge -0.063018)) \times t_{100} \times rb \times so \times cz$$

Formula for project-specific information

The project-specific formula can be applied if the following values are known for cogeneration and boiler parameters from the default formula:

- $\eta_{th\ Kessel}$
- t_{100}
- $\eta_{el\ KWK}$
- $\eta_{th\ KWK}$

10 Cooling and air conditioning in non-residential buildings

10.1 General

Air conditioning will play an increasingly significant role in final energy consumption in the coming years. Of primary importance here is how to reduce (or avoid completely) the requirement for cooling. In those cases where cooling and air conditioning is unavoidable, however, we also have (as in other areas) production systems with varying levels of energy efficiency.

From the many technologies available, two (not including district cooling) have been selected here, and evaluation methods presented for them. These technologies were selected because there is a system of energy efficiency classes in place for them. This makes it possible to approximate the final energy savings brought about by the use of more efficient technologies – under the assumption that the same type of generation technology is used in each case.

There are generally two options for calculating the final energy consumption for cooling (**cooling energy consumption**): either based on a **specific cooling requirement (according to ÖNORM B 8110-6)**, or through approximation using the installed **cooling capacity and full-load hours**.

The difficulty with both approaches is the availability of representative data, as the properties of non-residential buildings can vary very widely (compared to residential buildings) on account of their differing characteristics. The energy performance certificate does require calculation of the cooling requirement and cooling energy consumption (in accordance with ÖNORM H 5058), but in the context of energy efficiency monitoring the performance certificate is still considered to have too little penetration, particularly for existing buildings. Streicher (2008) underlines this issue: ‘There are currently no guidelines for the final energy consumption of non-residential buildings (author's note: for all types of useful energy provision) because there are no statistically sound values for this in Austria. The appropriate figures should be collected in the coming years and used to develop guideline values.’ In addition, there are currently no nationally agreed-upon values for expenditure factors to use in the calculation of final energy consumption based on cooling requirement.

Therefore, the following approach is suggested for the evaluation of energy-saving measures. Based on the installed cooling capacity and an engineering estimate of the full-load hours (cooling energy output divided by installed cooling capacity) for the specific application, the final electrical energy consumption is calculated using the **ESEER value** (the European Seasonal Energy Efficiency Ratio, a seasonal performance factor for chillers under specific test conditions) or the **EER value** (the Energy Efficiency Ratio, a performance factor for room air conditioning devices).

If measurements complying with the Energy End-use Efficiency and Energy Services Directive are known for the energy consumption before and after implementation of one of the measures described below, then those measurements can be used.

10.2 Air-cooled and water-cooled liquid chillers

These play an important role in the non-residential buildings sector, from a cooling capacity of about 100 kW upwards. The method for calculating final energy savings should take developments in this sector into account. The state of the art for water-cooled units is represented by highly-efficient compressor chillers with improved (partial load) performance factors (under test conditions). These devices are (speed-controlled) compressor chillers consisting of several scroll compressors (100–600 kW cooling capacity) or turbo compressors (200–2000 kW cooling capacity) connected in parallel. Water-cooled devices of this kind can achieve an ESEER figure of between 6 and 9.

There is a voluntary classification system for liquid chillers based on the Eurovent categories[46] but using the EER (Energy Efficiency Ratio). This system of classification will be used for selecting the most efficient technology and as a reference system, but it is the ESEER value that will be used for calculating energy savings. The ESEER value is not an expenditure factor for a specific building, and so it is not an exact means of converting useful energy into final energy; it also neglects losses and the energy consumption of auxiliary equipment. However, it does reduce the complexity of the energy savings calculation. This is particularly helpful given that we are once again using an approach that compares two different systems.

Project-specific formulas are proposed because (as already mentioned) the spectrum of non-residential buildings is very wide. For these, one should select the appropriate ESEER value and use the relevant values relating to installed capacity and full-load hours, as provided by the energy supply companies carrying out these energy efficiency improvement measures.

10.2.1 New installations

Description of measure

The installation of a highly efficient compressor chiller can be regarded as a measure for saving final energy. Therefore, installations of chillers of the highest energy efficiency class 'Eurovent Class A' are recorded. In this approach for new installations, air-cooled or water-cooled liquid chillers of 'Eurovent Class C' are used as a reference system to represent the average standard system. This assumption is based on information on the distribution of chillers in the individual energy efficiency classes.[47]

[46] Eurovent Certification: Programme Description. http://www.euroventcertifiction.com/en/Programmes/Programme_Descriptions.php?rub=02&srub=01&ssrub=&lg=en&select_prog=LCP (06/2008)

[47] See: ICS coolenergy: Energy efficiency – Classification of chillers.http://www.industrialcooling.co.uk/downloads/sales_aids/Eurovent.pdf (06/2008)

Project-specific formula

$$EE_{ges} = (P_K \times h_{VIst}) \times (1 / ESEER_{Sta} - 1 / ESEER_{neu}) \times rb \times so \times cz$$

EE_{ges}	Total final energy savings, electricity [kWh per year]
P_K	Installed cooling capacity of the chiller in the building [kW]
h_{VIst}	Full-load hours based on the maximum installed cooling capacity [h]
$ESEER_{Sta}$	Seasonal performance factor (European Seasonal Energy Efficiency Ratio) of an average standard compressor chiller [-]
$ESEER_{neu}$	European Seasonal Energy Efficiency Ratio of a compressor chiller of the highest energy efficiency class [-]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Lifetime of a compressor chiller: 15 years (according to ÖNORM H 7140)

10.2.2 Replacement of the chiller after the end of its lifetime

Description of measure

Where the compressor chiller in an existing building is replaced after the expiry of the chiller's lifetime, the comparison should be between a chiller of the highest efficiency class and a chiller from 'Eurovent Class E'.

Project-specific formula

$$EE_{ges} = (P_K \times h_{VIst}) \times (1 / ESEER_{Bestand} - 1 / ESEER_{neu}) \times rb \times so \times cz$$

EE_{ges}	Total final energy savings, electricity [kWh per year]
P_K	Installed cooling capacity of the chiller in the building [kW]
h_{VIst}	Full-load hours based on the maximum installed cooling capacity [h]
$ESEER_{Bestand}$	Seasonal performance factor (European Seasonal Energy Efficiency Ratio) of an average compressor chiller in the existing stock [-]
$ESEER_{neu}$	European Seasonal Energy Efficiency Ratio of a compressor chiller of the highest energy efficiency class [-]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Lifetime of a compressor chiller: 15 years (according to ÖNORM H 7140)

10.2.3 ESEER values

When specifying default values for the seasonal performance factors of chillers, a distinction should be made (at the least) between air-cooled and water-cooled chillers.

Water-cooled

The capacities of water-cooled compressor chillers range from around 100 kW of cooling capacity to 2000 kW. The lower threshold of the default values applies to scroll compressors with a cooling capacity from 100 kW, while the upper threshold applies to turbo compressors up to 2000 kW. Values can be interpolated for capacities that lie somewhere in-between.

	Eurovent classes	ESEER [-]
$ESEER_{neu}$	A	6–9
$ESEER_{Sta}$	C	5–6
$ESEER_{Bestand}$	E	3.5–4.5

Air-cooled

The figures for air-cooled compressor chillers apply to chillers with scroll compressors with a cooling capacity of roughly 100 to 500 kW.

	Eurovent classes	ESEER [-]
$ESEER_{neu}$	A	5.5
$ESEER_{Sta}$	C	4
$ESEER_{Bestand}$	E	3.5

10.3 Room air conditioners < 12 kW cooling capacity for applications in non-residential buildings (permanently installed split and multi-split systems)

For room air conditioners with a cooling capacity of less than 12 kW, energy efficiency improvement measures can be undertaken and documented consistently because a system of categorisation (based on energy efficiency classes) is in place for them, along with compulsory labelling under EU Directive 2002/31/EC of the Commission of 22 March 2002 *implementing Council Directive 92/75/EEC with regard to energy labelling of household air conditioners*.

However, only devices (split and multi-split) that are permanently installed in non-residential buildings where cooling is necessary should be considered (for example in shops / retail premises, small and medium-sized businesses, etc.). With regard to the categorisation, it should also be noted that the threshold of 3.2 (depending on capacity) for the ‘A’ energy efficiency bracket can already be easily exceeded by good split devices with values of 4 or higher. However, there still are a great number of products on the market with a lower energy efficiency rating.[48]

[48] Riviere Philippe (publisher): Preparatory study on the environmental performance of residential room conditioning appliances (airco and ventilation). Ecodesign Lot 10.

The calculation of final energy consumption and energy savings is performed based on the installed capacity, the appropriate EER value for that energy efficiency class (see default values) and an assumed full-load hours figure of 500 hours (cf. calculation of energy consumption[49]). This figure is appropriate for buildings that are similar to residential buildings; if required, project-specific values can be used that are different to this.

The EER value is a performance factor but it is not an exact means of converting from useful energy to final energy; nor does it reflect the variety and real-life conditions of systems in use. However, the use of this figure – for which categorised values exist – reduces the complexity of providing evidence for energy savings, particularly for the present case involving a comparison of systems.

10.3.1 New installations

Description of measure

The installation of a new, highly efficient room air conditioner of energy efficiency class A is compared with an average standard device of efficiency class C.

Default formula

$$EE_{ges} = (P_K \times h_{Vlst}) \times (1 / EER_{Sta} - 1 / EER_{neu}) \times rb \times so \times cz$$

EE_{ges}	Total final energy savings, electricity [kWh per year]
P_K	Installed cooling capacity of the room air conditioner [kW]
h_{Vlst}	Full-load hours based on the maximum installed cooling capacity [h] = 500 h
EER_{Sta}	Performance factor (Energy Efficiency Ratio) of an average room air conditioner [-]
EER_{neu}	Energy Efficiency Ratio of a room air conditioner of the highest energy efficiency class [-]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Lifetime of a room air conditioner: 10 years (according to ÖNORM H 7140)

10.3.2 Replacing an air conditioner after 10 years

The measure consists of the installation of a room air conditioner of the highest energy efficiency class when replacing an old device (of the same construction type and capacity) after the expiry of its lifetime of 10 years. A room air conditioner of the energy efficiency class ‘E’ is used as the system of reference.

[49] www.topprodukte.at: Auswahlkriterien Klimageräte [Selection criteria for air conditioners].

Default formula

$$EE_{ges} = (P_K \times h_{Vlst}) \times (1 / EER_{Bestand} - 1 / EER_{neu}) \times rb \times so \times cz$$

EE_{ges}	Total final energy savings, electricity [kWh per year]
P_K	Installed cooling capacity of the room air conditioner [kW]
h_{Vlst}	Full-load hours based on the maximum installed cooling capacity [h] = 500 h
$EER_{Bestand}$	Performance factor (Energy Efficiency Ratio) of an average room air conditioner in the existing stock [-]
EER_{neu}	Energy Efficiency Ratio of the room air conditioner of the highest energy efficiency class [-]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Lifetime of a room air conditioner: 10 years (according to ÖNORM H 7140)

10.3.3 EER values

The following default values are assumed. An average value of the available product categories (split or multi-split) is assumed across the whole spectrum of cooling capacities up to 12 kW.[50]

	Energy efficiency class	EER [-]
EER_{neu}	A	3.75
EER_{Sta}	C	2.90
$EER_{Bestand}$	E	2.50

[50] Toptest GmbH: Auswahlkriterien Klimageräte [Selection criteria for air conditioners]. http://www.topten.ch/index.php?page=auswahlkriterien_klimagerate&fromid= (06/2008)

11 Installation of photovoltaic systems

Description of measure

Final energy savings due to photovoltaic systems can be calculated in two different ways; multiplying the installed capacity by the appropriate hours of sun, or directly inputting the quantity of energy that has been measured (specifically per m² of module surface area). However, one also has to remember that according to the Energy End-use Efficiency and Energy Services Directive, only the portion of electricity that leads to a reduction in final energy usage can count towards the national savings target (i.e. not the portion that is fed into the grid). For this reason, the calculation has to take into account the portion that was fed into the grid.

Default formula

The following input values, to be provided by the operator of the system, are required for the default formula set out below:

Either

- Installed photovoltaic (PV) capacity: P_{PV}, ee_{Netz}

or

- Installed PV module surface area: m^2_{PV}, JWG, ee_{Netz}

$$\mathbf{EE_{ges} = (P_{PV} - P_{fr}) \times t_{SD} \times PR \times (1 - ee_{Netz}) \times rb \times so \times cz}$$

or

$$\mathbf{EE_{ges} = (m^2_{PV} - m^2_{fr}) \times EE_{PV} \times (1 - ee_{Netz}) \times rb \times so \times cz}$$

$$\mathbf{EE_{PV} = G_S \times WG \times PR}$$

EE_{ges}	Total final energy savings [kWh/year]
EE_{PV}	Annual energy production per m² installed module surface area [kWh/m²/year]
ee_{Netz}	Portion of the electricity produced that is fed into the electricity supply grid and therefore may not be counted towards final energy savings (grid-independent PV systems = 0) [%]
G_S	Solar insolation received on the collector area (dependent on location) [kWh/m²/year]
PR	Performance Ratio of the PV system, i.e. ratio of actual yield of alternating current (according to the inverter) to the system's target yield (which is calculated using insolation x the module's nominal efficiency under STC).
WG	Module's nominal efficiency [%]
m^2_{PV}	Installed module area [m²]
m^2_{fr}	Module area that would have been installed anyway regardless of the measure (= 0)
P_{PV}	Installed peak power of the PV system [kWp]
P_{fr}	Capacity that would have been installed anyway regardless of the measure (= 0)

t_{SD}	Sunshine duration at 1000 W/m² (full-load hours) at the location [h/year]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Lifetime of a PV system: 23 years (EU proposal)

Default values

Solar insolation: G_S

The solar insolation received on a horizontal area is listed for a wide range of weather stations on the website of the Austrian Institute of Meteorology and Geodynamics (Zentralanstalt für Meteorologie und Geodynamik)[51]. The measurement data listed for each weather station can then be assigned to the federal states where the stations are located and used to produce an arithmetic mean. This method was used to generate the following results:

Federal state	**Annual global radiation**
	kWh/m²/year
Burgenland	1 132
Carinthia	1 168
Lower Austria	1 073
Upper Austria	1 064
Salzburg	1 128
Styria	1 102
Tyrol	1 116
Vorarlberg	1 118
Vienna	1 084

Sunshine duration in the Austrian federal states: t_{SD}

The sunshine duration was measured at nearly all weather stations. This involved recording the hours for which the amount of solar radiation was greater than 120 W/m². Because the power capacity of the photovoltaic modules under standard test conditions is given (insolation of 1000 W/m²) and the system size also relates to this value, the sunshine duration for the calculation must relate to 1000 W/m².

The sunshine duration and annual global radiation are taken from the latest climate data of the Austrian Institute of Meteorology and Geodynamics. The sunshine duration is divided by the quantity of radiation energy received. The resultant radiant power represents the average radiant power if the sun is shining. The sunshine duration is divided by the radiant power per sunshine hour, and multiplied by 1000 W/m².

[51] Climate data from the website of the Austrian Institute for Meteorology and Geodynamics, http://www.zamg.ac.at/, retrieved on 22/03/2011

The sunshine duration can now be related to the system capacity, and is listed in the table below for all the federal states.

Federal state	Sunshine duration at 120 W/m²	Annual global radiation	Radiant power per sunshine hour	Full-load hours (Sunshine duration at 1000 W/m²)
	h/year	kWh/m²/ year	W/m²	h/year
Burgenland	1 911	1 132	592.5	1 132
Carinthia	1 880	1 168	621.6	1 168
Lower Austria	1 740	1 073	616.8	1 073
Upper Austria	1 665	1 064	639.2	1 064
Salzburg	1 594	1 128	707.8	1 128
Styria	1 745	1 102	631.3	1 102
Tyrol	1 797	1 116	620.6	1 116
Vorarlberg	1 649	1 118	678.2	1 118
Vienna	1 810	1 084	599.3	1 084

Performance Ratio: PR

The Performance Ratio is a figure indicating the quality of a photovoltaic system. It describes the losses that occur due to cabling, temperature, conversions, and so on, by comparing the amount of electricity actually produced (fed into the product that stores the solar energy) to the module's nominal efficiency under standard test conditions. A study from 2002 [52] (Kapusta, Karner & Heidenreich 2002) investigated the Performance Ratios of 18 systems, finding that the average Performance Ratio for the 18 systems was 63%. In various more recent sources, average Performance Ratios ranging from 70% to 75% have been found. A Performance Ratio of 70% is assumed for the present method.

Module's nominal efficiency: WG

The nominal efficiency of the module describes the ratio of the module's nominal power, achieved under standard test conditions, to the radiant power falling on the module under standard test conditions. It is dependent on the material and design of the cells, and relates to the gross area of one entire module.

Monocrystalline Si cells	14	%
Polycrystalline Si cells	13	%
Amorphous Si cells	5	%
Copper indium diselenide cells (CIS)	9	%
Cadmium telluride cells (CdTe)	7	%

[52] Kapusta F., Karner A., Heidenreich M. (2002) *200 kW Photovoltaik-Breitentest [Wide-range photovoltaic test]*. Berichte aus der Energie- und Umweltforschung [Reports from energy and environmental research]. (16/2002) BMVIT (Austrian Federal Ministry for Transport, Innovation and Technology) & nachhaltigwirtschaften konkret

Feed-in factor: ee_{Netz}

The feed-in factor gives the portion of energy that is fed directly into the grid. Due to insufficient data, experts were consulted in order to arrive at the initial assumptions. These should be evaluated prior to submission of the 3rd national energy efficiency action plan. The following default values were assumed for the feed-in portion, covering the two groups of final energy consumers and a specific type of PV system:

PV systems in private households	70	%
PV systems in businesses	10	%
Grid-independent systems	0	%

Formula for project-specific information

The project-specific formula can also be applied when the PV module area has been installed; the following additional information is required:

- EE_{PV}
- PR, WG, G_S
- PR, t_{SD}
- ee_{Netz}

Project-specific formula

$$EE_{ges} = (m^2_{PV} - m^2_{fr}) \times EE_{PV} \times (1 - ee_{Netz}) \times rb \times so \times cz$$

$$EE_{PV} = G_S \times WG \times PR$$

12 Smart meters and informative billing

The EU directive on energy end-use efficiency and energy services (2006/32/EC) requires in Article 13(1) that Member States ensure all final customers are provided with competitively priced individual meters that ‘reflect the final customer's actual energy consumption and that provide information on actual time of use’. Individual meters such as this must always be provided when existing meters are replaced.

Furthermore, Member States are called upon in Article 13(2) to ensure that the billing performed by the energy supply companies ‘is based on actual energy consumption, and is presented in clear and understandable terms’. The billing must provide the final customers with a comprehensive account of current energy costs. Billing based on actual consumption must be performed often enough ‘to enable customers to regulate their own energy consumption’.

Finally, Article 13(3) defines what information must be made available to the final customer in or with their bills, contracts, transactions and/or receipts ‘in clear and understandable terms’. The customer must be provided with their actual energy consumption and the current actual prices, along with comparisons to their energy consumption for the same period last year, comparisons with the average consumption of a similar user category (benchmarks), and contact information for organisations that can provide information on energy efficiency improvement measures.

12.1 Calculating the energy savings

Description of measure

The measure consists of the grid operator installing, in private households, individual meters that reflect the final customer's actual energy consumption and the actual time of use. In addition, the customer's billing must be based on the actual energy consumption and must occur often enough for customers to regulate their own energy consumption. A frequency of once per month shall be set, to make it possible to determine unambiguously whether or not the method's frequency requirement has been met. This time period seems feasible in the light of international comparisons.[53] The information included in the billing must take the requirements of Article 13(3) of the directive into account. Finally, the installation must be accompanied either by a one-off energy audit or by sufficient information on how best to use the meter, so that customers are genuinely put in a position where they can regulate their own energy consumption.

[53] Cf. requirements in Sweden, and the European Commission's proposals in the ‘third legislative package’ of September 2007, in which paragraph (i) was added to Annex A, requiring Member States to ensure that customers be ‘properly informed every month of actual electricity consumption and costs. No additional costs can be charged to the consumer for this service.’

Default formula

$$EE_{ges} = (n - fr) \times EEV_{HH} \times e_{SMART} \times rb \times so \times cz$$

$$EE_{ges/Strom} = (n - fr) \times EEV_{HH/Strom} \times e_{SMART} \times rb \times so \times cz$$

EE_{ges}	Total energy savings [kWh per year]
n	Number of metering points converted to smart metering and billing systems in private households
fr	Number of smart metering and billing systems that would have been installed anyway, regardless of the measure (free riders) (= 0)
EEV_{HH}	Final energy consumption of an average household [kWh per year]
$EEV_{HH/Strom}$	Electricity consumption of an average household [kWh per year]
e_{SMART}	Savings factor due to the introduction of a smart metering and billing system in a private household [%]
rb	Rebound effects (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

If meters for electricity, gas or district heating are installed, then the default formula takes into account the total average final energy consumption of a household. If it is solely electricity meters that are installed, then the average electricity consumption of a household is used in the default formula to calculate the total energy savings (represented by $EE_{ges/Strom}$).

Default values

Savings factor due to the introduction of a smart metering and billing system in a private household	3%
Lifetime for 'feedback on use from smart meters' according to CEN (CEN WS 27 Final CWA Draft)[54]	2 years
Final energy consumption of an average household [kWh per year][55]	22 000 KWh
Electricity consumption of an average household [kWh per year]	4 250 kWh

Lifetime

In the CEN WS 27 Final CWA Draft, a lifetime of 2 years is given for measures that change behaviour through a feedback mechanism.

[54] This lifetime is, according to CEN WS 27 Final CWA Draft, a default value that can be adjusted at a national level if transparent data/studies are available.

[55] For the year 2006 the micro-census (family and household statistics) recorded 3.508 million private households. The total final energy consumption of private households in 2006 stood at 276 128 TJ, with final consumption of electrical energy at 53 620 TJ (Source: Statistics Austria, energy balance 2006).

Project-specific savings factors

If transparent studies/investigations (e.g. quasi-experimental trial design) are available that demonstrate savings factors differing from the ones listed above, then these 'project-specific savings factors' can be applied.

12.2 Sources

Both in Austria and internationally, very few studies have been carried out concerning the effects of smart metering and billing cycle frequency on energy consumption (cf. Darby 2006). The savings value in the above method is a rather conservative one in the light of the studies discussed below. These studies evaluated pilot projects which were for the most part carried out using voluntary participants, as with Benders et al. (2006). In the event of a large-scale roll-out of the measure, however, one also has to consider households that are not especially interested or engaged. This would most likely lead to lower savings values. The studies also have many methodological problems (the results are not statistically significant, the drop-out rate is very high, etc.) and employ differing methodologies, limiting the extent to which they can be compared with each other.

Some countries in Europe, particularly Holland, Italy and the Scandinavian countries, have now gained some initial experience in smart metering and billing systems. There are also some studies from the USA and Canada on the savings potential of such systems. In Austria, individual pilot projects are being carried out in the electricity sector. In the natural gas sector, OÖ Ferngas AG has carried out initial test installations, although as yet no customer installations have taken place.[56]

12.2.1 Savings through energy consumption readings (real-time and direct feedback)

- A two-and-a-half-year study by Mountain (2006) on electricity consumption in 505 Canadian households showed an average saving of 6.5% above the baseline when portable monitors showing real-time energy consumption in kWh, US dollars and Co_2 were used.
- Benders et al. (2006) achieved a saving of 8.5% (compared to a control group) through the use of a personalised online tool in a study of 137 Dutch households. However, this result is not statistically significant. The households that participated were recruited by means of newspaper advertisements. The study had a high drop-out rate. Also, numerous problems were caused by the use of the internet.
- Nielsen (1993) gauged the effect of direct feedback about consumption via meters, and indirect feedback using additional information, in a Danish study lasting three years and examining around 1500 flats and houses. Savings of roughly 10% were achieved in single-family houses, whereas in flats the saving was only 1%. The savings that could be achieved in low-income groups in particular were comparatively low.

[56] Inbetriebnahme von smarten Gaszählern bei der OÖ Ferngas AG [Launch of smart gas meters by OÖ Ferngas AG]. Presentation by Konrad Peterka, IIR Smart Metering, 2 June 2008, Vienna.

- In Austria, the initial assessment of a pilot project by Linz AG suggested that intelligent energy management could provide a 7% saving in heating energy consumption (Breitschopf 2008). So far no other energy suppliers have carried out any studies of any note on savings effects.

12.2.2 Savings through informative presentation of energy consumption in bills (indirect feedback)

The most comprehensive empirical studies on the effects of informative billing on energy consumption have been conducted in Scandinavian countries.

- Wilhite and Ling (1995) were able to show in multiple studies (n = 190–210) in Oslo that frequent and informative billing could bring about an 8–12% reduction in electricity consumption even in the third year of the study, with changes in behaviour becoming ingrained: 'Our impression from interviews is that after 3 years the changes people made had become so routine that they had trouble identifying them.' Younger participants of the study were more likely to change their behaviour than older participants.
- Henryson et al. (2000) report on a number of large-scale studies (n = 600–1500) in several Scandinavian countries. In six out of seven studies, a lasting reduction in electricity consumption of 2–12% was achieved through simple, frequent and informative billing. The other study was not able to demonstrate any changes in behaviour or electricity savings.
- Dutch studies and field trials (source: KEMA Consulting) from 2003 showed that monthly billing could achieve an energy saving of 3.9–4.3%.
- No comparable studies have taken place in Austria.

[50] cf. Toptest GmbH: Section criteria for air conditioning systems. http://www.topten.ch/index.php?page=auswahlkriterien_klimagerate&fromid= (06/2008)

12.3 Bibliography

Benders et al. (2006). New Approaches for Household Energy Conservation. In Search of Personal Household Energy Budgets and Energy Reduction Options. Energy Policy Vol. 34, 3612–3622.

Brandon G. / Lewis A. (1999). Reducing Household Energy Consumption: A Qualitative and Quantitative Field Study. Journal of Environmental Psychology Vol. 19, 75–85.

Breitschopf N. (2008). Energiepark Plesching [Plesching energy park]. Presentation at the 10th Energy Innovation Symposium, 13–15 February 2008, Graz University of Technology.

Darby, Sarah. (2006). The Effectiveness of Feedback on Energy Consumption. A Review for DEFRA of the Literature on Metering, Billing and Direct Displays. April 2006. Environmental Change Institute, University of Oxford.

Henryson J. et al. (2000). Energy efficiency in buildings through information – Swedish perspective. Energy Policy Vol. 28, 169–180.

Mountain D. (2006). The Impact of Real-Time Feedback on Residential Electricity Consumption: the Hydro One Pilot. Mountain Economic Consulting and Associates Inc., Ontario.

Nielsen L. (1993). How to get the Birds in the Bush into your Hand: Results from a Danish Research Project on Electricity Savings. Energy Policy Vol. 21(11), 1133–1144.

Wilhite H. / Ling R. (1995). Measured Energy Savings from a more Informative Energy Bill. Energy and Buildings, Vol. 22, 145–155.

13 Solar thermal systems

13.1 Installation of solar energy systems

Description of measure

This measure concerns the installation of a solar energy system in order to provide hot water, or to provide hot water and also support the building's heating system. The measure can apply to existing buildings and to new buildings. Here the assumption is made that it is a modern gas, oil or biomass boiler or a heat pump whose hot water provision is being replaced by the solar energy system (and whose heat provision is being supported by the solar energy system, if applicable).

There are two basic types of solar thermal system:

- Glazed flat-plate collectors (standard collectors)
- Evacuated tube collectors

The two types are subsidised to differing extents because of the different investment costs specific to each of them; they also produce different amounts of useful energy.

Default formula

The default formula can be applied to measures that lack project-specific data, e.g. for subsidies for domestic solar energy systems.

$$EE_{ges} = ((m^2_{St} - fr_{St}) \times EE_{St} + (m^2_{Vak} - fr_{Vak}) \times EE_{Vak}) \times rb \times so \times cz$$

EE_{ges}	Total energy savings [kWh per year]
M^2_{st}	Subsidised and installed solar collector area (standard) in m^2
fr_{St}	Solar collector area (standard) that would have been installed anyway regardless of the measure (= 0)
EE_{St}	Average annual final energy savings per m^2 installed collector area (standard) -> 538 kWh/m^2/year (see default values)
M^2_{Vak}	Installed solar collector area (evacuated-tube type) in m^2
fr_{Vak}	Solar collector area (evacuated-tube type) that would have been installed anyway, regardless of the measure (= 0)
EE_{Vak}	Average annual final energy savings per m^2 installed collector area (evacuated-tube type) -> 846 kWh/m^2/year (see default values)
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

The key factor in calculating the final energy saving EE_{St} or EE_{Vak} is what alternative system would have been used to provide the same amount of useful energy. This can range from various types of gas boiler to oil or biomass boilers. In order to simplify matters, the alternative system is assumed to be providing hot water only, by means of a boiler during the summer months; its efficiency is assumed to be 50% to 80%. A calculation value of 65% is used.

Table 13-1: Calculation values[57,58]

	Yield of useful heat [kWh/m²/year]	**Efficiency – boiler system**	**Final energy usage of alternative system = Final energy savings per m² collector area [kWh/m²/year]**
Glazed flat-plate collector (standard)	350	65 %	538
Evacuated-tube collector	550	65 %	846

Lifetime of solar energy systems (standard and evacuated-tube collectors): 20 years (VDI 2067 p. 24)

Formula for project-specific information

This formula is used if concrete information on energy savings (EE_{St} or EE_{Vak}) is available for the project or for the installation of a solar energy system, e.g. due to measurements, manufacturer's information, etc.

$$EE_{ges} = \left(\sum_{i=1}^{n} m^2_{i.St} \times EE_{i,St} + \sum_{j=1}^{n} m^2_{j.Vak} \times EE_{j,Vak}\right) \times rb \times so \times cz$$

n	Number of projects carried out
EE_{ges}	Total energy savings [kWh per year]
$m^2_{i,St}$	Subsidised and installed solar collector area (standard) in project i in m^2
$EE_{i,St}$	Annual final energy savings per m^2 installed collector area (standard) in project i [$kWh/m^2/year$]
$m^2_{j.Vak}$	Installed solar collector area (evacuated-tube type) in project j in m^2

[57] BMVIT (publisher) (2006): Alternativenergie in Österreich – Marktentwicklung 2005 – Thermische Solarenergie, Photovoltaik und Wärmepumpen [Alternative energy in Austria – Market development 2005 – Thermal solar energy, photovoltaics and heat pumps]. Berichte aus Energie und Umweltforschung [Reports from Energy and Environmental Research] 37/2006. http://www.energieklima.at/fileadmin/user_upload/pdf/Zahlen_Daten/372006_Marktentwicklung_Alternativenergi en_2005_screen_neu.pdf (02/2006)

[58] Arbeitsgemeinschaft Erneuerbare Energie (Renewable Energy Association – AEE) (publisher) (1999): Sonne für Hotels – Planung von Kollektoranlagen zur Warmwasserbereitung für Beherbergungsbetriebe [Sun for hotels – Planning collector systems to provide hot water for the accommodation industry]. Verlag AEE, Gleisdorf

$EE_{j,Vak}$ Average annual final energy savings per m^2 installed collector area (evacuated-tube type) in project j [kWh/m^2/year]

rb Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)

so Spill-over effects = multiplier effects (= 1)

cz Confidence factor (= 1)

Basis of the data

The number of participants (= subsidy recipients) and the installed area are determined through various funding channels:

- Subsidies for solar energy systems in residential buildings, through the federal states (direct grants / via residential building subsidy).
- Subsidies of solar energy systems for hot water provision or partially-solar space heating, along with large-scale solar energy systems, for subsidy applicants that are commercially active (subsidy through Kommunalkredit Public Consulting).

Documentation requirements – default formula:

- Documents providing evidence for the installation of the solar thermal system, e.g. copy of the invoice for the solar thermal system including information on the type installed.

Documentation requirements – project-specific formula:

- Documents providing evidence for the values used, e.g. copy of the invoice for the solar thermal system including information on the type installed, planning documentation and/or energy consumption records that allow a comparison with the previous system of heating / hot water provision.

14 Efficient heating circulator pumps in residential buildings

14.1 New installations and replacements of existing circulator pumps

Description of measure

This method allows one to calculate the energy savings resulting from the installation of efficient circulator pumps. Circulator pumps count as ‘efficient’ if they have an Energy Efficiency Index (EEI) lower than 0.4, corresponding to class A of the current Energy Label. The lower the EEI, the lower the pump's consumption of electrical energy, and hence the better the energy classification.

Pumps of energy class A have a permanent magnet synchronous motor with electronic speed control, which takes place by means of a frequency inverter. For a speed-controlled pump (controlled via a frequency inverter), energy consumption is calculated based on the ‘Blue Angel’ (Blauer Engel) load profile.[59]

Due to a lack of data, the effect of recovery of the pump's motor heat (heat radiation losses) is ignored.

The energy savings are calculated as follows, under the assumption of an average annual runtime:

- For replacements of existing circulator pumps: from the difference between the energy consumption of an average circulator pump in the existing stock and the energy consumption of an efficient circulator pump (EEI = A)
- For first-time installations of circulator pumps (in new buildings): from the difference between the energy consumption of an average circulator pump available on the market and the energy consumption of an efficient circulator pump (EEI = A)

Default formula

$$EE_{ges} = ((n - fr) \times (P_{d,n} \times t_a - P_{eff} \times t_a \times f_{LPr}) \times rb \times so \times cz) / 1000$$

$$f_{LPr} = t_{Q100\%} \times Q_{100\%} + t_{Q75\%} \times Q_{75\%} + t_{Q50\%} \times Q_{50\%} + t_{Q}{}^{2}{}_{5\%} \times Q^{2}{}_{5\%} = 0.4575$$

EE_{ges}	Total energy savings [kWh per year]
n	Number of circulator pumps installed
fr	Number of circulator pumps that would have been installed anyway regardless of the measure (free riders) (= 0)
$P_{d,n}$	Power of an average circulator pump in the existing stock or an average circulator pump available on the market [W]

[59] European Commission (2008). EUP Lot 11: Circulators in buildings. Report prepared by AEA Energy & Environment, Didcot, UK, page 27. The document can be downloaded from the monitoring body's website.

P_{eff}	Power of a highly efficient circulator pump [W][60]
t_a	Average annual runtime for circulator pumps [h]
f_{LPr}	'Blue Angel' load profile factor
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

'Blue Angel' load profile

Delivery rating Q	*Relative load time* t_Q 2 5% -
%	*%*
100	*6*
75	*15*
50	*35*
25	*44*

Default values

$P_{d,n}$ for new installations of circulator pumps [W]	75[61]
$P_{d,n}$ for circulator pump replacements [W]	86[62]
P_{eff} [W]	25
Annual runtime t_a [h][63]	5 000
Lifetime	15 years

[60] For a speed-controlled pump (controlled via a frequency inverter), the energy consumption is calculated based on the 'Blue Angel' load profile. Cf. European Commission (2008). EUP Lot 11: Circulators in buildings. Report prepared by AEA Energy & Environment, Didcot, UK, page 27.

[61] The power of average circulator pumps available on the market is assumed to be roughly 75 W.

[62] The power of an average circulator pump in the existing stock is assumed to be 86 MW (see a study by OÖ Energiesparverband (Energy Saving Association of Upper Austria) which included 3 200 replacement circulator pumps; written information from Dr Dell of 03/04/2009).

[63] Source: EU SAVE II Project: 'Promotion of Energy Efficiency in Circulation Pumps, especially in Domestic Heating Systems', VHK for Grundfos A/S; 5 May 2001.

Formula for project-specific information

$$EE_{ges} = \frac{\sum_{i=1}^{n} (P_{d,i} \times t_{i,a} - P_{i,eff} \times t_{i,b} \times f_{LPr}) \times rb \times so \times cz}{1000}$$

EE_{ges}	Total energy savings [kWh per year]
n	Number of projects
$P_{d,i}$	Power of the existing circulator pump in project i or of an average circulator pump available on the market [W]
$P_{i,eff}$	Power of the efficient circulator pump in project i [W][64]
$t_{i,a}$	Annual runtime for project i prior to installation of the highly efficient circulator pump [h]
$t_{i,b}$	Annual runtime for project i after installation of the highly efficient circulator pump [h]
f_{LPr}	'Blue Angel' load profile factor
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Documentation requirements – default formula:

- Documents providing evidence for the installation of the efficient circulator pump, e.g. copy of the invoice for the circulator pump including information on the type installed and the Energy Label.

Documentation requirements – project-specific formula:

- Documents providing evidence for the values used, e.g. invoice for the efficient circulator pump including information on the type installed and the Energy Label, planning documentation and/or energy consumption records that give details of the consumption and/or power and average runtime of the existing pumps.

[64] For a speed-controlled pump (controlled via a frequency inverter), the energy consumption is calculated based on the 'Blue Angel' load profile.

15 Heat pump

Use is made of ‘expenditure factors’ (in German: Aufwandzahlen) to calculate the final energy savings brought about by a variety of heating technology measures. The expenditure factor describes the relationship of final energy (in the case of space heating and hot water, this is the ‘heating energy consumption’) to useful energy (the ‘heating requirement’ plus the ‘hot water heating requirement’). In this way the full chain of heat provision is included, taking into account the storage, distribution and emission of the heat.

$$EF = \frac{HEC}{HR + HWHR}$$

EF	Expenditure factor
HEC	Heating energy consumption
HR	Heating requirement
HWHR	Hot water heating requirement

The final energy savings are computed in a back-calculation using the useful energy.

The difference between the expenditure factor of a reference system and that of a system after an energy efficiency improvement measure has taken place is a key element for the final energy savings; also key (when calculating energy savings using the model buildings) is the heating requirement figure (determined using the specifics of the buildings) and the gross floor area.

The calculation of final energy and useful energy is based on information on model buildings and reference heating systems that take current standards into account. Detailed descriptions of the model buildings can be found in the report ‘Description of the model buildings for the calculation of expenditure factors’.

The details of the model buildings and reference heating systems, along with the calculations of final energy and useful energy that rest upon them, were formulated during the development of the methods in a participative process that involved the relevant stakeholders through workshops, position statements, etc. The expenditure factors were then derived from these.

The calculations of useful and final energy figures took place with the help of the OIB's Excel training tool for calculating energy indicators for residential buildings (2008-07-11 V 08 b – Dr. Pöhn, MA 39, City of Vienna) or using the software ‘Gebäudeprofi plus’.[65]

In line with how the statistical data is recorded, with electricity and fuels being categorised as sources of final energy, this method considers the difference between the final energy usage of electricity for the heat pump and of fuels in conventional boilers in order to provide space heating and hot water. However, with this approach one should remain mindful of the fact that there are two different sources of final energy involved. To fully understand the savings potential of both systems one would have to examine the primary energy usage.

[65] Gebäudeprofi plus, Version 1.2.2, ETU GmbH

15.1 Installation of ground source and water source heat pumps in new buildings

Description of measure

Instead of a new average boiler (e.g. an atmospheric boiler), an efficient ground source or water source heat pump (seasonal performance factor ≥ 4) is installed. The new heat pump provides space heating and hot water, and is therefore comparable with an oil- or gas-fired boiler system. The measure applies to single-family houses.

Default formula

$$EE_{ges} = (n - fr) \times m^2 \times \left(E_{Standard} - E_{WP}\right) \times rb \times so \times cz$$

$$E_{Standard} = (HWB_{NB} + WWWB) \times AZ_{Standard}$$

$$E_{WP} = (HWB_{NB} + WWWB) \times AZ_{WP}$$

EE_{ges}	Total final energy savings [kWh per year]
n	Number of participants / heat pumps
fr	Number of participants that would have had heat pumps installed anyway regardless of the measure (free riders) (= 0)
m^2	Average building size in m^2 (gross floor area – GFA)
$E_{Standard}$	Average annual final energy consumption per m^2 GFA in a new building with new average systems [kWh/m^2/year]
E_{WP}	Average annual final energy consumption per m^2 GFA in a new building when a heat pump is installed
HWB_{NB}	Heating requirement per m^2 GFA per year in the new building [kWh/m^2/year]
WWWB	Hot water heating requirement [kWh/m^2/year]
$AZ_{Standard}$	Expenditure factor for converting useful energy to final energy for a new average heating system
AZ_{WP}	Expenditure factor for converting useful energy to final energy with the installation of a heat pump
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Lifetime: 17 years (CEN proposal)

		Single-family house
		New building
GFA [m²]		176
HWB_{NB} [kWh/m²/year]		66
WWWB [kWh/m²/year]		12.5
Oil	$AZ_{Standard}$	1.53
Gas	$AZ_{Standard}$	1.45
Average	$AZ_{Standard}$	1.49
Heat pump, ground	AZ_{WP}	0.33
Heat pump, water	AZ_{WP}	0.25

Formula for project-specific information

$$EE_{ges} = \sum_{i=1}^{n} \left(m_i^2 \times \left((HWB_{i,NB} + WWWB_i) \times AZ_{i,Standard} - (HWB_{i,NB} + WWWB_i) \times AZ_{i,WP}\right)\right) \times rb \times so \times cz$$

EE_{ges}	Total final energy savings [kWh per year]
n	Number of participants / heat pumps
m^2_i	Gross floor area of participant i, in m^2
$HWB_{i,NB}$	Heating requirement of participant i in the new building [kWh/m²/year]
$WWWB_i$	Hot water heating requirement of participant i [kWh/m²/year]
$AZ_{i,Standard}$	Expenditure factor for converting useful energy to final energy for a new average heating system
$AZ_{i,WP}$	Expenditure factor for converting useful energy to final energy with the installation of a heat pump
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Documentation requirements – default formula:

- Documents providing evidence for the installation of the efficient heat pump (e.g. copy of the invoice for the heat pump including information on the type installed) and proof of the annual expenditure factor (e.g. according to VD 4650 – Short method for calculating the annual expenditure factors of heat pumps [Kurzverfahren zur Berechnung der Jahresaufwandszahlen von Wärmepumpenanlagen]) or a 5-year Heat Pump Performance Guarantee (see for example the form for the federal state of Styria[66]).

Documentation requirements – project-specific formula:

- Documents providing evidence of the values used (e.g an invoice for the efficient heat pump including information on the type installed) and proof of the annual expenditure factor (e.g. according to VD 4650 – Short method for calculating the annual expenditure factors of heat pumps) or a 5-year Heat Pump Performance Guarantee (see for example the form for the federal state of Styria [66]), planning documentation and/or energy consumption records that provide details of the consumption and/or power and average runtime of the existing pump.

[66] http://www.verwaltung.steiermark.at/cms/dokumente/10098196_2628408/ea30b5c3/5-Jahres-Leistungsgarantie_Waermepumpe.pdf

16 White goods (household appliances)

Overview of measures

In our opinion there is currently a need for bottom-up methods for the following measures relating to white goods:

- New acquisitions of fridges and freezers of the A++ efficiency class (or the best available efficiency class)
- Early replacement of existing fridges and freezers that are more than 10 years old by appliances of the A++ efficiency class (or the best available efficiency class)
- New acquisitions of tumble dryers of efficiency class A

In light of the current regulations on energy efficiency labelling, we believe that the acquisition of a new washing machine or dishwasher does not represent an energy efficiency improvement measure because the efficient label A is already extremely prevalent in the market.

Based on experience, the early replacement of washing machines or dishwashers is not currently considered to be feasible on a large scale because of the high total cost burden for the investor (the household), and because the energy expended to manufacture the product (grey energy) is detrimental to the overall energy balance.

16.1 New acquisitions of fridges and freezers of efficiency class A++ (or the best available efficiency class)

Description of measure

This measure consists of the new purchase of a fridge or freezer of the best available energy efficiency class (generally A++ but in some exceptional cases A+) compared to an appliance of efficiency class A.

Default formula

$$EE_{ges} = (n - fr) \times (E_A - E_{eff}) \times rb \times so \times cz$$

EE_{ges}	Total energy savings [kWh per year]
n	Number of fridges and freezers of efficiency class A++ (or the best available efficiency class) that were purchased as a result of the measure
fr	Number of fridges and freezers of efficiency class A++ (or the best available efficiency class) that would have been purchased anyway regardless of the measure (free riders) (= 0)
E_A	Average annual energy consumption of an appliance of efficiency class A [kWh]
E_{eff}	Average annual energy consumption of an appliance of efficiency class A++ (or the best available efficiency class) [kWh]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Average annual energy consumption of an appliance of efficiency class A (fridge-freezer combo, one-door, usable volume of 210 l) [kWh][67]	240
Average annual energy consumption of an appliance of efficiency class A++ (fridge-freezer combo, one-door, usable volume of 210 l) [kWh][68]	155
Lifetime [years] (Harmonised value in accordance with 'Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations – Final CWA draft (CEN WS 27)', 2007)	15

Note: For reasons of simplification, the above-listed default values can be used for every product category of fridge or freezer. The default values are adapted based on evaluations of appliance replacement schemes that have already been carried out.

[67] www.topprodukte.at, 2008
[68] www.topprodukte.at, 2008

Formula for project-specific information

$$EE_{ges,k} = \sum_{i=1}^{n} (E_{A,i} - E_{eff,i}) \times rb \times so \times cz$$

$EE_{ges,k}$	Total energy savings [kWh per year] in project/programme k
n	Number of purchased appliances i of efficiency class A++ (or the best available efficiency class) in project k
$E_{A\ i}$	Annual energy consumption of the class-A appliance i [kWh]
$E_{eff\ i}$	Annual energy consumption of the appliance i of efficiency class A++ (or the best available energy efficiency class) [kWh]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Note: For the following categories of appliances, appliances belonging to efficiency class A+ can be included in the scope of the measure; this is because the availability of A++ appliances is currently insufficient in these cases.

- Free-standing fridge-freezer combos with a usable volume < 260 litres
- Built-in freezers

16.2 Early replacement of existing fridges and freezers

Description of measure

Existing fridges and freezers are replaced early, by appliances of the best available efficiency class (generally A++, in exceptional cases A+).

Default formula

$$EE_{ges} = (n - fr) \times (E_{Bestand} - E_{eff}) \times rb \times so \times cz$$

EE_{ges}	Total energy savings [kWh per year]
n	Number of fridges and freezers of efficiency class A++ (or the best available efficiency class) that were purchased as a result of the measure
fr	Number of fridges and freezers of efficiency class A++ (or the best available efficiency class) that would have been purchased anyway regardless of the measure (free riders) (= 0)
$E_{Bestand}$	Average annual energy consumption of existing fridges or freezers [kWh]
E_{eff}	Average annual energy consumption of an appliance of efficiency class A++ (or the best available efficiency class) [kWh]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Default values

Average annual energy consumption of a fridge or freezer in the existing stock of 2007 in Austrian households [kWh]	360
Average annual energy consumption of a roughly 10–15 year old appliance (fridge-freezer combo, one-door, usable volume of 210 l) [kWh][69]	500
Average annual energy consumption of an A++ class machine (fridge-freezer combo, one-door, usable volume of 210 l) [kWh][70]	155
Lifetime [years] (Harmonised value in accordance with 'Saving lifetimes of Energy Efficiency Improvement Measures in bottom-up calculations – Final CWA draft (CEN WS 27)', 2007)	15

Note: For reasons of simplification, the above-listed default values can be used for every product category of fridge or freezer.

[69] Based on our own evaluations

[70] www.topprodukte.at, 2008

The default values are adapted based on evaluations of appliance replacement schemes that have already been carried out.

If the age of the appliance being replaced can be determined unambiguously to be 10 years or older, then the default value for the average annual energy consumption of a roughly 10–15 year old machine can be applied in the project-specific formula. If this condition cannot be met, then the average value for the energy consumption of the existing stock of appliances (referring to the year 2007) is to be used.

Formula for project-specific information

$$EE_{ges,k} = \sum_{i=1}^{n} (E_{Bestand,i} - E_{eff,i}) \times rb \times so \times cz$$

EE_{ges}	Total energy savings [kWh per year]
n	Number of appliances replaced early by appliances i of efficiency class A++ (or the best available efficiency class) in project/programme k
$E_{Bestand, i}$	Annual energy consumption of the existing appliance [kWh]
$E_{eff, i}$	Annual energy consumption of a new appliance of efficiency class A++ (or the best available efficiency class) [kWh]
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Note: For the following categories of appliances, appliances belonging to efficiency class A+ can be included in the scope of the measure; this is because the availability of A++ appliances is currently insufficient in these cases.

- Free-standing fridge-freezer combos with a usable volume < 260 litres
- Built-in freezers

16.3 Description of possible future measures

- It is expected that from 2010, the European Commission will further develop the regulations on energy efficiency labelling of household appliances, in order to keep pace with technological advances. As soon as these regulations (potentially an adjustment of the directive) are in place, further methods concerning the purchase of new appliances will be of relevance.

17 Standby savers in domestic households

Description of measure

Standby consumption is the energy consumed by electronic devices after they have been switched off, if they are not fully disconnected from the electricity supply. Standby shutdown devices or 'standby savers' will automatically recognise the standby power drain and disconnect downstream products from the grid. For this to be counted as a measure, the standby saver must be accompanied by some instruction in its proper everyday use, to prevent it leading to an increase in consumption. This can take the form of accompanying usage instructions, or an energy audit.

Default formula

The energy saving is given by the eliminated standby consumption minus the standby saver's own energy requirements.

$$EE_{ges} = n_{SBK} \times (P_G \times t_{SB} - P_{SBK} \times t_a) / 1000 \times rb \times so \times cz$$

EE_{ges}	Total final energy savings [kWh/year]
n_{SBK}	Number of standby savers installed due to the measure
P_G	Standby power drain of the downstream devices in W
P_{SBK}	Standby saver's own energy requirement in W
t_a	Hours per year = 8760 h/year
t_{SB}	Time with no regular use of the devices in h/year
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Lifetime: 10 years

Default values

Standby power drain of the downstream products:

P_G

As part of the IEE project ‘SELINA’, the standby consumption of electrical items in 12 federal states was recorded in 2009. The items were divided into consumption-based categories; the averages identified during the course of the project for passive standby power consumption in Austria shall be used here as default values.

Consumption category	Passive standby power consumption	Household energy consumption[71] [kWh/year]
Household appliances	1.45	46
Entertainment electronics and office devices	1.80	141

In determining the default value, it is assumed that the standby saver is in control of three downstream devices on average. Because the standby saver's exact point of use is not known, a further step is used to determine the average power of the connected devices for a typical standby saver. Values from the Statistics Austria project ‘Electricity and gas diary 2008’ (‘Strom- und Gastagebuch 2008’) are drawn upon for this. The standby power drain is also weighted using the annual standby consumption (ratio 46/187 and 141/187). Because of the automation integral to the standby saver, it also has a standby consumption of its own. In some cases this consumption can be higher than that of a single downstream device. Therefore, a standby saver is only really suitable if it is put in control of multiple devices (three on average), or devices with a high standby consumption.

This is why standby savers are, on average, connected up to devices with a standby power draw of **5.14 W**.[72]

The standby saver's own energy consumption:

P_{SBK}

The standby saver's own energy consumption depends on the design and functionality of the device. It is assumed that the standby saver can be activated by means of a remote control. Its energy consumption is **0.5**[73] Watts whether it is switched on or off.

[71] Wegscheider-Pichler Alexandra (2009), Electricity and gas diary 2008, Statistics Austria, Vienna, page 37

[72] $3 \cdot \left(1{,}45 \cdot \frac{46}{187} + 1{,}8 \cdot \frac{141}{187}\right)$

[73] http://www.topten.ch/deutsch/buro/standby/elektronische_abschalthilfen.html, retrieved on 20/02/2012

Standby time:
t_{SB}

The standby time is the time period for which the device is not used but is also not completely disconnected from the power grid. In international studies,[74] standby times of between 19 and 22 hours per day are assumed. This method therefore assumes a standby time of **20 hours**.

Results of the default formula:

Entering all default values into the default formula produces a saving of 33.14 kWh per installed device per year. This corresponds to roughly 1/5 of the standby consumption of an average household, according to the Statistics Austria project ‘Electricity and gas diary 2008’.

Formula for project-specific information

The formula for standby savers can also be used as a project-specific formula if additional information is available for parameters P_G and P_{SBK} :

$$EE_{ges} = (P_G \times t_{SB} - P_{SBK} \times t_a \times n_{SBK}) / 1000 \times rb \times so \times cz$$

EE_{ges}	Total final energy savings [kWh/year]
n_{SBK}	Number of standby savers installed due to the measure
P_G	Total standby power drain of the downstream devices in W
P_{SBK}	Standby saver's own energy requirement in W
t_a	Hours per year = 8760 h/year
t_{SB}	Time with no regular use of the devices in h/year
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

[74] Fraunhofer Institute for Reliability and Microintegration (2011), Preparatory Studies for Eco-design Requirements of EuP, Berlin

18 Improving the thermal insulation of accumulator tanks

Description of measure

Hot water accumulator tanks (thermal stores) are a way of decoupling energy demand from energy production. This measure consists of improving their energy efficiency by fitting insulation to reduce heat loss from the accumulator tank (used for hot water or space heating).

Default formula

The energy saving is determined from the difference between heat loss before and heat loss after the intervention.

The following input values, to be provided by the operator of the system, are required for the default formula set out below:

- Number of accumulators fitted with insulation through the measure
- Volume of the insulated accumulator, in litres
- Accumulator's insulation thickness before and after the improvement, in cm
- Location of the accumulator (heated/unheated room available)

$$\mathbf{EE_{ges} = (n - fr) \times (Q_{valt} - Q_{vneu}) \times AZ \times rb \times so \times cz}$$

EE_{ges}	Total final energy savings [kWh/year]
n	Number of accumulators fitted with insulation through the measure
Q_{valt}	Annual heat loss of the accumulator before improvement
Q_{vneu}	Annual heat loss of the accumulator after improvement
AZ	Expenditure factor of the heat provision that heats the accumulator
rb	Rebound effects, increase in energy consumption due to the lower cost of energy provision (= 1)
so	Spill-over effects = multiplier effects (= 1)
cz	Confidence factor (= 1)

Lifetime of an accumulator tank: 15 years (CEN proposal)

Default values and calculations

During the development of the method it was agreed that an empirical approximation formula would be used to calculate the savings.

Annual heat loss of the accumulator, Q_v

The annual heat loss of the accumulator is to be dependent on the following variables:

- Volume of the accumulator
- Insulation thickness
- Ambient temperature

From the results of a precise heat loss calculation,[75] the following approximation formula was determined:

$$Q_{V,i} = 3{,}4291 \cdot f_{tu} \cdot V^{0{,}685} \cdot \left(1 - 0{,}103 \cdot \ln(654 \cdot s_i - 528)\right)$$

$Q_{V,i}$	Annual heat loss before/after the improvement [kWh/year]
f_{tu}	Heat loss factor depending on the ambient temperature [-]
V	Accumulator volume in litres
s_i	Insulation thickness before/after the improvement, in cm

The insulation thickness is limited to a range of 1 to 25 cm because the formula is no longer valid beyond that range. The variables are calculated without dimensions, but do have to be entered in the units stated above.

The following assumptions were made during the precise calculation (listed here for the sake of transparency):

Average accumulator temperature [°C]	60
Operating time of the accumulator at an average temperature [h/year][76]	8760
Thermal transmittance (U-value) of a steel accumulator without insulation [W/m²K]	3.35
Thermal conductivity of the insulating material [W/mK]	0.035
Thermal transmittance (U-value) between the accumulator surface and the ambient air [W/m²K]	3.5
Emissive power of a black body (Stefan–Boltzmann constant) [W/m^2K_4]	5.67×10^{-8}
Emissivity factor of the accumulator surface compared to its surroundings [-][77]	0.871
Accumulator surface area as a function of the accumulator volume **$O = 0.0611 \times V^{0.685}$**	

[75] Calculation according to Recknagel, Sprenger, & Schramek. (2007). Taschenbuch für Heizung und Klimatechnik [The heating and climate technology handbook] (73th edition). (Prof. Dr.-Ing.- R. Schramek, publisher). Oldenbourg Industrieverlag, Munich. Chapter 1.3.5

[76] Assumption: The accumulator has to be kept above 60°C all year round for reasons of hygiene.

[77] Assumption: Area ratio of accumulator to surroundings 1:3, emissivity of both bodies = 0.9

The heat loss of the accumulator was calculated using the convective portion as well as the loss of radiant heat. Where there is no insulation, the loss of radiant heat can amount to more than half of the total loss of heat. Both heat loss calculations include the surface area only in a simplified form. The surface area is dependent on volume in the calculation, but independent of the insulation thickness of the accumulator or the thickness of its casing.

Heat loss factor depending on the ambient temperature: f_{tu}

Table 2: Temperature of the accumulator's location

Place installed	**Temperature [°C]**	**Factor**
Average internal temperature in an unheated space	13	66.4
Average internal temperature in a heated space	20	57.7

Further default values

AZ … Expenditure factor of the heat provision[78]	1.8

[78] Taken from the default method 'Extensive thermal renovation of building envelope'

19 Documentation requirements

The directive (2006/32/EC) states that energy savings should be verified by third parties (see Annex IV 6, How to verify energy savings). Documents and records providing evidence for the implementation of energy efficiency measures (and the savings achieved) must be kept for the purposes of this verification.

The following requirements must be met for the documentation of measures and for records of savings estimates or data gathering:

- The documents and records must be legible, clearly identifiable and traceable.
- The documents and records may include (for example) invoices, delivery confirmations, audit reports, analyses from the control system, copies of meter readings, or records on capacity utilisation, the product mix, downtime, manufacturer's information, delivery confirmations, the results of measurements, planning calculations, and so on.
- The documents and records must be kept (either as hard copy or electronically) until 2018.
- If the documentation and information required here was already provided during the course of an application for funding, then use can be made of the documents submitted for that purpose. Parallel documentation is not required as proof of the energy savings under the Energy End-use Efficiency and Energy Services Directive.

Below, the documentation requirements for each bottom-up method are described with the help of examples.

Lighting

Documentation requirements – default formula:

- Documents providing evidence for the distribution/installation of efficient lighting systems, e.g. copy of the invoice for the efficient lighting systems, delivery receipts including information on the type of lighting system, etc.

Documentation requirements – project-specific formula:

- Documents providing evidence for the values used, e.g. copy of the invoice for the efficient lighting systems, delivery receipts including information on the type of lighting system, planning documentation and/or records on energy consumption or power that allow a comparison with the previous lighting system.

Energy audits for businesses

- An audit report must be produced (see section 'Creation of an audit report') along with a documentation sheet for each measure.

- Documents providing evidence for the implementation of the measure, e.g. copies of delivery receipts, copies of energy source calculations, manufacturer's information, etc.
- Documents providing evidence for the energy savings, e.g. analyses from a control system, copies of meter readings, records on utilisation of capacity, product mix, downtime, measurement results, calculations, etc.

Energy advice

Documentation requirements – default formula:

Table 19-1: Documentation requirements – defaults

	Quality level 1	Quality level 2	Quality level 3
Audit on location		• Name, address and signature of the customer, confirming the quality level of the audit • Audit log with date, time, duration, location, type and quality of the audit • Signature of the advisor	• Name, address and signature of the customer, confirming the quality level of the audit • Audit log with date, time, duration, location, type and quality of the audit • Presentation of an energy concept (including suggested improvements and their estimated energy-saving potential) • Signature of the advisor
'Stationary' audits (not on location)	• Name and postcode of the customer; • Signature of the advisor.	• Name and postcode of the customer; • Audit log with date, time, duration, type and quality of the audit • Signature of the advisor.	• Name, postcode and signature of the customer, confirming the quality level of the audit; • Audit log with date, time, duration, type and quality of the audit • Presentation of an energy concept (including suggested improvements and their estimated energy-saving potential) • Signature of the advisor.
Phone audit	• Name, postcode and phone number of the customer; • Date of the audit • Name of the advisor.	• Name, postcode and phone number of the customer; • Audit log • Date of the audit • Name of the advisor.	

Personalised online audit	• Data inputted by the customer; • Personalised audit documentation (feedback) • Web access data		

Project-specific documentation requirements:

- Presentation of the results of a study carried out by an independent company or institute.

District heating

Documentation requirements – default formula:

- Documents providing evidence for the connection to district heating, e.g. copy of the district heating supply contract including date of the formation of the contract and the address of the connection.

Documentation requirements – project-specific formula:

- Documents providing evidence for the values used, e.g. copy of the district heating supply contract, planning documentation and/or energy consumption records that allow a comparison with the previous heating system.

Thermally improved building envelopes

Documentation requirements:

- Documents providing evidence for the replacement of building elements, e.g. copy of the invoice including a description of the building element, size in m^2 and U-value.

Boiler replacement

Documentation requirements – default formula:

- Documents providing evidence for the boiler replacement, e.g. copy of the invoice including information on the type of boiler installed.

Documentation requirements – project-specific formula:

- Documents providing evidence for the values used, e.g. copy of the invoice, planning documentation and/or energy consumption records that allow a comparison with the previous heating system.

Cooling and air conditioning in non-residential buildings

Documentation requirements:

- Documents providing evidence for the installation of a highly efficient compressor chiller or air conditioner, e.g. copy of the invoice including Eurovent class and power of the compressor chiller, along with records/estimates of the full-load hours.

Smart metering

Documentation requirements:

- Documents providing evidence for the installation of an individual meter, e.g. confirmation of receipt by the household.
- Basic information about billing, enough to allow one to judge whether the customers' bills put them in a position to regulate their own energy consumption, e.g. what information is included in the bills, how often bills are sent, etc.

Solar thermal systems

Documentation requirements – default formula:

- Documents providing evidence for the installation of the solar thermal system, e.g. copy of the invoice for the solar thermal system including information on the type installed.

Documentation requirements – project-specific formula:

- Documents providing evidence for the values used, e.g. copy of the invoice for the solar thermal system including information on the type installed, planning documentation and/or energy consumption records that allow a comparison with the previous system of heating / hot water provision.

Efficient heating circulator pumps in residential buildings

Documentation requirements – default formula:

- Documents providing evidence for the installation of the efficient circulator pump, e.g. copy of the invoice for the circulator pump including information on the type installed and the Energy Label.

Documentation requirements – project-specific formula:

- Documents providing evidence for the values used, e.g. invoice for the efficient circulator pump including information on the type installed and the Energy Label, planning documentation and/or energy consumption records that give details of the consumption and/or power and average runtime of the existing pumps.

Heat pump

Documentation requirements – default formula:

- Documents providing evidence for the installation of the efficient heat pump (e.g. copy of the invoice for the heat pump including information on the type installed) and proof of the annual expenditure factor (e.g. according to VDI 4650 – Short method for calculating the annual expenditure factors of heat pumps) or a 5-year Heat Pump Guarantee (see for example the form for the federal state of Styria[79]).

[79] http://www.verwaltung.steiermark.at/cms/dokumente/10098196_2628408/ea30b5c3/5-Jahres-Leistungsgarantie_Waermepumpe.pdf

Documentation requirements – project-specific formula:

- Documents providing evidence of the values used (e.g an invoice for the efficient heat pump including information on the type installed) and proof of the annual expenditure factor (e.g. according to VD 4650 – Short method for calculating the annual expenditure factors of heat pumps) or a 5-year Heat Pump Performance Guarantee (see for example the form for the federal state of Styria[66]), planning documentation and/or energy consumption records that provide details of the consumption and/or power and average runtime of the existing pump.

White goods (household appliances)

Documentation requirements – default formula:

- Documents providing evidence of the new purchase or early replacement of appliances, e.g. copy of the invoice including energy efficiency class of the appliance, or a copy of vouchers that have been cashed-in.
- Documents showing that the fridge or freezer was replaced early and was not a new acquisition, e.g. a receipt for the removal of the old machine, or an audit report from an energy audit suggesting the replacement of the fridge or freezer as an energy-saving measure.

Documentation requirements – project-specific formula:

- Documents providing evidence for the values used, e.g. copy of the invoice, planning documentation and/or energy consumption records that allow a comparison with the previous stock of appliances or previous state of the art.
- Proof of the energy savings achieved can also be provided in the form of evaluations by independent advisors, energy service companies or other market operators in accordance with the European Ex-post Evaluation Guidebook for DSM and EE Service Programmes; IEA, INDEEP database; IPMVP published guidelines, Volume 1 (Edition of March 2002).

Resource security
Competitiveness
Sustainability
Perspectives

ÖSTERREICHISCHE ENERGIEAGENTUR – AUSTRIAN ENERGY AGENCY
A-1150 Vienna, Mariahilfer Straße 136 | Phone +43-1-586 15 24 | Fax +43-1-5861524-340
office@energyagency.at | www.energyagency.at | www.monitoringstelle.at

Energy efficiency monitoring body